SIGN LANGUAGE RESEARCH SIXTY YEARS LATER: CURRENT AND FUTURE PERSPECTIVES

EDITED BY: Valentina Cuccio, Erin Wilkinson, Brigitte Garcia, Adam Schembri, Erin Moriarty and Sabina Fontana

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SIGN LANGUAGE RESEARCH SIXTY YEARS LATER: CURRENT AND FUTURE PERSPECTIVES

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Manual and Spoken Cues in French Sign Language's Lexical Access: Evidence From Mouthing in a Sign-Picture Priming Paradigm

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Although Sign Languages are gestural languages, the fact remains that some linguistic information can also be conveyed by spoken components as mouthing. Mouthing usually tend to reproduce the more relevant phonetic part of the equivalent spoken word matching with the manual sign. Therefore, one crucial issue in sign language is to understand whether mouthing is part of the signs themselves or not, and to which extent it contributes to the construction of signs meaning. Another question is to know whether mouthing patterns constitute a phonological or a semantic cue in the lexical sign entry. This study aimed to investigate the role of mouthing on the processing of lexical signs in French Sign Language (LSF), according the type of bilingualism (intramodal vs. bimodal). For this purpose, a behavioral sign-picture lexical decision experiment was designed. Intramodal signers (native deaf adults) and Bimodal signers (fluent hearing adults) have to decide as fast as possible whether a picture matched with the sign seen just before. Five experimental conditions in which the pair sign-mouthing were congruent or incongruent were created. Our results showed a strong interference effect when the sign-mouthing matching was incongruent, reflected by higher error rates and lengthened reaction times compared with the congruent condition. This finding suggests that both groups of signers use the available lexical information contained in mouthing during accessing the sign meaning. In addition, deaf intramodal signers were strongly interfered than hearing bimodal signers. Taken together, our data indicate that mouthing is a determining factor in LSF lexical access, specifically in deaf signers.

Keywords: Lexical access, sign language, LSF, mouthing, sign-picture priming, intramodal bilingualism, bimodal bilingualism

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INTRODUCTION

Spoken Components in a Signed Language

Reducing sign languages to their manual dimension is simplistic, as non-manual parameters are also used to produce messages. Several body parts – the whole face, gaze, eyebrows, chest, and mouth – play a linguistic role by bringing fine non-manual articulators to bear (Boyes-Braem et al., 2001; Woll, 2014; Johnston et al., 2016). The study of mouth actions is particularly relevant because it raises the issue of the influence of spoken and gestural languages contact on lexical access.

To study the effect of mouthing on sign recognition, researchers must work at the interface of the linguistic, psycholinguistic, and sociolinguistic domains. To date, very few models of lexical access in sign language have been proposed and those few have focused on the role of sublexical elements such as location and handshape in relation to the neighborhood density effect during lexical access (see the spreading activation architecture proposed by Caselli and Cohen-Goldberg, 2014). The aim of this study was to understand what other sublexical factors in addition to location and handshape may play a determining role in the organization of and access to the mental lexicon in sign language. We particularly focused on the role of mouthing.

Our goal here was to search for behavioral evidence of the linguistic relevance of *mouthing* in accessing lexical information provided by signs in French Sign Language (LSF). Several studies (see below) have proposed that mouth actions can be divided into two types that are formally and functionally different: mouth gestures and mouthing. These two types of mouth actions are performed simultaneously with the manual sign and mobilize the mouth, lips, and tongue. One fundamental difference between the two categories of mouth actions is that while mouthing has a lexical function, mouth gestures convey more frequently morphosyntactic information. Crasborn et al. (2008) proposed a fine-grained typology of mouth actions to distinguish between mouth gestures and mouthing, based on three properties: (1) the independent or dependent meaning carried by the mouth; (2) whether the mouth action is or is not lexically associated with the manual sign; and (3) whether the mouth component is or is not borrowed from the ambient spoken language. In essence, a mouth gesture is frequently qualified as an oral component that is not derived from spoken language. More specifically, a mouth gesture can be an unvoiced syllable produced one or more times or an expiration of air, both of which echo the kinematic structure of the sign and are semantically empty (Woll, 2001; Crasborn et al., 2008). Woll and Sieratzki (1998) named this phenomenon *echo phonology*, with the idea that "the mouth 'echoes' the movement of the hand" (Johnston et al., 2016).

Other types of mouth gestures, which do have semantic content, exist: enaction (the mouth mimes the action meant by the sign, for example chewing gum); or adverbial/adjectival (the mouth gesture adds linguistic properties to the manual sign: a thin vs. large object or person represented by sunken cheeks vs. puffed cheeks, respectively). Mouth gestures are not borrowed from a spoken language and vary in the way that the manual component and mouth component are articulatorily and semantically associated.

Conversely, mouthing is a vocal production always borrowed from the surrounding spoken language, subvocalized or almost inaudible, and usually an approximation of the spoken word. Johnston et al. (2016) analyzed a large sample of AUSLAN (Australian Sign Language) corpora and highlighted different types of mouthing: the manual sign could be combined with a complete spoken word articulation or an incomplete articulation as the initial segment *diff(erent)*, the medial one *(re)mem(ber)*, the final segment *(im)prove*, or both initial and final segment *f(in)ish*. While mouthing is usually performed simultaneously with the manual sign, in some cases it may anticipate or follow the manual production.

Several studies based on video corpora analyses have investigated the frequency of mouthing, in different sign languages and among deaf signers (Boyes-Braem et al., 2001; Crasborn et al., 2008; Woll and Mesch, 2008). There is general agreement that mouthing, even though it is not systematic or obligatory, tends to co-occur with noun signs and fingerspelling, more rarely with verbs. However, in Japanese Sign Language, mouthing coexist with verbs (Penner, 2013). In addition to proposing the typology of mouth actions, Crasborn et al. (2008) compared the frequency of mouth actions in three typologically different sign languages (Dutch Sign Language, British Sign Language – BSL and Swedish Sign Language) and observed a similar tendency across all three sign languages: 50% to 80% of manual signs were produced with mouth actions, and mouthing was the most frequently occurring type of mouth action. This result suggests that mouthing is a useful clue to the lexical specification of a sign.

McKee (2007) reported that mouthing has various functions: (1) phonemic: mouthing can disambiguate two manual signs (e.g., in LSF, the signs meaning *chocolate* and *empty* are manually similar and are discriminated by mouthing); (2) morphemic: mouthing can specify or extend the meaning of a manual sign (e.g., in LSF, the mouthing of *apple* is articulated simultaneously with the manual sign EAT to produce the sentence "to eat an apple"; see several examples in Crasborn et al. (2008); (3) prosodic: to emphasize or stress the manual sign or bind elements within a clause (Weisenberg, 2003); (4) grammatical: to distinguish between nouns (mouthed) and verbs (not mouthed) (Kimmelman, 2009); and (5) psycholinguistic: to highlight the written/signed bilingual ability. Deaf people who use spoken language, in either the oral or written modality, tend to produce mouthing more frequently.

Although mouthing is a linguistic phenomenon observed in all sign languages studied, the question of whether it constitutes an inherent part of a lexical unit of sign languages has been raised. Johnston et al. (2016) suggested that, because mouthing is not obligatory, it is not part of the lexical representation of a sign and is more a code-blending phenomenon, i.e., a phenomenon observed in bimodal communication, characterized by the simultaneous production of signs and vocal words, than a spoken component of the lexical sign. Because there are no articulatory constraints, manual signs, and vocal speech can be produced simultaneously using different output channels (Emmorey et al., 2008a). Sociolinguistic and psycholinguistic factors can be invoked to explain more or less frequent use of mouthing, which is the trace of contact between the surrounding spoken language and the sign language. Johnston et al. (2016) suggested that English mouthing on AUSLAN signs is the consequence of contact of the second language (English) with the native one (AUSLAN) or may be related to oralist education (Bank et al., 2011). Boyes-Braem et al. (2001) reported that chronological age, age of acquisition and type of education (oralist vs. bilingual) could influence mouthing frequency, explaining that frequency of mouthing varies among individuals. Some researchers and deaf people themselves reported that more mouthing is produced

when the communication occurs with a hearing speaker and this mouthing is louder. Some researchers strongly support the assumption that mouthing is not a real part of sign language and claim that it is just an optional complement of manual signs (Ebbinghaus and Heβmann, 2001). Ebbinghaus and Heβmann (2001) observed that the frequency of mouthing may dependent on exposure to the surrounding spoken language (Padden, 1980; Hohenberger and Happ, 2001), and suggested there is a relation between literacy and mouthing: the more literate the deaf signer is, the more frequent the mouthing will be.

All these studies investigated the linguistic characteristics of mouthing, but we also need to understand its psycholinguistic characteristics during processing. One fundamental question is how mouthing is processed by signers. What kind of information do signers use? How is mouthing represented in the lexicon of sign language? Muir et al. (2003) used an eye tracking technique with 8 deaf British Sign Language (BSL) signers while watching BSL video clips; they observed that the deaf participants' gaze direction focused more on the characters' faces than on their hands or body, which tended to mobilize peripheral vision. Most of the gaze points (75% to 90%) lay within 2.5° of the central regions (i.e., the face), with occasional rapid gazes toward other regions. Boutora and Meillon (2010) reported similar results with an eye-tracking pilot experiment with 3 LSF signers (2 deaf and 1 hearing) in which they have to understand a short story in LSF in order to resume it to the experimenter. The authors analyzed the eye gaze path between face and hands. Deaf and hearing signers did not use same gestural information when they perceived LSF utterances: while deaf signers focused mainly on the face, the hearing signer looked at both the face and the hands. To account for these different patterns of results, which were not discussed by the authors, we speculate that, since deaf signers are skillful at processing manual information, they have no problem simultaneously processing both manual and mouthing information. This may explain the results of Muir et al. (2003) and Boutora and Meillon (2010) indicating that deaf signers focus more on mouthing information and process manual information in the peripheral visual field. Furthermore, Huguet (2016) provided interesting results with an LSF eye-tracking study. She showed two LSF video clips to 4 deaf signers, one with the expected mouthing and one without mouthing. After each condition, participants gave a qualitative response to several questions, such as: Do you understand the video sentence? Does the absence of mouthing impede your understanding? The first result reported by Huguet was that the complete lack of mouthing strongly disturbed the deaf participants, who found it difficult to properly understand the meaning of the video. The second determining result in Huguet's study concerned the eye movement data: the heat map revealed greater fixation point density on labial zone, even in the condition without mouthing in which no linguistic information was available there. This result suggests that the perceptual mechanism looks for crucial information in this part of the face. In addition, in the no mouthing condition, the author observed that the paths of eye movements were larger, and fixation points more spread out, undoubtedly because the deaf participants were searching for some "facial" linguistic information. Although these studies provide strong evidence that deaf signers use mouthing information in real time, little is known about how they use the mouthing information to access signs stored in the mental lexicon.

Regarding the role of mouthing in accessing the lexicon, Vinson et al. (2010) raised a central question about the semantic representations of mouthing. They ran an experimental study in BSL to investigate the extent to which mouthing and manual signs share semantic representations despite the fact that these two types of linguistic information do not use a common articulatory channel. They observed that mouthing and manual errors were dissociated, suggesting that they do not share same semantic representation. In addition, authors observed that mouthing's semantic errors were more frequent in a picture-naming task than a word-translating task, suggesting that the presence of the orthography of the written word probably inhibited the semantic competition during lexical retrieval. The authors concluded that mouthing is not embedded in the manual component in the sign language lexicon. These results support the hypothesis that mouthing is not a "sign language phenomenon" and is not part of the sign language system. Addressing the same question, Giustolisi et al. (2017) ran a word–sign matching experiment in LIS (Italian Sign Language) to study the influence of mouthing on Italian word reading. They observed that deaf signers presented shorter reaction times in a condition in which there was strong mapping between mouthing and orthography. Since mouthing is highly facilitative, the authors argued that it is processed as phonemes and correlated with the spoken Italian lexicon, providing new evidence on the extrinsic status of mouthing in sign languages.

Lexical Access in Spoken Language

The arbitrary nature of the relationship between the form and meaning of a word implies that it must be acquired and preserved, in one way or another, in the learner's permanent memory. The expression "mental lexicon" is commonly used in psycholinguistics to refer to the body of knowledge that individuals have about words in their language (Segui, 2015). This knowledge concerns words' semantic, syntactic, morphological, phonological and orthographic properties. Any model of language perception or production must necessarily include a lexical component. Indeed, the lexicon constitutes the fundamental interface that links the formal level to the interpretive level of language. If one accepts the principle that lexical knowledge is represented in the form of a mental dictionary (Treisman, 1960), the question arises of how one accesses the "entries" in this dictionary during word production and comprehension.

In cognitive psychology, almost all of the current models of language perception and production refer to the notion of activation. It is important to distinguish between activation and access. The activation of a lexical unit is a necessary but not sufficient condition for gaining access to the information that it contains. In addition to the notion of access to the lexicon, a crucial issue concerns the nature of the lexical representation in the mental lexicon. In the following section, we describe his point for sign languages. Several studies investigated the link between spoken and signed lexical access (Marshall et al., 2005; Kubus

et al., 2015). One interesting result regarding sign/speech mental lexicon has been reported in Kubus et al.'s (2015) research. These authors studied visual word recognition in deaf bilinguals proficient in German Sign Language (DGS) and German. And investigated whether DGS signs are activated during a monolingual German word recognition task. They showed that lexical representations were associated cross-linguistically in the bilingual lexicon.

Lexical Access in Sign Language

Although the study of lexical access in sign language is still in its infancy, the first study dates from the 1990s. Psycholinguistic studies of sign recognition aimed to determine whether the lexical recognition process is modality-specific or more general. In their review article on lexical access in sign language, Gutiérrez-Sigut and Baus (2021) reported a strong similarity between speech and sign processing. They showed that well-known lexical effects observed in spoken languages are also found in sign languages: lexicality, lexical frequency, and semantic priming. The seminal gating study by Emmorey and Corina (1990) investigated the role of manual sublexical information, that is, the three parameters of location, movement and handshape, in the sign recognition process. In their experiment, the gating task involved repeated presentation of a gestural sign, such that its duration from onset increased by a constant amount with each successive presentation. Their results highlighted the role of manual sublexical information in lexical access, and more specifically the singular role of each phonological parameter of a sign. They found that the location of the sign was identified first, followed by its manual handshape, and finally the movement made, which ensured the sign was recognized. Interestingly, these behavioral data were confirmed by a simulation conducted by Caselli and Cohen-Goldberg (2014) using a spreading activation architecture.

Although the same trends are observed in the lexical access process in sign language as in spoken language, the gestural modality influences the temporality of access. Because of the simultaneity of sublexical features and the minimal sequentiality, a sign is recognized faster than a spoken word: signs are recognized when around 35% of the sign has been produced, while words are recognized when around 80% of the word has presented (Emmorey and Corina, 1990; Gutiérrez-Sigut and Baus, 2021). These results are supported by the simulations generated by Caselli and Cohen-Goldberg's (2014) computational model. Caselli and Cohen-Goldberg observed that model simulations matched the experimental data: the location parameter was activated earliest and seemed to be the most robust parameter due to its high sublexical frequency (the inventory of locations is smaller than those of handshapes or movements) and high perceptual saliency (location is the first parameter placed in the signing space, and due to its articulatory characteristics (i.e., more global motoric articulation), hold a large part of signing space. Consequently, this perceptual saliency led to a stronger memory encoding/trace that will improve sign production; Gutiérrez-Sigut and Baus, 2021).

Regarding to more modality-general effects, which are frequently observed in spoken languages, Baus et al. (2008) reported semantic interference in a picture-naming experiment in both native and non-native deaf signers of LSC (Catalan Sign Language). Deaf signers named pictures slower when they were presented in the semantically related condition than in the unrelated condition. The lexicality effect (sign or non-sign processing) has also been observed in several sign language studies (Emmorey, 1991; Emmorey and Corina, 1993; Carreiras et al., 2008; Guttiérez and Carreiras, 2009; Dye et al., 2016). In contrast, the lexical frequency effect is more difficult to investigate in sign language, because sign frequency databases are not yet available though they are being created for different sign languages (British Sign Language: Vinson et al., 2008; Fenlon et al., 2015; Australian Sign Language: Johnston, 2012; Spanish Sign Language: Gutiérrez-Sigut et al., 2016; American Sign Language: Caselli et al., 2017; French Sign Language: Perin et al., in progress). Sign language studies have found robust familiarity effects, which have been quantified with a Likert scale by deaf signers with a native or high level of proficiency in the respective sign language. In other words, familiar signs are recognized faster than less familiar signs (Spanish Sign Language: Carreiras et al., 2008 (American Sign Language: Emmorey and Corina, 1993; Mayberry and Witcher, 2005; Ferjan-Ramirez et al., 2016). Finally, some studies also noted a semantic priming effect in sign language using a sign-sign priming task, in both native and late signers (Emmorey and Corina, 1993; Mayberry and Witcher, 2005; Bosworth and Emmorey, 2010; for a review, see Gutiérrez-Sigut and Baus, 2021).

One question that remains open is which word/sign recognition characteristics are universal (language-general) in spoken and sign languages in models, and which are specific to each language modality (language-specific). To the best of our knowledge, few studies have investigated the role of mouthing in lexical access. In linguistic theory, some researchers consider mouthing to be part of the signs themselves, while others consider it to be an incidental consequence of language contact and not part of the sign lexicon (Sutton-Spence, 1999; Boyes-Braem et al., 2001; Sutton-Spence and Day, 2001; Nadolske and Rosenstock, 2007).

The question addressed in the present study concerns the status of mouthing, and more specifically the extent to which mouthing is a relevant cue to lexical processing in sign language, specifically LSF study. Should we consider mouthing as a sublexical feature or a semantic cue? Does the contact between spoken and sign information facilitate or inhibit the lexical access process? Does the spoken experience facilitate or inhibit the signed lexical access process? For this purpose, we designed a sign–picture priming experiment, in which participants had to decide if the manual sign–mouthing pair that composed the lexical sign fitted with the picture (Bishop, 2003; Friedrich and Friederici, 2008; Barcroft, 2009; Marinis, 2010). The congruency of the manual sign–mouthing pair varied. In our experimental design, the critical condition to assess the impact of mouthing on lexical decision was provided by interference between manual sign and mouthing. We predicted that condition would have an effect: incongruent conditions (semantic and phonological interference) should lead to higher error rates and longer decision times than congruent conditions. In addition, based on

previous studies (see above), we hypothesized that the mouthing effects should vary according to the type of bilingualism: intramodal vs bimodal bilingualism. This should be reflected by more difficulties managing the manual–mouthing conflict of information in deaf signers than in hearing ones, since hearing signers could be less skilled at simultaneously processing manual and spoken information. Finally, we expect an interaction between condition and type of bilingualism with an increase of error rates and reaction times all the greater for the deaf Intramodal signers than the hearing bimodal ones.

THIS STUDY

Participants

Thirteen deaf native signers of LSF (M_{age} 31;02 years; SD = 8;01 years), and 11 hearing native speakers of French who are fluent LSF signers (M_{age} 27;02 years; SD = 8.;07 years) were recruited for this experiment (M_{age} group difference $p > 0.05$). We called deaf signers *Intramodal bilinguals* given that they processed both sign and spoken language by the sole visual modality; LSF is their native or early language (exposure to LSF before 3 years of age). In contrast, hearing signers, either children of deaf adults (CODA, 2 participants) or French-LSF interpreters, are called in this study as *bimodal bilinguals* given that they processed sign and speech with two different channels (i.e., by the appropriate sensorial-perceptive modality, namely visuo-gestural and audio-oral). Except the two CODAs, for whom LSF was a native language, participants in this group learned LSF as a second language and they have a C2-Level (high skilled signers; Common European Framework of References for Languages). Their LSF/French interpreter function ensured robust sign language skills and frequent exposure to sign language, enough to imagine that mouthing could interfere with manual recognition. We collected metadata of each participant on their judgment for sign language proficiency using a self-rate Likert Scale from 1 (very low) to 6 (native). In average, Intramodal signers judged their sign language proficiency as 5 and Bimodal signers judged their sign language proficiency as 4.5. This result confirms that all participants have a high proficiency level in LSF. In addition, we calculated 1) the written French abilities on a Likert scale from 1 (low) to 3 (good), and 2) the spoken French exposure from 1 (rare) to 3 (frequent) for Intramodal signers. In average, the results showed that written French proficiency was assessed around 2.5 and for spoken French exposure 2.4. These results suggest that the Intramodal signers have a high level of familiarity with French.

Stimuli

There are no lexical norms for LSF signs. Consequently, we decided to use concrete signs belonging to current LSF lexicon, in the following semantic categories: fruits, vegetables, clothes, animals, objects and vehicles (see **Supplementary Table 1** for complete list of stimuli). The stimuli were chosen according to the easiness of their pictorial representation. Isolated lexical signs (i.e., manual sign–mouthing pairs) were presented in five experimental conditions and participants had to decide if the lexical sign presented corresponded to the picture presented next on the screen. In the first condition *Control*, both sign and mouthing were congruent with the picture. In the second and third conditions, the sign was congruent with the picture but not with the mouthing: in the *Pseudo-Word,* the incongruent mouthing was a pseudoword; in the *Semantically incongruent*, the incongruent mouthing was a word semantically related to the sign. In the fourth condition, *Absence of Mouthing*, the sign was congruent with the picture and there was no mouthing. In the fifth condition, *Mouthing Alone*, the mouthing was congruent with the picture and there was no sign (**Figure 1** and **Table 1**; all conditions are available in **Supplementary Video 1**). We created the stimuli in the incongruent mouthing conditions according to several factors: 1) the incongruent mouthing, either phonological either semantic, were fitted with the number of syllables of the congruent mouthing (e.g., the manual sign ARAIGNEE (SPIDER) was paired with a trisyllabic word, and respectively with the congruent mouthing/areɲe/in Control condition; with the pseudo-word/itufi/in Pseudo-Word condition, with/eskargo/in Semantically Incongruent condition; 2) the incongruent mouthing was created by paying careful attention to avoid a labial double, e.g., the pseudo-word/ʃifu/was visually too close of the word/ʃifɔ/and changed in/ʃifal/; 3) for Pseudo-Word condition, we payed attention to exaggerate the visual opposition between the expected congruent mouthing and the phonological mouthing (rounded lips, mouth aperture), e.g.,/ma/and/ti/syllables are strongly contrastive; and 4) for Semantically incongruent condition, the mouthing had to belong to the same semantic category, and to be close to the referent, e.g., the manual sign SPIDER can be paired with *snail* semantic incongruent mouthing, but not with *bear* or *dolphin.*

For the unrelated pair (fillers), each manual sign-mouthing pair was associated to a picture that did not match with the sign (control condition). The pictures were taken from a standardized set of pictures (Snodgrass and Vanderwart, 1980).

Procedure

As described in the section on Stimuli, we created five experimental conditions in which the combination of both the manual sign and the mouthing was systematically manipulated (**Table 1**). Participants had to make a lexical decision: they had to decide as fast as possible whether a picture matched the sign presented (Bishop, 2003; Friedrich and Friederici, 2008; Barcroft, 2009; Marinis, 2010). In each condition, 40 signs were presented.

The experiment was run using E-Prime 2 Software on a laptop computer. The screen background color was white. Each trial began with a black fixation cross (500 ms), followed by the sign video and then by the picture. The picture was displayed for 5000 ms. The intertrial interval was 3000 ms. The experiment was preceded by a short training block of 10 stimuli to familiarize participants with the experimental task. The instructions were given in LSF and were repeated by the researcher if some points were not clear to the participants. Given that the experiment aimed to study the processing of mouthing, we decided to induce participants to focus on the mouth. For this purpose, the fixation cross was located in the same place, as accurately as possible, where the mouth would appear on the screen with the stimuli.

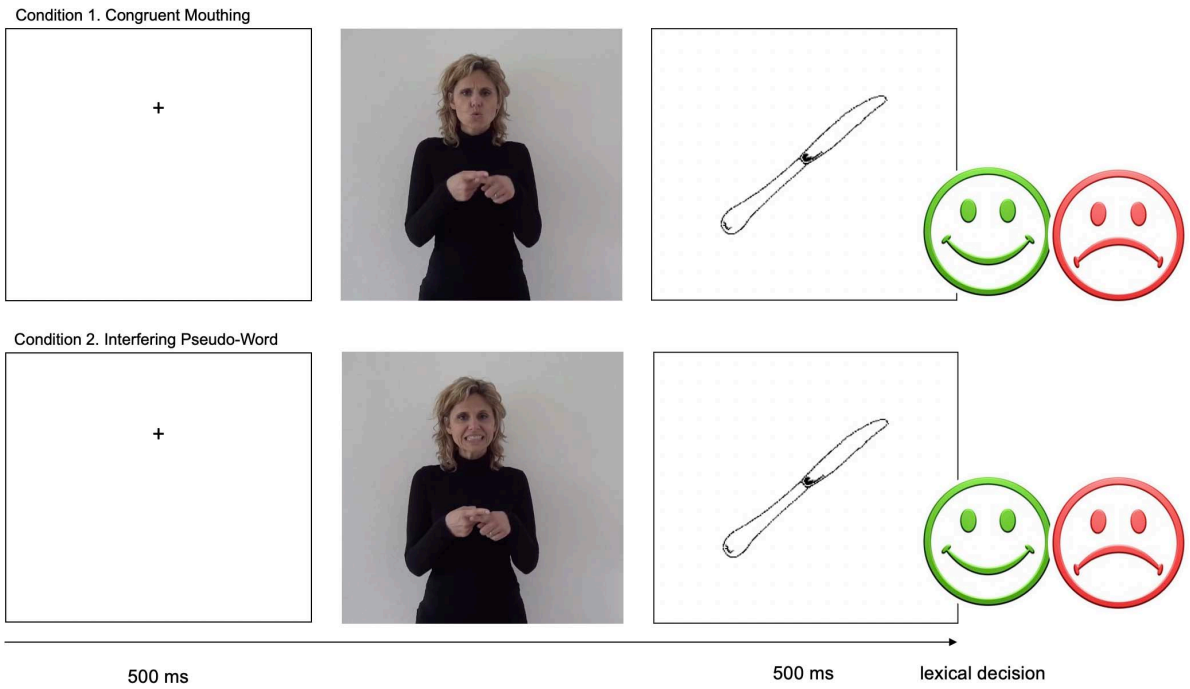


FIGURE 1 | Flow chart for the lexical decision experiment. In the control condition, the congruent mouthing/kuto/feats with manual sign COUTEAU (/naɪf/KNIFE). In * Pseudo-Word condition, a pseudoword is presented with the manual sign KNIFE. In both conditions, participants have to decide if the picture matches the sign presented before it. All items are listed in the **Supplementary Table 1**.

During the presentation of the picture, participants could press the green button (D key) if they thought the picture matched the lexical sign (*same*) or the red button (K key) if they thought the picture did not match the lexical sign (*different*). Participants had a maximum of 5000 ms to respond (**Figure 1**). Participants were given 400 stimuli, which were distributed in 10 blocks of 40 stimuli each. In each block, 8 stimuli in each of the 5 conditions were presented, with half of the stimuli presented in the related condition and the other half in the unrelated condition (fillers). Block order was counterbalanced across participants and stimuli were pseudo-randomized within each block.

Predictions

For Bilingualism, we expect both higher Error Rates and longer Reaction Times (RT) for Bimodal than Intramodal due to possible interference between gestural and spoken linguistic channel in hearing bimodal signers.

For Condition, the following pattern for both ER and RT should be observed: *Control* < *Absence of mouthing* < *Pseudo-Word* < *Semantically incongruent* < *Mouthing Alone*.

At a more fine-grained level, the five hypotheses were formulated for both ER and RT:

- H1. Higher Error Rates and longer Reaction Times for Pseudo-Word than Control.
- H2. Higher Error Rates and longer Reaction Times for Semantically Incongruent than Control.
- H3a. If mouthing plays a role in lexical access, then Error Rates in the Absence of Mouthing condition should be higher, and ReactionTimes longer, than in the Control one.

TABLE 1 | The five experimental conditions presented in the lexical decision experiment.

Stimuli. MANUAL SIGN + /mouthing/	Picture in Related Condition (expected response: same)	Picture in Unrelated Condition (expected response: different)
Condition 1: Manual sign and congruent mouthing KNIFE + /naɪf/	KNIFE	CAT
*Condition 2: Manual sign and pseudo- word KNIFE + /pɔ̃fi/	KNIFE	SCOTTER
*Condition 3. Manual sign and semantically Incongruent mouthing KNIFE + /mɪksəʳ/	KNIFE	BELT
Condition 4: Manual sign and absence of mouthing KNIFE without mouthing	KNIFE	CAR
Condition 5: No manual sign and mouthing alone /naɪf/without manual sign	KNIFE	SPIDER

*Interfering conditions are marked with an asterisk *. In the LSF experiment: Condition 1: COUTEAU + /kuto/; *Condition 2: COUTEAU+/pɔ̃fi/; *Condition 3: COUTEAU+/batœr/; Condition 4: COUTEAU without mouthing; Condition 5:/kuto/without manual sign.*

- H3b. Else no Error Rates differences between Absence of Mouthing and Control should be observed.
- H4. Error Rates should be higher, and Reaction Times longer, in Mouthing Alone than in Control.
- H5a. Under the hypothesis that during sign processing there is retrieval of the lexical information conveyed by mouthing, then the Semantically Incongruent condition should give rise to higher Error Rates, and longer Reaction Times, than the Pseudo-Word conditions (which contains no lexical information).
- H5b. Else, no difference should be found between Semantically Incongruent and Pseudo-Word conditions.

Finally, for Error rates, we expect a Bilingualism by Condition interaction reflecting higher error rates for bimodal signers in condition favoring a possible gestural and spoken interference (Pseudo-Word & Semantically incongruent).

For Reaction Times, a Bilingualism by Condition interaction should also be observed. Whereas longer Reaction Times for Bimodal compared to Intramodal bilinguals should be found in the comparisons implying both gestural and spoken channels (H1, H2), longer Reaction Times should be expected for Intramodal in comparison with Bimodal for Mouthing alone (H4).

RESULTS

We ran two analyses of variance (ANOVAs), one on error rates and one on reaction times. Incorrect responses were excluded for the reaction time analysis. ANOVAs were run with Bilingualism (2 levels: intramodal vs. bimodal) as between-subject factor, and Condition (5 levels: Control, Pseudo-Word, Semantically incongruent, Absence of mouthing, Mouthing alone) as within-subject factor. Before running the statistical analyses, we first computed the interval [mean ± 2SD]. Results that were outside of this interval (8.5% on average for Error Rate and 2.5% on average for Reaction Time) were considered as outliners and therefore were excluded of our statistical analysis.

Error Rates

The ANOVA revealed that the main effect of Bilingualism was significant [$F(1,16) = 5.51$; $p = 0.032$; $\eta_p^2 = 25.61\%$; **Figure 2**), indicating that on average Intramodal made fewer errors than Bimodal signers (respectively $M = 3.7\%$, $SD = 2.9\%$ and $M = 6.9\%$, $SD = 4.9\%$).

The main effect of Condition also reached the significance level [$F(4,64) = 6.25$; $p < 0.001$; $\eta_p^2 = 28.08\%$; see **Table 2**). Further *post hoc* tests using the Bonferroni corrected threshold of $p < 0.001$ showed that the mean error rate was significantly higher in 1) Pseudo-Word condition ($M = 4.1\%$, $SD = 2.2\%$, $p = 0.004$), 2) Absence of Mouthing ($M = 3.7\%$, $SD = 2.9\%$, $p = 0.002$), and 3) Mouthing Alone ($M = 9.2\%$, $SD = 5.7\%$; $p = 0.001$) than in Control condition ($M = 2.9\%$, $SD = 2.4\%$).

Finally, the ANOVA failed to show a significant Bilingualism by Condition interaction ($F < 1$).

Reaction Times

The ANOVA only showed a significant main effect of Condition [$F(4,76) = 8.06$; $p < 0.001$; $\eta_p^2 = 29.78\%$), indicating that reaction times varied as a function of the different experimental conditions (see **Table 2** and **Figure 3**).

Further *post hoc* analyses with a Bonferroni corrected threshold at $p < 0.005$ indicated that mean reaction times were significantly shorter in Control than in Pseudo-Word condition (respectively $M = 629.6$ ms, $SD = 217.6$ ms, and $M = 716.2$ ms, $SD = 299.6$ ms; $p = 0.004$) or in Semantically incongruent one ($M = 759.7$ ms, $SD = 363.7$ ms; $p < 0.001$).

Finally, Mouthing Alone significantly lengthened the mean reaction time ($M = 765.7$ ms, $SD = 310.9$ ms) in comparison with Control condition ($M = 629.6$ ms, $SD = 217.6$ ms; $p = 0.003$).

There was also a significant Bilingualism by Condition interaction [$F(4,76) = 2.50$; $p = 0.049$; $\eta_p^2 = 11.64\%$). This interaction indicates that the difference between Reaction Times in Semantically incongruent condition and Control conditions was greater in Intramodal signers (respectively $M = 759.7$ ms vs. $M = 629.6$ ms; $d = 181.3$ ms, $p = 0.001$) than in Bimodal signers (respectively $M = 590.1$ ms vs. $M = 535.7$ ms; $d = 54.3$ ms, $p = 0.003$). In addition, reaction times were significantly longer in Mouthing Alone condition than in Control one for Bimodal signers ($M = 722.4$ ms vs. $M = 535.8$ ms; $p < 0.001$) but not for Intramodal ones ($p > 0.05$).

DISCUSSION

As Schermer (1985) claimed, "the existence of a pure sign language, without the occurrence of any speech, among deaf adults, is more or less a theoretical construct" (p. 288; cited in Bank et al., 2015). We know now that sign language is not solely a manual language, and it must be recognized that mouthing may play a role in sign recognition. In this study, we aimed to investigate the "spoken cue" in sign language, by specifically investigating the role of mouthing in the lexical access. To do this, we decided to create an experimental task to compare error rates and reaction times in different conditions in which mouthing matched or did not match the produced manual signs. We know that age and frequency of exposure to a sign language have a strong impact on sign recognition, but the more relevant issue here was analyzing the effect of Intramodal exposure (only sign language) vs. bimodal exposure (spoken language in addition to a gestural one). More specifically, what is interesting here is the fact that deaf signers perceive spoken cues through the visual modality ("seen speech"; Capek et al., 2008). As reported in the literature on reading by the deaf, deaf signers develop some phonological awareness and may activate a kind of silent phonology (MacSweeney et al., 2008; Hirshorn et al., 2015). So, we can postulate that LSF signers have phonological representations, undoubtedly incomplete, of French spoken words. From these observations, we hypothesized that signers used the spoken stream to retrieve lexical information. To evaluate this modality effect, we administered our experimental task to two groups: (1) a group of deaf native signers of LSF, that is, Intramodal bilinguals, with no access to any spoken

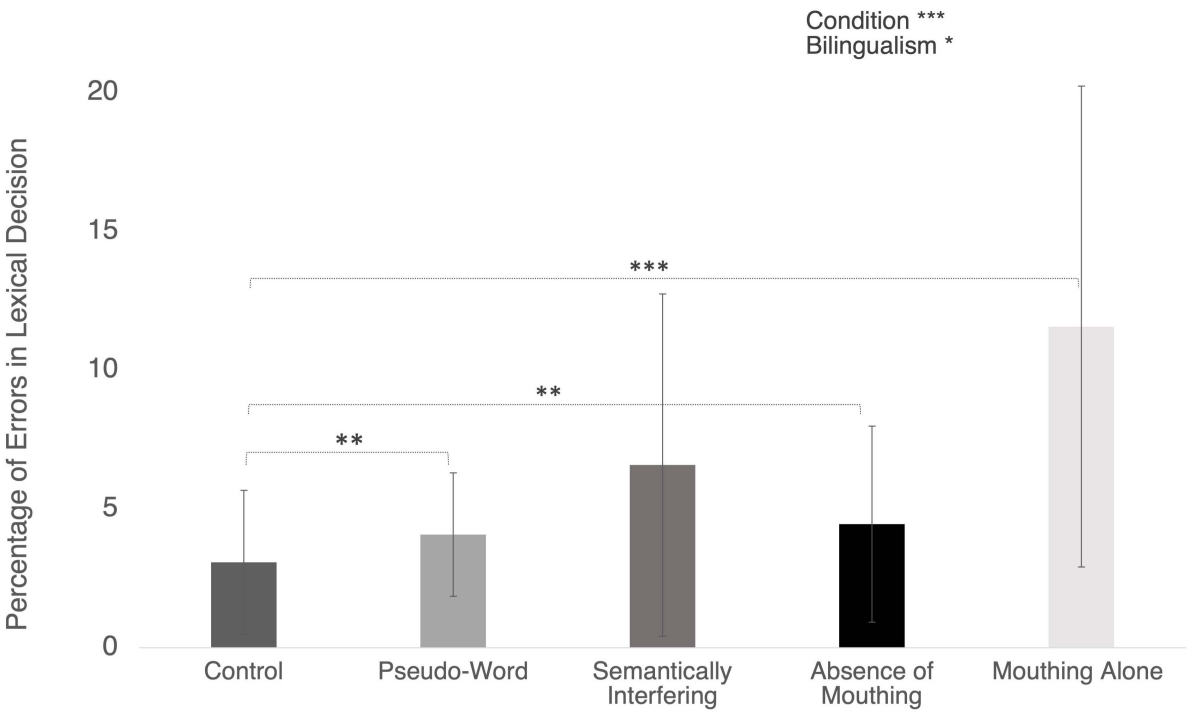


FIGURE 2 | Error rates (in percentage) in the different conditions. Error bars represent standard deviations. Significant post hoc comparisons are indicated with conventional asterisks (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$).

language in its audio-aural modality; and (2) hearing signers whose native language was French, that is, bimodal bilinguals, with a high proficiency in LSF because they work as LSF–French interpreters.

This study revealed that signers exploit mouthing to recognize signs and to retrieve linguistic information in the signed lexicon: accuracy was lower in Pseudo-Word condition than in Control one, and Reaction Time was lengthened in both Pseudo-Word and Semantically incongruent conditions than in the Control condition. More precisely for Reaction Times, whereas the effect for Semantically Incongruent was 117.8 ms, it was only 77.5 ms for Pseudo-Word. Interestingly, we showed a trade-off effect between accuracy and speed for incongruent conditions: Intramodal Signers were more accurate but slower to make a sign lexical decision compared to the Bimodal Signers. In contrast, Bimodal signers answered faster but did more errors in comparison with Intramodal Signers. This result suggests that Bimodal and Intramodal signers used different the processing strategies. Taken together, these findings suggest that mouthing may play a determining role at a lexical-semantic stage of processing.

As mentioned above, we aimed to assess the role of mouthing in lexical access as a function of bilingualism, the Intramodal signers (deaf native signers) vs. Bimodal ones (hearing fluent signers). In our study, during sign language processing, Intramodal signers seem to be functionally bimodal and Bimodal signers functionally Intramodal: Intramodal signers use both spoken and manual input, while bimodal signers seem to prefer manual information and ignore mouthing. One surprising result concerned the number of errors made by Bimodal signers: they produced more errors than Intramodal signers in Mouthing Alone condition, in which the lexical decision was made from the mouthing cue alone (Bimodal: 13.3% *SD = 8.3;* Intramodal: 5.0% *SD = 3.1*). In addition, Bimodal

TABLE 2 | Error rates (in percent) and Reaction Times (in ms) in the five conditions according to bilingualism (Intramodal vs. Bimodal).

	Control	Pseudo-word	Semantically incongruent	Absence of mouthing	Mouthing alone
Intramodal signers					
Error rates (SD)	2.8 (1.6)	3.4 (1.7)	5.9 (6.2)	2.3 (2.3)	5.0 (3.1)
Reaction times (SD)	708.9 (231.4)	824.8 (324.9)	890.2 (410.5)	743.2 (247.7)	801.9 (319.0)
Bimodal signers					
Error rates (SD)	4.0 (3.6)	4.8 (2.8)	7.3 (6.2)	5.0 (3.5)	13.3 (8.3)
Reaction times (SD)	535.8 (163.6)	574.9 (198.6)	590.1 (205.2)	586.1 (201.6)	722.4 (312.1)

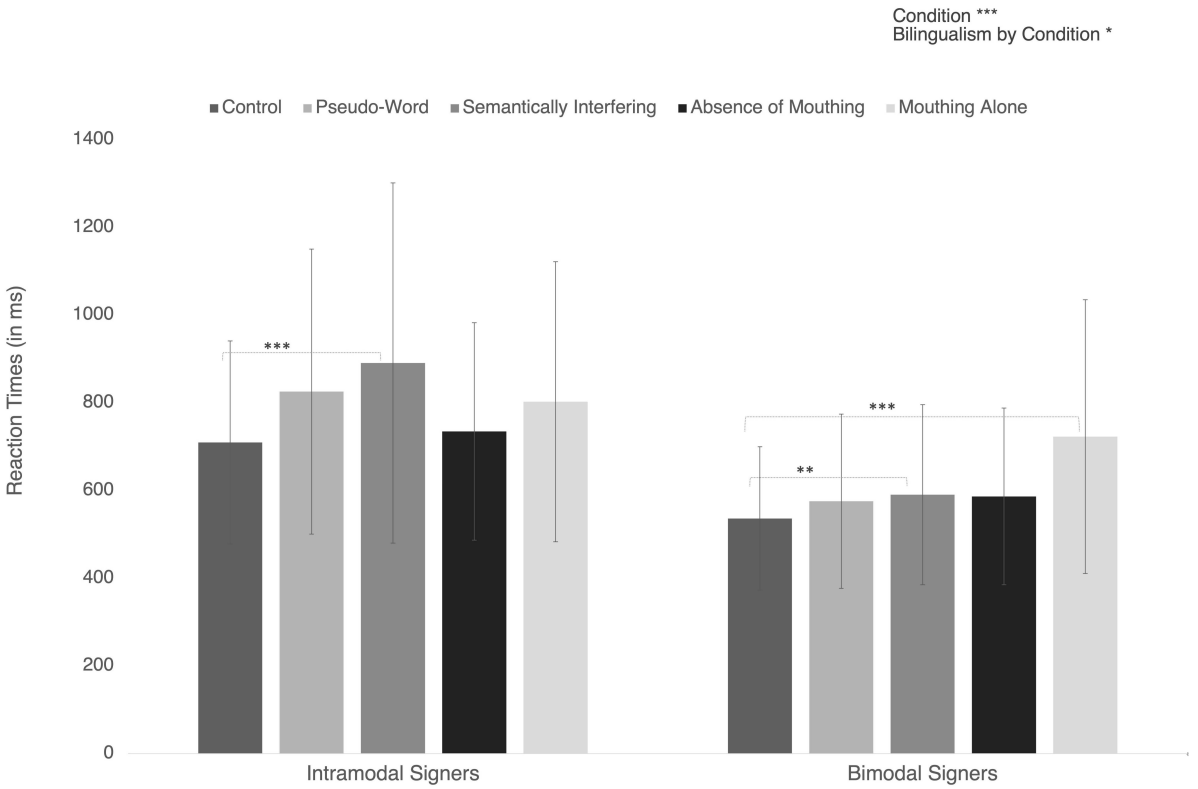


FIGURE 3 | Reaction times in the different in the two groups of bilinguals. Error bars represent standard deviations. Significant post hoc comparisons are indicated with conventional asterisks (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$).

signers presented consistent response times in all experimental conditions, except in the Mouthing Alone condition in which reaction times were strongly lengthened (around 150 ms slower than the 4 other conditions with the manual sign). These results suggest that bimodal signers paid less attention to the mouthing whatever the experimental condition. We hypothesized that the "spoken condition" would be successfully processed by the "spoken participants." But contrary to our expectations, Intramodal signers performed better than Bimodal signers at processing mouthing. One possible explanation is that the Bimodal signers' processing strategy was to rely on manual signs when making lexical decisions because they are more salient and more robust, and that mouthing was too interferent for them. We hypothesize that mouthing is not a sufficiently reliable cue for them to process the sign, and they strategically decide to make their lexical decisions by focusing on manual information. These latter could adopt a strategy to process the lexical unit by choosing the more reliable sensorial modality to process it, focusing on spoken trace or manual cue. Previous results of Emmorey et al. (2008b) suggested that hearing signers used frequently mouthing to process signs. But, contrary to our study, these signers were beginning signers and they used the spoken cue to support sign processing when they need any helpful semantic information. In our study, hearing signers were highly fluent signers, and this may have as a consequence to adopt the strategy to focus only on manual sign and consciously ignore the mouthing in order to not be interfered in lexical decision.

Regarding to Intramodal signers, we observed another type of lexical processing.These results seem give new evidence about the semantic role of mouthing in the lexical retrieval and question us about its possible involvement in the semantic representation. Intramodal signers' better performance in our study reinforces results previously reported by Huguet (2016) and Muir et al. (2003), in which deaf signers experienced difficulties when they had to process signs without mouthing. Intramodal signers focused on the face and lips, suggesting that this zone provides relevant information during lexical access. Taken together, these studies confirm that Intramodal signers use mouthing information to assist with lexical access if it is available. Several studies on sign languages argue that mouthing is optional and useful only to disambiguate the meanings of two signs and claim that is proof that mouthing is not a component of sign languages. We disagree with this claim as (1) Reaction Times were significantly lengthened when mouthing does not match with signs as in Pseudo-Word and Semantically Incongruent condition, and (2) accuracy was lower in Pseudo-Word condition compared to Control condition. This finding provides new evidence that mouthing supports manual sign processing in signers, particularly deaf signers and highlight the specificity of processing of spoken cues by deaf and hearing signers.

Although we failed to show an effect of presence of congruent mouthing on sign recognition, however it is important to note that an incongruent mouthing produce more errors and/or longer reaction times. In addition, previous eye-tracking studies demonstrated that the deaf signers rely more on mouth information than manual one in comparison with either hearing or late signers. We do not support the conclusion of Vinson et al. (2010) and Giustolisi et al. (2017) who claimed that mouthing is external to the lexical representations of signs. As we described previously, mouthing is not mandatory, but it seems be a reliable cue to facilitate lexical access. If our results cannot clearly support that mouthing made part of lexical representation of a sign, we wonder the reason for these authors supporting an external role of mouthing in lexical access. Maybe we can consider mouthing as a linguistic component that is acquired later because it is less salient than manual cues. Or mouthing may be a later stage of language development because it is related to the spoken language or has a spoken origin. During the developmental trajectory, children focused and used different cues, according to the integrity and maturity of their perceptual and processing systems. As soon as they learned the writing system of spoken language, their lexical processing should be influenced by this knowledge. Then the surrounding spoken language would be mastered, and the spoken cue (mouthing) could be used to process a sign and integrated to the specification of the sign. So, further investigations are necessary to provide evidence about the semantic role of mouthing in lexical access.

In addition, Giustolisi et al. (2017) suggested that a complete sign requires the specification of all manual parameters, while mouthing can be dropped from this specification. We disagree with this view because missing or impaired information about one of the manual parameters can have the same consequence as missing or impaired mouthing: lexical retrieval is inaccurate or slowed. This is not sufficient evidence neither to conclude that mouthing is part of sign language, nor to conclude that is not part of.

Finally, we propose that researchers are inaccurate in describing mouthing as a trace of spoken language. In Capek et al.'s (2008) article, they refer to *seen speech* to talk about mouthing. We believe it is essential to adopt this terminology to conduct a fine-grained analysis of mouthing. At first glance, mouthing is a spoken component from the surrounding spoken language attached to a sign language. But mouthing is more than just a word from spoken language: it is a loan that has been phonologically adapted. Deaf people cannot acquire complete phonological information, so spoken information is reduced to a gesture, a seen speech gesture. To study the relation between lipreading and phonological representation in deaf people, one way could be to use a mediated priming paradigm, varying indirectly the lipreading prime and the target picture (i.e., lipreading prime *car* - reduced form of carpet-, and a target picture of ship).

Future behavioral and neurophysiological studies are needed to test the role of mouthing during lexical access in sign language in different populations of signers. In particular, a hybrid dual-route architecture taking mouthing into consideration may be relevant to account for sign recognition in sign language. As our study suggests that Intramodal and Bimodal signers may not rely on mouthing in the same way to access the lexicon, we propose a first version of a processing model for LSF signs. This speculative model postulates that according to the type of signers (i.e., intramodal or bimodal) different processing strategies might be used. These strategies could be captured in a functional architecture postulating two processing routes to access the lexicon in sign language. A first route, the direct route, would constitute a direct mapping between the parameters of signs (manual such as location, handshape and movement) contained at a sublexical level and the stored lexical representation of each sign. This direct route is preferentially used by Bimodal signers. The direct route depends on processing a holistic representation of the sign. A second route, the decompositional route, an analytic one, involved the mouthing processing during sign lexical access. This latter route may be preferentially used by intramodal signs which need to rely on the analysis of the different parameters constituting each sign, including mouthing. Taken together, the data of our study suggest that mouthing information supports the processing system in order to facilitate recognition of signs that need to be assisted by mouthing.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Local Ethics Committee of the Paris Nanterre University – Department of psychology and was performed in accordance with the Declaration of Helsinki. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CB: conceptualization, methodology, investigation, and writing – original draft preparation. Funding Acquisition FI: conceptualization, methodology, writing – original draft preparation. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.655168/full#supplementary-material

Supplementary Table1 | List of stimulus items. The table lists all 400 items presented in the lexical decision experiment.

Supplementary Video 1 | Pomme (Apple) manual sign presented in the five conditions.

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REVIEW
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New Perspectives on the Neurobiology of Sign Languages

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The first 40 years of research on the neurobiology of sign languages (1960–2000) established that the same key left hemisphere brain regions support both signed and spoken languages, based primarily on evidence from signers with brain injury and at the end of the 20th century, based on evidence from emerging functional neuroimaging technologies (positron emission tomography and fMRI). Building on this earlier work, this review focuses on what we have learned about the neurobiology of sign languages in the last 15–20 years, what controversies remain unresolved, and directions for future research. Production and comprehension processes are addressed separately in order to capture whether and how output and input differences between sign and speech impact the neural substrates supporting language. In addition, the review includes aspects of language that are unique to sign languages, such as pervasive lexical iconicity, fingerspelling, linguistic facial expressions, and depictive classifier constructions. Summary sketches of the neural networks supporting sign language production and comprehension are provided with the hope that these will inspire future research as we begin to develop a more complete neurobiological model of sign language processing.

Keywords: sign language, fingerspelling, non-manual features, neuroimaging, event-related potentials

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INTRODUCTION

Once sign languages were shown to be natural, full-fledged languages, it became clear that investigating their neural substrates could provide unique evidence for how the brain is organized for human language processing. Beginning in the 1980's, case studies of deaf signers with unilateral left hemisphere damage revealed impairments in sign language production and comprehension; in contrast, deaf signers with right hemisphere damage did not exhibit aphasic deficits (Poizner et al., 1987). In addition, as with spoken languages, left frontal damage was found to result in sign production deficits (Hickok et al., 1996), while left temporal lobe damage resulted in sign comprehension deficits (Hickok et al., 2002). Early neuroimaging studies of sign production (Petitto et al., 2000) and comprehension (Neville et al., 1998) supported these findings in neurotypical signers, revealing activation in the left inferior frontal gyrus for sign production and in left superior temporal cortex for sign comprehension. This evidence showed that the same key frontal and temporal regions in the left hemisphere support both spoken and signed languages; for reviews of these earlier studies see Corina and Knapp (2006), Emmorey (2002), MacSweeney et al. (2008a). Further, early lesion and neuroimaging studies indicated that the right hemisphere is involved in processing classifier/depictive constructions, particularly those constructions that express spatial relationships (e.g., Emmorey et al., 2002; Atkinson et al., 2005). This work suggested that the right hemisphere may be uniquely involved in processing some of the visual-spatial aspects of sign language structure.

This article builds on this early work and focuses primarily on what we have learned about the neural bases of sign language processing within the last ~15 years. The aim is to sketch a neurobiological model of sign language production and comprehension that includes linguistic phenomena that are fundamentally shaped by the visual-manual modality (pervasive iconicity, depictive classifier constructions, and the modality overlap with manual actions) and variables that are unique to sign languages (e.g., visual-manual phonological units, mouthing, fingerspelling, the use of signing space for co-reference). Production and comprehension processes are addressed separately in order to capture whether and how output and input differences between sign and speech might impact the neural substrates supporting linguistic articulation versus perception. By widening our scientific lens in this way, we move beyond classic models of brain-language relationships which focus on shared neural substrates for signed and spoken languages, and we can begin to develop richer models that map psycholinguistic processes and linguistic units that may or may not be shared with spoken language onto a functional neuroanatomical network that supports sign language processing.

THE NEUROBIOLOGY OF SIGN LANGUAGE PRODUCTION

Psycholinguistic evidence indicates that production processes are largely parallel for speech and sign. For example, both sign and speech production require phonological assembly of sublexical units (handshape, location, and movement for sign language), as evidenced by systematic production errors (slips of the hand: Hohenberger et al., 2002; slips of the tongue: Fromkin, 1971). Both sign and speech production involve a two-stage process in which lexical semantic representations are retrieved independently of phonological representations, as evidenced by tip-of-the-tongue and tip-of-the-finger states (Brown and McNeill, 1966; Thompson et al., 2005). At the sentence level, syntactic priming in sentence production occurs for both signed and spoken languages (Bock, 1986; Hall et al., 2015), supporting a distinction between syntactic and conceptual representations. In this section, we explore the neural regions that are involved at these processing levels, starting with sign articulation and phonological encoding and then discussing regions that are associated with higher-level processing: lexical retrieval (including fingerspelled words) and sentence and phrase production (including classifier constructions). We end this section with a summary sketch of the neural network for sign production.

Sign Articulation and Phonological Encoding

Although there are detailed models of the neural underpinnings of speech articulation (e.g., Tourville and Guenther, 2011), the data needed to develop such a model for sign articulation are relatively sparse. Nonetheless, recent research has begun to illuminate the neural circuits that are recruited during signing. One obvious difference between sign and speech production is the nature of the linguistic articulators. The manual articulators for sign are relatively large, can move independently within a large space, and are visible to the addressee but not always to the signer (signing is not visually guided). These sensorimotor characteristics are likely to impact the neural networks for language production in the visual-manual modality.

To begin to identify neural regions involved in the manual articulation of signs, Emmorey et al. (2016) used positron emission tomography (PET) and an English translation task to elicit different sign types in American Sign Language (ASL): one-handed signs, two-handed signs, and body-anchored (i.e., body contact) signs. In the baseline comparison task, deaf ASL signers also viewed English words and indicated whether the word contained a descending letter (e.g., j, p) using the signs YES or NO. The translation task required retrieval of an ASL sign, phonological assembly, and different articulation demands depending on sign type, while the baseline comparison task did not involve these processes. Not surprisingly, the production of two-handed signs engaged sensorimotor cortex in both hemispheres, while one-handed signs activated sensorimotor cortex in the left hemisphere (all signers were right-handed). Less activation in parts of the motor circuit was found for two-handed compared to one-handed signs, possibly because handshape and movement goals could be spread across the two limbs for symmetrical two-handed signs. Within non-linguistic motor domains, cortical activity in premotor regions is reduced when the goal of finger movements (e.g., to direct a cursor) is spread across the two hands, rather than controlled by a single hand (Post et al., 2007). In addition, the articulation of one-handed signs may require active suppression of the non-dominant hand (cf. Cincotta and Ziemann, 2008). Thus, the production of two-handed symmetrical signs may require fewer neural resources than the production of one-handed signs.

Emmorey et al. (2016) also found that the production of body-anchored (one-handed) signs engaged the left superior parietal lobule (SPL) to a greater extent than one-handed signs produced in neutral space. Emmorey et al. (2016) hypothesized that increased SPL activation reflects the increased motor control and somatosensory monitoring needed to direct the hand to a specific location on the body. For nonlinguistic motor tasks, SPL is known to be involved in planning reaching movements and updating postural representations of the arm and hand when movements are not visually guided, as in signing (Parkinson et al., 2010; Striemer et al., 2011). In addition, data from two electrocorticography (ECoG) studies with hearing bimodal bilinguals provide evidence that sign, but not speech production activates left superior parietal cortex (Crone et al., 2001; Shum et al., 2020; see also Emmorey et al. (2007) and Emmorey et al. (2014) for PET evidence). Shum et al. (2020) found that activity in left SPL immediately preceded sign production (~120 ms prior to initiating hand movement), suggesting that left SPL plays an important role in planning sign articulation. Furthermore, this temporal pattern of left SPL activity was not observed for non-linguistic reaching movements or for speech production. In addition, Crone et al. (2001) reported that electrical cortical stimulation of regions in left SPL interfered

with sign (but not speech) production, although the nature of this interference was not specified. Overall, the data indicate that left SPL is uniquely involved in the planning and execution of signs, but not spoken words.

The supramarginal gyrus (SMG) is another region known to be involved in sign language production. Corina et al. (1999a) was the first to suggest that left SMG was involved in phonological encoding of signs based on cortical stimulation mapping in a deaf ASL signer undergoing awake craniotomy for surgical treatment of epilepsy. Stimulation of left SMG resulted in phonological errors (e.g., handshape substitutions), rather than articulatory execution errors (e.g., lax articulation of an intended sign). In the Emmorey et al. (2016) PET study, the conjunction analysis revealed that all sign types activated the SMG bilaterally, with more extensive activation in the left hemisphere. Activation in left SMG has also been found when signers name pictures/videos in ASL (Emmorey et al., 2003; Kassubek et al., 2004; Okada et al., 2016) or Chinese Sign Language (CSL) (Hu et al., 2011). Further, activation in left SMG is observed during covert production when signers are asked to "sub-manually" name pictures (Kassubek et al., 2004), mentally rehearse learned pseudosigns (Buchsbaum et al., 2005) or make phonological decisions about internally-generated signs using picture stimuli (i.e., do the British Sign Language (BSL) sign names have the same location?) (MacSweeney et al., 2008b). Thus, the SMG is engaged when signers retrieve or rehearse the form of signs, even when overt articulation does not occur. The SMG is also engaged during speech production (Hickok, 2012), and it is possible that this region supports amodal processes such as retrieval of phonological lexical forms or phonological computations. However, direct contrasts between speech and sign production consistently reveal greater activation in SMG (and SPL) for sign production (Braun et al., 2001; Kassubek et al., 2004; Emmorey et al., 2007, Emmorey et al., 2014). Thus, left SMG may be more extensively involved in phonological processing for sign compared to speech production. Another possibility is that some regions within the SMG are involved in modality-specific processing and representation of sign phonology (possibly more dorsal regions; see Buchsbaum et al., 2005), while other regions support amodal phonological functions (perhaps more anterior regions that overlap with speech production).

Finally, the recent ECoG study by Leonard et al. (2020) found that single electrodes over SMG, pre-central (motor) cortex, and post-central (sensory) cortex in the left hemisphere exhibited neural selectivity for specific ASL handshapes and/or locations. In this study, a profoundly deaf signer with early ASL exposure produced ASL signs while viewing real signs and pseudosigns as part of a lexical decision paradigm. However, rather than performing the "yes/no" lexical decision task, the participant often repeated the ASL sign, fingerspelled the sign, or repaired the pseudosign to a real sign. The finding of neural selectivity for phonological units in ASL within sensorimotor cortex is parallel to what has been found for speakers. For example, using ECoG data Bouchard et al. (2013) identified speech-articulator representations (such as the tongue and lips) that were laid out somatotopically along sensorimotor cortex, and spatiotemporal patterns of neural activity that were hierarchically organized by articulatory-defined phonetic features, such as lip-rounding or tongue position. Similarly, Leonard et al. (2020) found that the spatial distribution of the neural activity across location- and handshape-selective electrodes was clustered along a linguistically-relevant hierarchy, e.g., open and closed handshapes were clustered together at a low (phonological) level, while fingerspelled words and lexical signs were clustered together at a higher (lexical) level. Further, these cortical responses were specific to linguistic production, rather than simply reflecting general motor actions of the hand and arm because these cortical patterns were not observed during transitional movements. This study presents some of the first evidence that sublexical phonological representations are supported by the same neural principles and hierarchical architecture, regardless of language modality.

Lexical Production

Lexical sign production has been found to be more strongly left-lateralized than spoken word production (Gutierrez-Sigut et al., 2015; Gutierrez-Sigut et al., 2016). Gutiérrez-Sigut and colleagues used functional transcranial Doppler sonography (fTCD) to investigate hemispheric lateralization during speech and sign production in neurotypical adults. fTCD measures event-related changes in blood flow velocity within the middle cerebral arteries in the two hemispheres. Hearing BSL-English bilinguals exhibited stronger left lateralization for sign than speech production when performing verbal fluency tasks (e.g., produce as many animal signs/words as you can in a short time period). A control experiment with sign-naïve participants indicated that the difference in degree of laterality was not driven by greater motoric demands for manual articulation. Left-lateralization was stronger for overt than covert sign production in deaf BSL signers, but the strength of lateralization was not correlated with the amount of time moving the right hand during overt signing, indicating that strong left-lateralization is not simply due to right-hand motor demands. In addition, covert sign production was more strongly left-lateralized than overt word production in hearing speakers. Gutierrez-Sigut and colleagues speculated that greater left lateralization for sign production compared to word production might be due to increased use of somatosensory self-monitoring mechanisms and/or to the nature of phonological encoding for signs.

Left inferior frontal cortex (IFC) is one region that is consistently engaged during both single sign and single word production, and damage to left IFC results in impairments in lexical production. This region is associated with several linguistic functions in spoken languages, with more anterior regions (Brodmann Area (BA) 47) associated with lexical-semantic processes and more posterior regions associated with phonological processing (BA 45) (Devlin et al., 2003). Corina et al. (2003) reported nearly identical activation in left IFC (BA 45, 47) when ASL signers performed a verb generation task with either their right or left hand, supporting the hypothesis that this region supports lexical processing and demonstrating that left IFC activation is not driven by right-handed signing. Further

evidence that left IFC is involved in lexical retrieval or selection processes is that this region was more engaged when signers translated from an English word to an ASL sign than when they fingerspelled a printed English word or detected a descending letter in a word–the latter two tasks do not require lexical retrieval or selection of an ASL sign (Emmorey et al., 2016). In addition, left IFG was engaged when deaf and hearing signers imitated CSL signs, but activity in left IFC was not observed for non-signers who did not know the meanings of the signs (Li et al., 2014), again pointing to a role for left IFC in lexical semantic and/or phonological processing during lexical production.

With respect to the connectivity of the neural network for lexical sign production, evidence from cortical stimulation in another deaf signer suggests that the posterior, superior region of the left inferior frontal gyrus (IFG) is connected both functionally and anatomically to the superior part of the left SMG (Metellus et al., 2017). Stimulation of this left IFG region elicited sign production errors (mistakes in handshape or location or sign blockage) in both object-naming and word-translation tasks. Similar errors were observed when the arcuate fasciculus (the fiber tract connecting the IFG and SMG) was stimulated. Further, stimulation of this left IFG region induced an after-discharge (stimulation-induced neural spiking) that occurred 6–8 s later in left superior SMG, providing evidence for functional connectivity between these regions. Other cortical stimulation studies with deaf ASL signers have found that stimulation of left SMG can produce lexical errors (Corina et al., 1999a; Leonard et al., 2020). In addition, most studies of lexical sign production report neural activity in left IFG and SMG (ASL: Okada et al., 2016; San José-Robertson et al., 2004; CSL: Hu et al., 2011; Li et al., 2014). Together, these data provide evidence for a dorsal fronto-parietal network that supports lexical sign production.

Finally, studies that elicit sign (and word) production using picture-naming tasks typically report neural activity in left inferior temporal (IT) cortex (Damasio et al., 1996; Emmorey et al., 2003, Emmorey et al., 2007). This neural region is hypothesized to mediate between conceptual representations of objects and lexical retrieval processes. In addition, there appears to be a topographic gradient along left IT, such that unique object concepts (e.g., known people, landmark buildings) are represented in the anterior temporal pole, while more general object concepts (e.g., animals, tools) are represented along posterior IT (Grabowski et al., 2001; Martin and Chao, 2001). Evidence for such a semantic gradient has also been found for sign language (Emmorey et al., 2003; Emmorey et al., 2013). In addition, the left posterior middle temporal gyrus (pMTG) is also often engaged during sign production elicited by picture/video naming, translation tasks, and verb generation tasks (CSL: Hu et al., 2011; ASL: San José Roberson et al., 2004; Okada et al., 2016). Activation in this region likely reflects an interface that links lexical semantic representations to phonological representations (Indefrey and Levelt, 2004; Hickok and Poeppel, 2007).

Iconicity and Lexical Retrieval

The traditional view has been that iconicity (i.e., the perceived resemblance between a form and its meaning) plays no role in sign language acquisition or processing (Emmorey, 2002; Meier and Newport, 1990). However, new evidence is emerging that iconicity can facilitate first language acquisition (BSL: Thompson et al., 2012; ASL: Caselli and Pyers, 2020) and impact sign processing (Thompson et al., 2009; Vinson et al., 2015; Navarrete et al., 2020; Occhino et al., 2020). Further, iconicity is much more pervasive in sign languages, possibly due to the greater ability of the body (vs the vocal tract) to depict actions and objects. These facts raise several questions. Does the more "embodied" nature of iconic signs impact their neural representation? Do iconic signs exhibit different functional connectivity within the brain (e.g., with greater connectivity to sensorimotor cortex)? Is there a neurophysiological response that is related to lexical iconicity, as found for lexical frequency and concreteness in spoken language (Kutas and Federmeier, 2011)?

Thus far, the evidence that iconicity impacts the neural network supporting lexical retrieval and sign production is mixed. In a PET study, Emmorey et al. (2004) reported no significant differences in neural activity when deaf ASL signers named pictures of actions with iconic handling signs (e.g., **STIR**, **BRUSH-HAIR**) versus less iconic, non-handling verbs (e.g., **YELL**, **READ**). Similarly, Emmorey et al. (2011) reported no significant differences between iconic "pantomimic" verbs (e.g., **HAMMER**, **SCRUB**) and non-iconic verbs (e.g., **SWEEP**, **MEASURE**) when ASL signers generated verbs associated with objects. In both PET studies, sign production engaged left IFG (compared to a baseline task), but this neural activity was not modulated by iconicity.

In contrast to these neuroimaging studies, results from event-related potential (ERP) studies suggest that iconicity can modulate the brain response during lexical production (Baus and Costa, 2015; McGarry et al., 2021a; Gimeno-Martinez and Baus, 2021). Behavioral results from picture-naming studies across different sign languages have found that iconic signs are retrieved more quickly than non-iconic signs: Catalan Sign Language (LSC; Baus and Costa, 2015), Italian Sign Language (LIS, Navarrete et al., 2017; Peressotti et al., 2018), BSL (Vinson et al., 2015), and ASL (Sehyr and Emmorey, Forthcoming). For these studies, iconicity is typically assessed using a rating scale with deaf signers or hearing non-signers rating the degree to which a sign form resembles its meaning (ratings by the two groups are highly correlated; Sehyr and Emmorey, 2019). Baus and Costa. (2015) found an early ERP effect (70–140 ms after picture onset) when hearing signers named pictures in LSC, which they suggested reflects early engagement of the conceptual system, with greater activation of semantic features for iconic signs. McGarry et al. (2021a) found that iconicity modulated the N400 response, with a larger N400 for iconic than non-iconic signs, when deaf ASL signers named pictures. McGarry et al. (2021a) hypothesized that this effect was similar to a concreteness effect. Concrete words elicit a larger N400 than abstract words, which is generally attributed to increased activation of perceptual and action-related semantic features associated with concrete words (e.g., Barber et al., 2013). The concreteness-like N400 response for iconic sign production could reflect more robust encoding of sensorimotor semantic features that are depicted by these signs and that are emphasized by the picture naming task.

In fact, Gimeno-Martinez and Baus (2021) provide evidence suggesting that ERP effects of iconicity may be task-dependent because a larger negativity for iconic signs was only observed for LSC picture-naming, but not for a Spanish-LSC translation task. One possible explanation for this finding is that the structural mapping between the visual features of pictures and the visual form of iconic signs (e.g., the ASL sign BIRD depicts a bird's beak and maps to the beak of a bird in a picture) facilitates lexical retrieval and leads to increased semantic feature activation (and a larger N400 for iconic signs). Another possibility is that the translation task requires little semantic processing (Navarrete et al., 2015) and therefore iconicity does not impact the neural response for this task. However, preliminary results from McGarry et al. (2021b) show effects of iconicity (larger negativity for iconic signs) in an English-ASL translation task, perhaps due to more semantic mediation for this group of signers. This finding supports the hypothesis that iconic signs have a more robust representation of sensorimotor semantic features than non-iconic signs. Overall, however, these mixed results indicate that more work is needed to establish whether or not iconic signs have a distinct neural representation and the extent to which iconicity effects are task-dependent (and why).

Production of Fingerspelled Words

Fingerspelling systems that represent the alphabetic orthography of the surrounding spoken language exist for a number of sign languages and can be one-handed (as in ASL) or two-handed (as in BSL). Fingerspelled words differ from lexical signs because they require the production of sequences of hand configurations in neutral space without movements to the body (except to the non-dominant hand for two-handed systems). Thus, the articulatory demands differ for fingerspelled words and lexical signs. Emmorey et al. (2016) found that when deaf ASL signers fingerspelled in response to written English words, ipsilateral (right) motor cortex was recruited in addition to left motor cortex, which was somewhat surprising because fingerspelling was produced by the dominant right hand. However, research with non-linguistic hand actions indicates that ipsilateral motor responses increase with the complexity of hand movements (Verstynen et al., 2005). Emmorey et al. (2016) hypothesized that right motor cortex may contribute to fine motor control of right-handed fingerspelling via callosal connections to the left hemisphere or via uncrossed descending projections (or both). ASL fingerspelling also recruited the cerebellum to a greater extent than the production of one-handed signs, which likely reflects the role of the cerebellum in the precise timing needed to rapidly articulate a string of complex handshapes (the average length of fingerspelled words in this study was six handshapes).

Compared to one-handed signs, Emmorey et al. (2016) found that the production of fingerspelled words engaged the left fusiform gyrus, encompassing the visual word form area (VWFA), a region involved in orthographic processing of words and letters. Activation in the VWFA in this study likely reflects the more detailed orthographic analysis required to fingerspell a written word presented on the screen than to translate a written word into ASL. Interestingly, however, when ASL signers named pictures of famous people using fingerspelling, activation in the fusiform gyrus including the VWFA was also observed (in contrast to a control face-orientation decision task; Emmorey et al., 2003), and VWFA activation was not found for hearing speakers who named the same people with spoken English (Damasio et al., 1996). This result suggests that the production of fingerspelling recruits the VWFA, even without a written prompt, and demonstrates that the function of the VWFA is not limited to the orthographic representation of printed text.

Sentence and Phrase Production

Very few lesion or neuroimaging studies have examined the neural basis of phrase or sentence production in sign languages. Poizner et al. (1987) described an ASL signer with a large left frontal lesion (GD) who produced simplified ("telegraphic") sentences. However, damage that is circumscribed to Broca's area (BA 45/44) does not appear to result in simplified or ungrammatical sentence production, but does result in persistent phonological errors (Hickok et al., 1996). Poizner et al. (1987) described another aphasic ASL signer (PD) who produced fluent signing but with grammatical errors (e.g., incorrect aspectual morphology). PD also failed to maintain spatial agreement across sentences, i.e., he failed to preserve a consistent association between a referent and a location in signing space. PD's lesion involved a subcortical region underneath Broca's area, extending into white matter underlying the inferior parietal lobule (SMG and the angular gyrus). Similarly, an aphasic ASL signer (WL) described by Corina et al. (1992) had damage to Broca's area and underlying white matter tracts, as well as damage to white matter underlying the inferior parietal lobule and a small lesion in left SMG. WL's sentence production was also fluent (with frequent phonological errors), but his sentences consisted largely of uninflected verbs with few nouns, and virtually no pronouns. Another aphasic signer (LK) first described by Chiarello et al. (1982) had a lesion in left parietal cortex (including SMG and angular gyrus) which spared the inferior frontal gyrus and superior temporal cortex. LK produced fluent signing (with many phonological errors), but she used pronouns inconsistently and failed to establish locations for referents in her spontaneous signing (see also Poizner et al., 1987). The sentence production of "Charles," a BSL aphasic signer, was severely impaired - his description of the Cookie Theft picture was composed almost entirely of gesture (Marshall et al., 2004). Interestingly, his lesion was located in the left posterior frontal and parietal lobes with only possible involvement of the temporal lobe, suggesting a weaker role for the posterior temporal cortex in sign sentence production (compared to sentence comprehension, see below). These sparse lesion data do not provide many clues to the neural substrates that support sentence-level computational processes, beyond lateralization to the left hemisphere (i.e., these types of errors do not occur with right hemisphere damage). Nonetheless, the case studies of PD, WL, and LK suggest that left inferior parietal cortex (SMG and the angular gyrus) may be involved in pronoun use and reference establishment in signing space. All three had damage involving parietal cortex and exhibited specific impairments in the use of pronouns or agreeing verbs.

With respect to neuroimaging data, there is only one study that targeted phrase-level sign production. Blanco-Elorrieta et al. (2018) used magnetoencephalography (MEG) to investigate the neural circuits that support online construction of linguistic phrases in both sign (ASL) and speech (English). Two-word compositional phrases and two-word non-compositional "lists" were elicited from deaf signers and hearing speakers using identical pictures. In one condition, participants combined an adjective and a noun to describe the color of the object in the picture (e.g., white lamp) and in the control condition, participants named the color of the picture background and then the object (e.g., white, lamp). For both signers and speakers, phrase building activated the left anterior temporal lobe (LATL) and ventromedial prefrontal cortex (vmPFC) more than the list condition, and with a similar time course. Neural activity related to combinatorial processing began in vmPFC at about 100–150 ms, followed by an increase in activity in LATL. The vmPFC is hypothesized to be involved in constructing combinatorial plans (Pylkkänen et al., 2014), while the LATL is hypothesized to be involved in computing the intersection of conceptual semantic features (Poortman and Pylkkänen, 2016). Very similar effects for ASL and English were confirmed by a representational similarity analysis (RSA). Thus, the phrasal combinatory processes supported by vmPFC and LATL are likely modality-independent.

Production of Classifier Constructions

Classifier constructions, also known as depictive constructions, are found in most, if not all sign languages and are complex expressions that convey information about the relative location, path and manner of movement, and the size and shape of a referent (see papers in Emmorey, 2003). Damage to either the left or the right hemisphere can cause impairments in the production of these constructions. Hickok et al. (2009) found that right hemisphere damaged ASL signers (n = 8) produced significantly more errors on classifier signs than lexical signs in a narrative picture description task, while left hemisphere damaged signers (n = 13) produced a similar number of errors for both types of signs. Neuroimaging research has confirmed that the right hemisphere (specifically, right parietal cortex) is engaged during the production of classifier constructions that express spatial relationships (Emmorey et al., 2002, Emmorey et al., 2005, Emmorey et al., 2013).

The PET study by Emmorey et al. (2013) was designed to tease apart the neural regions that support the retrieval of entity classifier handshapes that express object type (e.g., cylindrical object, long-thin object, vehicle, etc.) and the regions that support the expression of location and movement path by where the hands are moved or placed in signing space. Deaf ASL signers performed a picture description task in which they named objects or produced classifier constructions that varied in location, movement, or type of object. In contrast to the gradient, analog expressions of location and motion, the production of both lexical signs and object classifier handshapes engaged left IFG and left inferior temporal cortex, supporting the hypothesis that classifier handshapes are categorical morphemes that are retrieved via left hemisphere language regions. Classifier constructions expressing locations or movement paths both engaged posterior SPL bilaterally. One potential explanation for this result is that right SPL is activated due to the need to mentally transform the visual representation of object locations and movements shown in the picture into a body-centered reference frame for sign production (cf. Harris and Miniussi, 2003), while left SPL is activated due to the need to reach toward target locations in signing space for these constructions (Emmorey et al., 2016). In addition, the left intraparietal sulcus was more engaged when producing location than movement constructions, similar to the results for comprehension (see *Comprehension of Classifier Constructions*; McCullough et al., 2012). Overall, these results indicate that classifier handshapes, like lexical signs, are represented and retrieved via a left fronto-temporal network, while the analog, depictive expression of location and movement within these constructions is supported by bilateral superior parietal cortex.

Sign Language Production: Summary

Sign production is strongly left-lateralized, even more so than speech (Gutierrez-Sigut et al., 2015; Gutierrez-Sigut et al., 2016). **Figure 1** provides a sketch of the left hemisphere neural network for sign language production, based on the studies reviewed here. The evidence thus far indicates that phonological encoding for signs involves left parietal cortex. Left SPL is recruited during the planning of sign articulation, (Shum et al., 2020) as well as in monitoring and guiding the hand toward locations on the body (Emmorey et al., 2016), and left SMG appears to be engaged in the storage and assembly of phonological units (Buchsbaum et al., 2005; Corina et al., 1999a). Bimanual coordination for two-handed signs does not necessitate increased involvement of the motor circuit; rather, production of these signs requires fewer neural resources, possibly because production goals can be spread across the two articulators (at least for symmetrical signs) (Emmorey et al., 2016). Sensorimotor cortex exhibits selectivity to linguistically contrastive hand configurations and body locations in a manner that is parallel to the speech articulators, but of course this selectivity occurs within different regions along sensorimotor cortex (Leonard et al., 2020). Finally, in contrast to comprehension (see *Perception of Non-Manual Features*), almost nothing is known about the neural substrate that supports the production of non-manual sublexical components of sign (e.g., mouth gestures, linguistic facial expressions), beyond lateralization to the left hemisphere (Corina et al., 1999b).

The retrieval of lexical signs engages a fronto-parietal network consisting of left IFC and SMG. More anterior regions of left IFC (BA 45, 47) are likely involved in lexical selection and semantic processes, while the SMG is likely involved in phonological processing (Corina et al., 2003; Emmorey et al., 2016). Left pMTG is hypothesized to link lexical semantic representations with phonological representations (Indefrey and Levelt, 2004; Hickok and Poeppel, 2007). For picture naming, left IT is hypothesized to mediate between conceptual processing of objects and lexical retrieval (Emmorey et al., 2003). The retrieval of iconic signs may more robustly activate

sensorimotor semantic networks compared to non-iconic signs (Navarrete et al., 2017; McGarry et al., 2021a), but more research is needed. The production of fingerspelled words engages the visual word form area, suggesting a neural link between fingerspelling and orthographic representations (Emmorey et al., 2003; Emmorey et al., 2016). The production of location and motion classifier constructions is supported by bilateral superior parietal cortex (Emmorey et al., 2002; Emmorey et al., 2005; Emmorey et al., 2013). The data suggest that activation in left SPL may be associated with the need to target locations in signing space, while right SPL may be engaged in mapping visual representations of figure and ground objects onto the location and movements of the hands in signing space. In addition, the retrieval of whole entity object classifiers recruits left IFG and left inferior temporal cortex (Emmorey et al., 2013).

Little is known about the neural regions that support sentence and phrase production in sign languages. The aphasia literature clearly indicates that the left hemisphere is critical for sentence production (Poizner et al., 1987; Atkinson et al., 2005), but the within-hemisphere functional organization is largely unknown. Clues from the early cases of sign language aphasia suggest that the left inferior parietal lobule may be involved in maintaining associations between spatial locations and referents, as well as directing verbs or pronouns toward these locations (Poizner et al., 1987; Corina et al., 1992). The MEG study by Blanco-Elorrieta et al. (2018) indicated that the left ATL and vmPFC are involved in phrase-level compositional processes, but the potential roles of left posterior temporal cortex or left IFG in sentence production are less clear. In contrast, more is known about the contribution of these regions to sentence comprehension in sign languages (see below).

Perhaps surprisingly, the sketch of the sign language production network in **Figure 1** does not include left middle or posterior superior temporal cortex (STC). While many studies report activation in these STC regions for sign comprehension (see below), most studies of overt and covert sign production do not find activation in STC (Corina et al., 2003; Emmorey et al., 2003; Emmorey et al., 2004; MacSweeney et al., 2008b; Pa et al., 2008; Hu et al., 2011; Emmorey et al., 2016). Nonetheless, a few studies have reported activation in left posterior STC for covert sign production (Kassubek et al., 2004; Buchsbaum et al., 2005). Other studies that report left posterior STC activation used production tasks that were linked to the perception of signs, such as sign repetition (San José Robertson et al., 2004; Li et al., 2014). Interestingly, the conjunction analysis of ASL verb generation and action naming by San José Robertson et al. (2004) did not report STC activation. In contrast, studies of speech production consistently report bilateral STC activation, due at least in part to the auditory feedback that accompanies speech, and some models propose that auditory targets for production are represented in middle and posterior STC (e.g., the DIVA model; Tourville & Guenther, 2011). Thus, it appears that STC may not be as intimately involved in language production for sign as it is for speech.

Overall, output differences between sign and speech result in greater left parietal (SPL and SMG) engagement for sign compared to speech production (likely due to differences in the nature of phonological units across the two modalities), and greater engagement of left superior temporal cortex for speaking than signing (likely due to auditory feedback and auditory targets for speech production). Both sign and word production engage the left inferior frontal cortex, which is likely involved in lexical selection and lexical-semantic processes for both language types. At the sentence level, phrase production in sign and speech engage the same regions (left ATL and vmPFC), but much more research on sentence production by signers is needed to determine the extent of similarities and differences across modalities (e.g., confirming whether or not left SMG is uniquely engaged for reference establishment and the production of agreeing verbs and pronouns) (**Figure 1**).

THE NEUROBIOLOGY OF SIGN LANGUAGE COMPREHENSION

As for language production, psycholinguistic evidence points to many parallel processes for the comprehension of signed and spoken languages. For example, at the phonological level, both signers and speakers become tuned to the phonological units of their language, as evidenced by categorical perception effects (Palmer et al., 2012), and both sign and speech are segmented using the same form-based constraints (e.g., the Possible Word Constraint; Orfanidou et al., 2010). Sign and word recognition are automatic, as evidenced by Stroop effects (Bosworth et al., 2021), and are both influenced by lexical frequency (faster recognition times for high frequency signs/words; Carreiras et al., 2008) and phonological neighborhood density (slower recognition for signs/words with many form-similar neighbors; Caselli et al., 2021). At the sentence level, the mechanisms for processing pronominal referents are parallel (e.g., antecedent re-activation; Emmorey et al., 1991), and the implicit causality of verbs guides pronoun interpretation for both language types (Frederikson and Mayberry, 2021). Of course, for sign languages, linguistic information must be extracted from a visual signal expressed by the body, whereas an acoustic signal is the primary information source for spoken languages. In this section we explore whether and how modality differences in perception impact the neural underpinnings of sign comprehension. The review covers neural regions involved in the perception of sublexical units of signs (handshape, location, movement), lexical sign recognition, and sentence comprehension. In addition, we examine comprehension of typologically-unique properties of sign languages: non-manual features, iconic signs, fingerspelling, and classifier constructions. Parallel to the review of sign production, we end with a summary sketch of the neural network that supports sign language comprehension.

Perception of Sublexical Phonological Structure

For spoken language, bilateral auditory regions in superior temporal cortex differentiate speech from non-speech stimuli (e.g., Binder et al., 2000) and do so very rapidly, as early as 100–150 ms (e.g., Shtyrov et al., 2000). Similarly, using MEG,

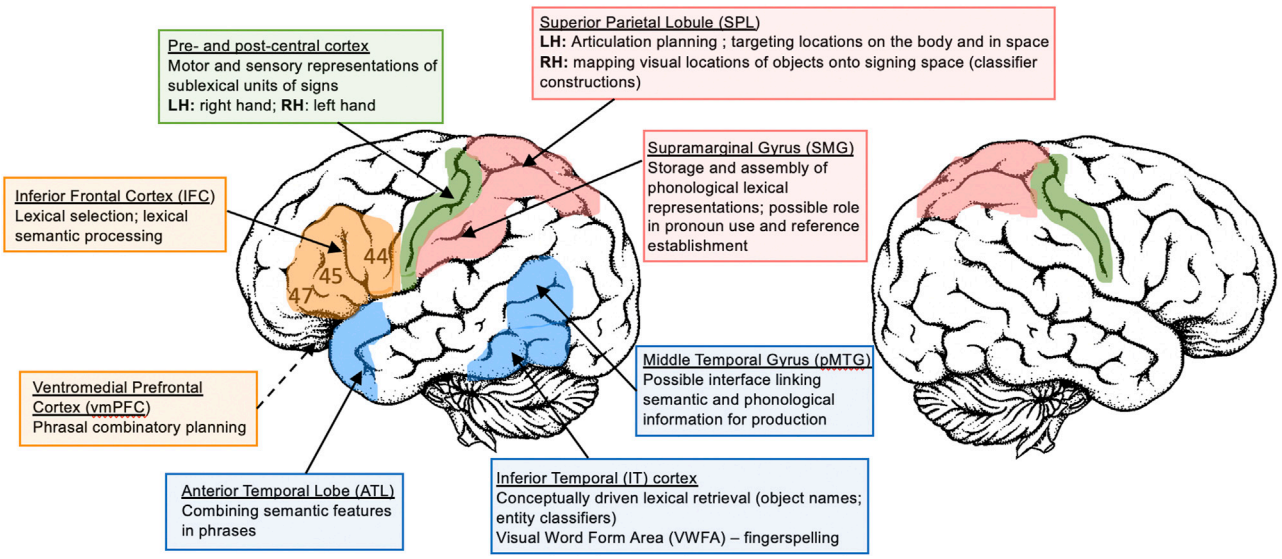


FIGURE 1 | A sketch of the neural network that supports the production of sign language. LH = left hemisphere; RH = right hemisphere.

Almeida et al. (2016) demonstrated that the earliest visual cortical responses (M100 and M130) exhibited specific modulations in deaf signers to ASL signs (still images) that violated anatomical constraints (e.g., a left hand on a right arm); this early visual response was not observed for hearing non-signers. Deaf signers also exhibited increased perceptual sensitivity compared to non-signers (i.e., better discrimination between possible and impossible signs). These results indicate that the early neural tuning that underlies the discrimination of language from non-language information occurs for both speakers and signers, but in different cortical regions (superior temporal cortex for speech vs occipital cortex for sign). Further, visual cortex shows entrainment to visual oscillations (rhythms) in signing, and entrainment in visual cortex is not observed for non-signers watching ASL (Brookshire et al., 2017). Thus, although entrainment may be driven in part by low-level visual features of signing (e.g., quasi-periodic fluctuations in visual movements), it is also modulated by top-down sensory predictions based on linguistic knowledge.

Cardin et al. (2013) and Cardin et al. (2016) used functional magnetic resonance imaging (fMRI) and the sign language equivalent of a phoneme monitoring task to investigate the neural networks that support processing of handshape and location parameters. Participants (deaf BSL signers and deaf/hearing non-signers) pressed a button when they detected a sign form containing a cued location or handshape. The stimuli consisted of BSL signs, pseudosigns, and illegal sign forms that violated phonological constraints (e.g., non-occurring handshapes or points of contact or illegal phonological combinations). For all groups and stimulus types, monitoring for handshape engaged regions involved in the representation of the hand/arm and hand/arm movement goals (bilateral intraparietal sulcus, inferior temporal cortex), while monitoring for location engaged regions involved in spatial attention and the localization of body parts (bilateral precuneus, angular gyrus, and medial prefrontal cortex). These findings indicate that perception and recognition of handshape and body locations are supported by distinct neural regions, but these networks are not modulated by linguistic knowledge (or structure). Similarly, sign movement, the third major phonological parameter in sign language, activates neural regions that are sensitive to biological motion (area MT+ in the posterior temporal lobe) in both signers and nonsigners (e.g., Levänen et al., 2001).

Cardin et al. (2013) and Cardin et al. (2016) also reported two cortical areas that were activated only in the deaf signing group, indicating that these regions were specifically engaged in linguistic processing: superior temporal cortex (STC) and SMG in both hemispheres. All stimuli (real signs, pseudosigns, and illegal signs) engaged bilateral STC to a greater extent for deaf signers than non-signers (deaf or hearing). This result suggests that language-like stimuli engage bilateral STC for signers, regardless of semantic content (or phonological structure). However, the precise role of left STC in processing the linguistic form of signs remains to be determined. Illegal sign forms that violated BSL phonotactic constraints elicited stronger activation in bilateral SMG only in deaf signers. One interpretation of this result is that bilateral SMG plays a role in the integration of phonological parameters during sign perception, such that phonological violations increase neural activity in this region, perhaps due to the difficulty of integrating non-occurring handshapes, locations, and combinations.

Electrophysiological evidence also indicates that handshape and location parameters are processed differently in the brain, but this difference is not purely perceptual and can impact lexical-level processes. Using an ERP priming paradigm and delayed lexical decision, Gutiérrez et al. (2012) found that location-only overlap between a prime and target sign led to a "reversed" N400 response (greater negativity for location-related than unrelated target signs) for Spanish Sign Language (LSE). The N400 is an ERP component associated with lexical-level processing (see Kutas and Federmeier, 2011, for review). Crucially, modulation of the N400 was not observed for pseudosign targets, indicating that location overlap impacted lexical, rather than sublexical processing. Handshape overlap did not modulate the N400 component, although a later (600–800 ms) more typical priming effect was observed (i.e., reduced negativity for handshape-related than unrelated targets). Gutiérrez et al. (2012) hypothesized that the increased N400 negativity for signs sharing location reflects lexical competition via lateral inhibition. Meade et al. (2021a) reported similar results for ASL and provided further support for this hypothesis. Deaf ASL signers performed either a go/no-go repetition detection task which could be performed based only on perceptual processing (lexical access/selection is not required) and a go/no-go semantic categorization task (is this a country sign?) which required lexical selection and semantic processing. Handshape-related targets elicited smaller N400s than unrelated targets (indicative of facilitation), but only for the repetition detection task. The N400 effect for location-related targets reversed direction across tasks: a smaller N400 amplitude for the repetition detection task (indicating facilitation), but a larger N400 in the semantic task, indicative of lexical competition. Together, these results provide evidence that handshape and location play different roles during sign recognition. Specifically, both handshape- and location-related prime signs can pre-activate sublexical representations of handshapes and locations and thus facilitate processing of target signs. However, at the lexical level, signs compete for selection (via lateral inhibition) and this competition appears to be primarily driven by the location parameter (see also Carreiras et al., 2008). Sublexical facilitation and lexical competition are features of interactive-activation models proposed for word recognition (e.g., McClelland and Elman, 1986), and these data indicate that such models and their neural underpinnings apply to sign recognition as well.

Perception of Non-manual Features

Non-manual features (e.g., facial expressions, headshake, eye gaze) constitute a non-trivial component of the structure of sign languages. At the phonological level, non-manual features can distinguish between minimal pairs, such as the ASL signs NOT-YET and LATE, which are distinguished only by tongue protrusion produced with NOT-YET. At the syntactic level, distinct facial expressions (e.g., furrowed or raised eye brows) mark different types of questions, and headshake marks negation in many sign languages, although the scope of negation (when and where the headshake must occur) varies cross-linguistically (Zeshan, 2006). Eye-gaze has deictic, referential functions in many sign languages (Garcia and Sallandre, 2020). Despite the importance of non-manual features, very little is known about how they are represented and processed in the brain.

Two fMRI studies have examined how non-manual components of signs are processed in the brain. Capek et al. (2008) compared neural activity for comprehending BSL signs produced with and without non-manual features. Signs with non-manual features were produced either with mouthings (speech-derived mouth movements) or mouth gestures (mouth actions unrelated to speech). In this study, mouthings disambiguated manual BSL signs, e.g., mouthing "Asian" vs "blue" distinguishes the meaning of identical manual signs, representing a minimal pair distinguished only by mouthing. Mouth gestures were obligatory mouth actions that constituted a sublexical non-manual feature of the sign, e.g. producing a closing mouth gesture simultaneously with the downward movement of the hand in the sign TRUE (an example of "echo phonology" in which the mouth and hand movements resemble each other; Woll, 2014). Signs with non-manual features (both mouthing and mouth gestures) generated greater neural activity in the superior temporal sulcus (STS) in both hemispheres (extending into SMG in the left hemisphere) and in left IFG, compared to manual-only signs. This result suggests that bilateral STS and left IFG are involved in recognizing mouth actions that accompany manual signs, possibly because these regions are particularly sensitive to movements of the mouth, even for non-linguistic mouth articulations (Pelphrey et al., 2005). The fact that activation extended into left SMG suggests that this region may be involved in integrating both manual and non-manual phonological features during sign recognition. The contrast between signs with mouthing and those with mouth gestures revealed greater neural activity in left middle STS for signs with mouthing, and this region overlapped with the STS region activated when the same deaf BSL signers comprehended silent speech (Capek et al., 2010). Comprehending signs with mouth gestures generated greater neural activity in a more posterior region along the STS bilaterally, which overlapped with the posterior temporal regions engaged by manual-only signs. These findings suggest that mouthings may represent a form of language mixing (code-blending) since the recognition of mouthings was supported by the same left STS region engaged during speech-reading. In contrast, mouth gestures engaged the same bilateral posterior temporal regions involved in perceiving hand movements, possibly because their articulation is linked to the dynamic movements of the hands (Woll, 2014).

McCullough et al. (2005) investigated the neural underpinnings of ASL facial expressions that convey adverbial distinctions, such as "effortlessly" (lips pressed together) or "carelessly" (tongue protrudes). Deaf signers and hearing non-signers made same-different judgements to pairs of static images of different signers producing the same verb with either the same or a different non-manual adverbial; the baseline comparison was a same-different gender decision for images of signers producing verbs with neutral facial expressions. Neural activity for recognizing linguistic facial expressions (compared to the baseline) was strongly left-lateralized in posterior STS only for the deaf signers. The left STS neural activity for ASL adverbial

facial expressions was posterior to the left STS region that Capek et al. (2008) reported for mouthings in BSL, but similar to the posterior STS region engaged for BSL mouth gestures. In addition, Capek et al. (2008) reported greater activation for mouth gestures than mouthings in the left fusiform gyrus, and McCullough et al. (2005) also found left-lateralized activity for adverbial facial expressions (compared to neutral faces) in the fusiform gyrus for deaf signers only. This region includes the fusiform face area, which is specialized for face perception (Kanwisher, 2000). Together these results indicate that comprehension of sublexical facial components of signs engages face-sensitive neural regions (posterior STS and the fusiform gyrus; Ishai, 2008). Furthermore, the finding that neural activity is larger in the left hemisphere indicates that these face-sensitive regions are modulated by linguistic processing demands and form part of the language network for sign language.

Finally, Atkinson et al. (2004), found that comprehension of non-manual negation in BSL (headshake with furrowed brows, narrowed eyes and/or downturned mouth) was impaired for signers with right hemisphere damage and spared for signers with left hemisphere damage. Atkinson et al. (2004) hypothesized that non-manual negation may function prosodically, rather than syntactically, under an analysis in which non-manual negation is associated with syntactic structure, but is not itself syntactic. This hypothesis fits with evidence that the right hemisphere is involved in prosodic processing for spoken language (e.g., Meyer et al., 2003), and with other linguistic evidence suggesting that non-manual negation can be a prosodic marker in sign languages (Pfau, 2008).

Lexical Comprehension

A MEG study by Leonard et al. (2012) demonstrated that the initial neural response to lexical signs (80–120 ms post onset) occurs in bilateral visual (occipital) cortex, in contrast to the early neural response in auditory cortex for spoken words. In this study, deaf ASL signers performed a picture–sign matching task, while hearing English speakers performed a picture–auditory word matching task with the same items. Neither the early visual response to signs nor the early auditory response to words was sensitive to semantics (i.e., whether the sign was congruent or incongruent with the preceding picture). However, a later time window (300–350 ms) showed evidence of semantic sensitivity (greater negativities for incongruent than congruent trials) and high overlap in the neural regions for sign and word comprehension. Regions in bilateral STC (planum temporale, superior temporal sulcus, temporal pole) exhibited lexical semantic sensitivity, with a stronger response in the left than right hemisphere for both signs and words. However, the left intraparietal sulcus (IPS) exhibited semantic sensitivity only for ASL signs, suggesting a modality-specific role for this parietal region in the lexical semantic processing of signs. This finding points to the possible overlap in lexical processing for sign comprehension and production in left parietal cortex.

Emmorey et al. (2015) also observed left IPS activation when deaf ASL signers made semantic decisions to signs (concrete or abstract meaning?), in comparison to a low-level baseline task, and activation was not observed for hearing non-signers viewing the same ASL signs. Importantly, left IPS was not engaged when ASL signers made the same semantic decision to fingerspelled words, and the direct contrast between ASL signs and fingerspelled words revealed greater activation for ASL signs in left SMG (extending into IPS). ASL fingerspelling is produced at a single location in signing space and most fingerspelled letters are not specified for movement. Thus, to comprehend fingerspelled words, handshapes do not need to be integrated with locations on the body or with different movement types. In contrast, to recognize and comprehend ASL signs, all three phonological parameters must be integrated. In addition, ASL signs have stored lexical representations, whereas the fingerspelled words presented in the Emmorey et al. (2015) study did not; they were not loan signs and did not have ASL translations. The finding that neural activity in SMG is strongly left-lateralized when signers perform a lexical semantic task, but not when they perform a form-based monitoring task as found by Cardin et al. (2016), suggests that left SMG supports lexical-level phonological processing during comprehension. Right SMG may engage in form-based/phonetic-level processing of signs, particularly when lexical-semantic processing is not required.

Neuroimaging studies targeting lexical-level processing in deaf signers of several different languages consistently report bilateral activation in posterior STC, typically with more extensive activation in the left hemisphere: ASL (Corina et al., 2007; Emmorey et al., 2015); BSL (MacSweeney et al., 2006; Capek et al., 2008), CSL (Li et al., 2014), German Sign Language (Deutsche Gebärdensprache or DGS; Klann et al., 2002; Trumpp and Kiefer, 2018); Langue des Signes Québecoise (LSQ; Petitto et al., 2000); and Polish Sign Language (Polski Język Migowy or PJM; Banaszkiewicz et al., 2020). Interestingly, Inubushi and Sakai (2013) did not report activation in STC when deaf signers of Japanese Sign Language (JSL) performed a pseudosign detection task with unrelated sentences, but the baseline comparison was backward videos of sentences, and many signs remain intelligible when viewed backward, unlike reversed speech (Bosworth et al., 2020). Thus, because both the experimental and baseline tasks engaged lexical-semantic processing, activation in STC may have been cancelled out. Lesion data indicate that left STC (and likely left middle temporal gyrus) is critical to lexical semantic processing. ASL signers with damage to left posterior temporal cortex were more impaired in a sign-picture matching task than signers with cortical damage that spared this region (Hickok et al., 2002).

The neuroimaging studies cited above that investigated lexical comprehension in ASL, BSL, CSL, DGS, LSQ, and PJM all report additional neural activity within left inferior frontal cortex (IFC), often accompanied by less extensive neural activity in the homologous region in the right hemisphere. Left IFC includes Broca's area (BA 44 and 45) along with a more anterior frontal region (BA 47); these regions have been associated with multiple functions for spoken word comprehension, including selecting among competing possible words, linking semantics with phonology, and maintaining words in memory (Hagoort, 2005; Price, 2012). Bilateral IFC has also been shown to be

part of a fronto-parietal network for encoding and retrieving signs in working memory (Rönnberg et al., 2004; Bavelier et al., 2008). However, the precise role(s) of left IFC (and its subregions) and the homologous region in the right hemisphere in lexical-level comprehension for sign language requires further research.

Iconicity and Lexical Comprehension

Most of the evidence to date indicates that iconic signs are not comprehended differently in the brain compared to non-iconic signs. Atkinson et al. (2005) found that deaf signers with aphasia were equally impaired in their comprehension of iconic and non-iconic signs and did not use iconicity as a cue to sign meaning, in contrast to hearing non-signers performing the same sign-picture matching task. Using event-related fMRI and representational similarity analyses, Evans et al. (2019) found that iconicity did not influence the neural representation of BSL signs in left posterior middle/inferior temporal cortex. Emmorey et al. (2020) found no ERP effects of iconicity in a go/no-go semantic categorization task with deaf ASL signers, even though hallmarks of lexical access–frequency and concreteness effects–were observed during the N400 time window. Mott et al. (2020) also found no effects of iconicity during this time window for deaf signers in a cross-language translation recognition task, although effects of iconicity were found for hearing adult ASL learners.

Finally, a recent ERP study by McGarry et al. (2021c) examined the neural response when ASL signers performed a picture-sign matching task in which the picture either visually-aligned with the iconic sign (e.g., a bird in profile for the sign BIRD in which the fingers depict a bird's beak) or was not aligned with the sign (e.g., a picture of a bird in flight). Replicating previous behavioral studies (Thompson et al., 2009; Vinson et al., 2015), signers were faster for the aligned than non-aligned trials. However, the ERP data indicated that aligned trials were associated with a reduced P3 amplitude rather than a reduced N400, suggesting that visual picture-sign alignment facilitated the decision process (indexed by the P3 component), rather than lexical access (indexed by the N400 component). Thus, the faster response times found in these studies for the picture-aligned trials likely occurred because it was easier for participants to make the picture-sign matching decision, rather than to a priming effect in which the visual alignment between the picture and the iconic sign facilitated sign recognition and lexical access.

Comprehension of Fingerspelled Words

Two studies have examined the neural underpinnings for the comprehension of fingerspelled words, investigating the two-handed BSL system (Waters et al., 2007) and the one-handed ASL system (Emmorey et al., 2015). The contrast between fingerspelled words and lexical signs for both ASL and BSL revealed greater neural activity for fingerspelling in the visual word form area (VWFA) located in ventral occipito-temporal cortex. Differential VWFA activation was not found for hearing sign-naïve controls, indicating that linguistic knowledge underlies this result and that it cannot be accounted for by perceptual differences between fingerspelling and signing. Waters et al. (2007) also found that the right VWFA was engaged by fingerspelled words, which could reflect the fact that skilled deaf readers tend to engage the VWFA bilaterally for written words (Glezer et al., 2018; see also Emmorey et al., 2017). Overall, both studies found that fingerspelling was more left-lateralized than signing, which parallels the finding that reading text is more left-lateralized than listening to speech (Buchweitz et al., 2009). Like text, fingerspelling is acquired later in childhood when children learn to make associations between handshapes and written letters, and both reading and fingerspelling build on already established left-hemisphere language regions. In sum, both the comprehension and production of fingerspelled words recruit the VWFA, highlighting its role in accessing orthographically structured representations.

Sentence Comprehension

Neuroimaging studies of sentence-level comprehension in different sign languages report engagement of a similar bilateral fronto-temporal network as found for single sign comprehension, again with more extensive activation in the left hemisphere: ASL (Newman et al., 2010; Mayberry et al., 2011), BSL (Mac Sweeney et al., 2002a; MacSweeney et al., 2006), CSL (Liu et al., 2017), DGS (Gizewski et al., 2005), JSL (Sakai et al., 2005; Inubushi & Sakai, 2013), Langue des Signes Francaise (LSF; Moreno et al., 2018), and PJM (Jednoróg et al., 2015). Lesion data from ASL signers support the hypothesis that left posterior temporal cortex is critical to sentence comprehension (Hickok et al., 2002). For example, on simple sentences from the Token Test involving single clause commands (e.g., "point to any square"), signers with left posterior temporal damage (extending into parietal cortex) scored 53% correct, while signers with left hemisphere lesions that did not involve temporal cortex scored near ceiling. A few neuroimaging studies have worked to isolate the neural regions that are specifically engaged in sentence-level comprehension processes. MacSweeney et al. (2006) found that BSL sentences engaged left IFG and left posterior temporal cortex to a greater extent than lists of BSL signs, indicating that this left fronto-temporal network is recruited when words are integrated to create meaning.

Inubushi and Sakai. (2013) probed word-, sentence-, and discourse-level processing by presenting JSL sentences to deaf signers who performed a pseudoword detection task or a grammatical error detection task (e.g., verb agreement or word order violations) for sets of unrelated sentences. For the discourse-level task the same sentences constituted a dialogue between two signers, and the task was to detect a sentence that did not fit into the conversation, but was otherwise syntactically and semantically well-formed. The baseline task was to detect a repeated video from the same sentences played backwards. A key result of this study was that as attention shifted to higher levels of processing, neural activity increased in the following left IFG regions (word < sentence < discourse): lateral premotor cortex (LPMC), Broca's area (BA 44, 45), and anterior IFG (BA 47). Furthermore, neural activity expanded along this dorsal-ventral axis as attention shifted to higher linguistic levels, moving from words (left LMPC) to sentences (left BA 44, 45) to discourse (bilateral BA 47).

The role of the left IFG in sign language comprehension was further documented in a recent ALE (activation likelihood

estimate) meta-analysis by Trettenbrein et al. (2021) of 23 fMRI/PET studies with deaf signers (N = 316) of seven different languages. The meta-analysis revealed bilateral IFG activation extending into lateral premotor cortex in the left hemisphere for sign comprehension compared to control/baseline tasks (more than half of the contrasts involved sentence processing). Activation in Broca's area (BA 44, 45) was strongly left-lateralized, particularly for BA 44. Further, a comparison with another meta-analysis of the perception of non-linguistic action gestures (by non-signers) indicated that sign language comprehension engaged left IFG (with a peak in BA 44) to a greater extent than human action observation, but the conjunction analysis revealed overlap in right IFG (BA 45). Based on these results, Trettenbrein et al. (2021) hypothesized that left IFG computes linguistic aspects of sign language during comprehension, while right IFG may be involved in processing aspects of the visual-manual signal that are shared with action gestures. Similarly, a graph theoretical analysis of fMRI data from hearing signers comprehending CSL sentences compared to non-signers observing these sentences revealed that left BA 44 served as a central network hub in signers only (Liu et al., 2017), supporting the hypothesis that this region plays a role in integrating information within the language network for sign language.

A typologically unique feature of sign language syntax is the use of "agreeing" verbs that can be directed toward locations in signing space to express grammatical relations (see Mathur and Rathmann, 2012, for an overview). In these sentence types, referents are associated with locations in signing space and the agreeing verb can be directed toward these locations to indicate grammatical roles (e.g., subject, object). Electrophysiological and neuroimaging data suggest that comprehension of sentences with these verbs may engage spatial processing mechanisms that are unique to the signed modality. Similar to ERP results from spoken languages, Capek et al. (2009) observed an early anterior negativity followed by a P600 response to syntactic violations involving ASL agreeing verbs. However, the distribution of the anterior negativity differed depending upon the type of agreement violation. Violations in which the verb direction was reversed (moving toward the subject instead of the object location) elicited a left anterior negativity, whereas for violations in which the verb was directed toward a previously unspecified location, the anterior negativity was larger over the right hemisphere.

Following up on this study, Stroh et al. (2019) used fMRI to probe the underlying neural correlates of processing verb agreement violations. DGS signers were presented with sentences that contained an agreement violation in which the incorrect direction of movement was from neutral space to the first person, as well as sentences that contained a semantic violation and correct sentences (task: acceptability judgment). Sentences with semantic violations vs correct sentences elicited greater activation in left calcarine sulcus (a low-level visual processing region) and left IFG. Stroh et al. (2019) hypothesized that the increased neural activity in early visual cortex reflected sensitivity to violations of sensory predictions of the incoming signed signal (the semantically anomalous word always occurred at the end of the sentence), whereas left IFG activation likely reflected lexical semantic integration processes. Syntactic violations elicited greater neural activity in right SMG compared to both correct sentences and compared to sentences with semantic violations; left IFG did not exhibit sensitivity to agreement violations. Stroh et al. hypothesized that right SMG is involved in attending to and tracking the spatial location of referents. Together these results confirm the role of left IFG in sentence-level semantic processes and point to the role of the right SMG in comprehending "spatial syntax" expressed by agreeing verbs.

An fMRI study of ASL signers by Newman et al. (2010) also points to the possible role of bilateral superior temporal cortex (STC) in comprehending sentences with agreeing verbs and other types of simultaneous morphology (e.g., aspectual inflections and numeral incorporation). This study compared the comprehension of ASL sentences that contained signs inflected with grammatical morphology with sentences that contained the same uninflected signs or lexical signs that conveyed the same information (e.g., lexical adverbs or separate number signs). The sentences that contained simultaneous morphology elicited greater activation in anterior and posterior STC bilaterally and in a region in left IFG (BA 45) compared to sentences without morphology. This pattern resembles the fronto-temporal network hypothesized to support the recognition and interpretation of inflectional morphology in spoken languages (Marslen-Wilson and Tyler, 2007).

Finally, Matchin et al. (2021), recently investigated the neural regions involved in syntactic/semantic combinatorial processes by presenting ASL signers with stimuli of the same length, but which parametrically increased in the size of the linguistic constituents: lists of six unrelated signs, three two-sign simple sentences (e.g., subject verb), and complex six-sign sentences (e.g., sentences with embedded clauses). The neural region that was sensitive to this parametric variation in combinatorial structure was the left STS with an anterior and a posterior peak of activation. This result mirrors what has been found for spoken language (French) using a very similar paradigm (Pallier et al., 2011). In addition, the anterior STS peak was in the left ATL, suggesting that this region supports combinatorial processes for both comprehension and production. Interestingly, left IFG was not sensitive to the manipulation of syntactic combinatorial structure in ASL. This result is consistent with other studies that have failed to find evidence that Broca's area (BA 44, 45) is a core region involved in syntactic structure building during comprehension of spoken languages (e.g., Brennan and Pylkkänen, 2012). Recently, Matchin and Hickok. (2020) argued that the role of Broca's area in syntactic processing is primarily tied to production (linearalizing lexical information from posterior temporal cortex) and that during comprehension activation in Broca's area is driven by working memory resources.

Comprehension of Classifier Constructions

As with production, results from lesion studies indicate that either left or right hemisphere damage can result in comprehension deficits for classifier constructions expressing

spatial relationships (Emmorey et al., 1995; Atkinson et al., 2005). However, the neuroimaging evidence for right hemisphere involvement is somewhat mixed. Using fMRI and a semantic anomaly detection task, MacSweeney et al. (2002b) compared neural activation for deaf BSL signers when comprehending topographic versus non-topographic sentences. Topographic sentences used signing space and/or the signer's body to express spatial information, while non-topographic sentences did not. The contrast between these two sentence types revealed greater activation for the topographic sentences in left but not right parietal cortex. However, the topographic sentences did not focus specifically on spatial relationships and included a wide range of constructions, e.g., *The woman shaved her legs* and *I flew from London to Dublin* (English translations). It is possible that activation in right parietal cortex was not observed for the topographic sentences because only a handful of sentences required mapping the location of the hands in signing space to the location of figure and ground referents (e.g., *The cat sat on the bed*).

Using event-related fMRI and a sentence-picture matching task, a recent study by Emmorey et al. (2021) specifically targeted the comprehension of ASL locative classifier constructions by deaf signers and their English translations by hearing speakers. The sentences expressed either a perspective-dependent spatial relationship (*left, right, in front of, behind*) or a perspective-independent relationship (*in, on, above, below*) between a figure and ground object. In contrast to non-spatial control sentences, perspective-dependent sentences engaged SPL bilaterally for both ASL and English, consistent with a previous study using the same design with written English (Conder et al., 2017). The ASL-English conjunction analysis revealed bilateral SPL activation for perspective-dependent sentences, but left-lateralized activation for perspective independent sentences. The direct contrast between perspective-dependent and perspective-independent expressions revealed greater SPL activation for perspective-dependent expressions only for ASL. Emmorey et al. (2021) hypothesized that the increased SPL activation for ASL perspective-dependent expressions reflects the mental transformation required to interpret locations in signing space from the signer's viewpoint (Brozdowski et al., 2019).

Newman et al. (2015) failed to find activation in either left or right parietal cortex when deaf ASL signers comprehended sentences containing location and motion classifier constructions (descriptions of animations designed specifically to elicit these constructions; Supalla, 1982). These sentences were compared to a "backward/layered" control condition in which the sentence videos were played backward with three different videos superimposed. The experimental task was to decide whether a sentence matched a preceding video, and the control task was to determine whether three hands had the same simultaneous handshape in the backward/layered video. Compared to this control condition, comprehension of ASL location and motion classifier constructions engaged bilateral STC and left IFG, i.e., the neural network described above for sentence comprehension in sign languages. However, the visually complex baseline video and spatial attention task may have swamped any additional parietal activation related to interpreting expressions of motion or location in the signed sentences. When neural activity for the ASL sentences was compared to a fixation baseline, neural activity in both left and right parietal cortices was found (Supplementary Table S1 in Newman et al., 2015).

MacSweeney et al. (2002b) also found that a motion-sensitive region, area MT+, in bilateral posterior temporal cortex was more engaged for BSL topographic sentences (some of which expressed the movement of a referent) compared non-topographic sentences. McCullough et al. (2012) followed up on this result and targeted the comprehension of ASL sentences with classifier constructions that expressed motion (e.g., *The deer walked along a hillside*) versus matched sentences that expressed static location information (e.g., *The deer slept along a hillside*). MT+ was localized individually for each deaf signer using motion flow fields. The results revealed greater neural activity in bilateral MT+ for motion compared to location sentences. This finding indicates that linguistic semantics modulates motion-sensitive cortex (cf. Saygin et al., 2010). Further, this top-down modulation is not disrupted by the visual motion in the signed signal, possibly because the physical movement of the hands and the motion semantics are always congruent (e.g., an upward hand movement expresses upward motion of a referent). In addition, locative sentences engaged left parietal cortex to a greater extent than motion sentences, consistent with the left parietal activity observed when producing locative classifier constructions.

Finally, Jednoróg et al. (2015) compared comprehension of PJM sentences that expressed the same location and movement concepts either with classifier constructions or with lexical signs (passive viewing by deaf signers). Bilateral SMG and right SPL were more active during the comprehension of sentences with classifier constructions than sentences without them. The reverse contrast revealed greater activation in anterior STC bilaterally (more extensive on the left) for the sentences with lexical signs only. These differences were not observed when sign-naïve participants viewed the PJM sentences. Right SPL and bilateral SMG activation for comprehending classifier constructions is consistent with the lesion data and neuroimaging results from production studies. The greater activity for lexical sentences in left anterior STC extended into the left ATL, and Jednoróg et al. (2015) hypothesized that this region may be involved in semantic combinatory processes for lexical signs. This finding and interpretation are consistent with the left anterior STC region that Matchin et al. (2021) found to be sensitive to combinatorial structure in ASL and that Blanco-Elorietta et al., 2018) found to be engaged in phrase production.

Sign Language Comprehension: Summary

Figure 2 provides a sketch of the neural network for sign language comprehension based on the studies reviewed here. With respect to the early phonetic/phonological perception of signs, occipital cortex appears to be tuned to quickly discriminate linguistic from non-linguistic stimuli in deaf signers (Almeida et al., 2016; see also Corina et al., 2007), and activation in early visual cortex can be modulated by top-down linguistic processes (Brookshire et al., 2017). For both signers and non-signers, neural regions involved

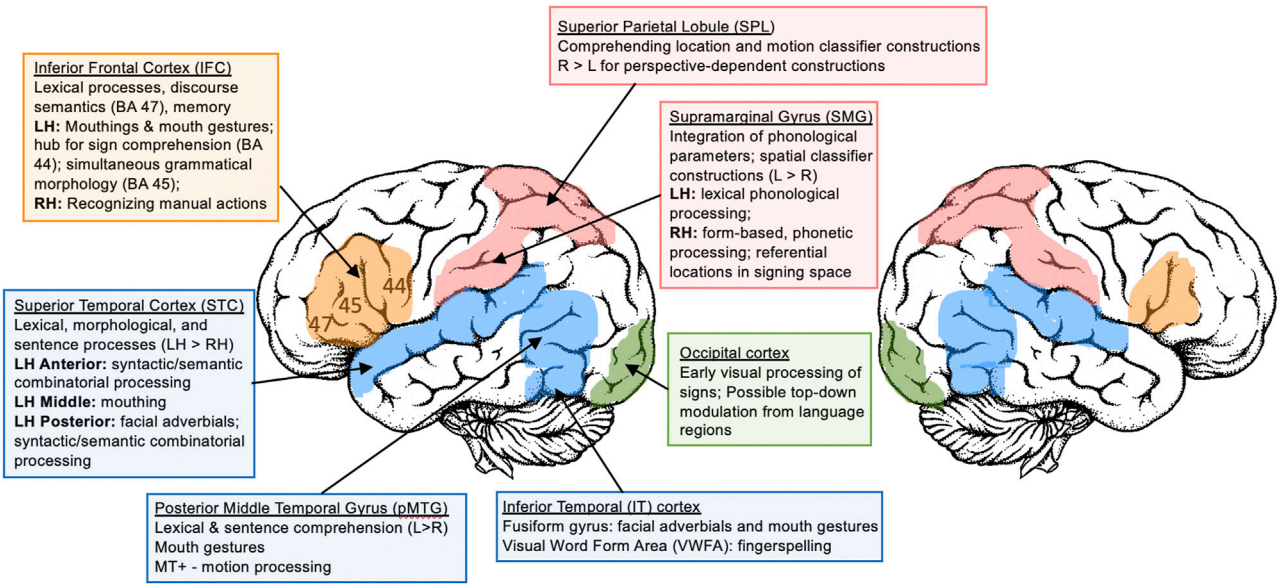


FIGURE 2 | A sketch of the neural network that supports the comprehension of sign language. LH = left hemisphere; RH = right hemisphere.

in the perception of hand movements and body locations are recruited during sublexical processing of sign stimuli (i.e., detecting a specific handshape or body location) (Cardin et al., 2016). Bilateral STS is more activated when signers (vs non-signers) engage in sublexical processing, but this activation is not influenced by lexicality or phonological structure; thus, the precise role of STS in the sublexical processing of signs is unclear (Cardin et al., 2013). Bilateral SMG may be involved in the integration of phonological parameters during sign perception, as only signers exhibited sensitivity in SMG to phonological violations (Cardin et al., 2016). The electrophysiological data indicate that signers develop neural sublexical representations of handshapes and locations that can be primed (Meade et al., 2021a; see also Meade et al., Forthcoming). In addition, lateral inhibition between signs sharing location results in an increased N400 response when lexical selection is required to perform the task (Gutierrez et al., 2012; Meade et al., 2021a). These distinct electrophysiological responses provide evidence for a hierarchical organization of sublexical and lexical representations in the brain for sign languages.

There is some suggestion that left SMG may also be involved in integrating mouth actions with manual signs during sign recognition (along with left IFG) (Capek et al., 2008). Recognition of mouthings appears to rely on the same left middle STS region that supports speech-reading, while mouth gestures and adverbial facial expressions engage more posterior regions of STS. Comprehension of both mouth gestures and facial adverbials also engages the left fusiform face area in inferior temporal cortex (McCullough et al., 2005; Capek et al., 2008). Thus, the temporo-parietal network involved in phonological decoding of the manual and non-manual features of signs includes bilateral SMG and STS (more extensive in the left) and the left fusiform gyrus. However, comprehension of non-manual negation may be right-lateralized because right, not left hemisphere damage impairs its comprehension (Atkinson et al., 2004).

Comprehending lexical signs engages bilateral inferior frontal, posterior superior temporal, and inferior parietal cortices (e.g., MacSweeney et al., 2006; Emmorey et al., 2015). Lexical-semantic processing is associated with neural activity in IFC and posterior STC bilaterally, and lesion studies suggest that left posterior STC is critical for lexical sign comprehension (Hickok et al., 2002). Left inferior parietal cortex (SMG extending into IPS) may be involved in phono-lexical processing during sign comprehension, interfacing between semantic and phonological processing (Leonard et al., 2012; Emmorey et al., 2015). The precise contributions of left IFC in comprehending lexical signs requires further investigation, but there is evidence that this region plays a role in maintaining signs in memory (see also Buchsbaum et al., 2005; Pa et al., 2008). Thus far, there is little evidence that iconicity modulates the neural response during sign comprehension (e.g., Emmorey et al., 2020). However, it should be noted that neither the subjective nature of iconicity (Occhino et al., 2017) nor the different types of iconic mappings (e.g., Caselli and Pyers, 2020) have been taken into account in these studies. Finally, comprehension of both one-handed and two-handed fingerspelled words activates the visual word form area in ventral occipito-temporal cortex (Waters et al., 2007; Emmorey et al., 2015).

Although most neuroimaging studies of signed sentence comprehension find bilateral fronto-temporal activation in

comparison to low-level baselines, studies that specifically target sentence-level computational processes find left-lateralized activation in superior temporal cortex. In particular, posterior STC and the left ATL may be involved in syntactic/semantic integration processes for lexical signs within phrases or sentences (Matchin et al., 2021). Left IFG (particularly BA 44, 45) appears to be a hub in the sentence processing network for sign languages, as for spoken languages, with several possible integrating and memory functions (e.g., Bavelier et al., 2008; Inubushi and Sakai, 2013). Left IFG (BA 45) along with bilateral STS appears to support comprehension of simultaneous morphology in signed sentences (Newman et al., 2010), but right SMG may be recruited to track the direction of agreeing verbs and the location of referents in signing space (Stroh et al., 2019).

Neuroimaging studies targeting comprehension of sentences with classifier constructions indicate involvement of left or bilateral SMG (MacSweeney et al., 2002b; McCullough et al., 2012; Jednoróg et al., 2015; Emmorey et al., 2021). In addition, bilateral SPL is implicated in comprehending classifier constructions that express object locations, and SPL may be particularly involved when signers comprehend perspective-dependent expressions, due to the mental transformation required to interpret spatial locations from the signer's perspective (Emmorey et al., 2021). In addition, motion sensitive regions in bilateral posterior temporal cortex are engaged when comprehending sentences with classifier constructions that express movement (McCullough et al., 2012), as found for spoken language (Saygin et al., 2010).

Overall, the input differences between sign and speech comprehension can be seen, not surprisingly, in the early involvement of occipital (visual) versus superior temporal (auditory) cortices (Leonard et al., 2012). Similar to sign production, parietal cortex (bilateral SMG) appears to be more involved in form-level processing of signs (Cardin et al., 2016), likely due to differences in phonological units (e.g., handshapes and body locations, rather than consonants and vowels). Comprehension of both signed and spoken language engages IFC bilaterally (left > right). Left IFC (particularly BA 44) may serve as central hub in the language network (Liu et al., 2017), while right IFC (BA 45) may be involved in modality-specific processing of human manual and body actions (Trettenbrein et al., 2021). Sentence comprehension for both signed and spoken language relies on left STC, and many studies have now demonstrated a parallel left-lateralized fronto-temporal network for sign and speech comprehension (e.g., Mac Sweeney et al., 2002a; Sakai et al., 2005; Emmorey et al., 2014) (**Figure 2**).

CONCLUSION AND FUTURE DIRECTIONS

In the 60 years since Stokoe's linguistic description of ASL, there is abundant evidence for overlap in the neurobiology of spoken and signed languages, particularly around perisylvian cortex. However, much work remains to understand the specific neural computations that are involved in the production and comprehension of sign languages. Although a given neural region may be engaged for both signed and spoken language, it is possible that the neural computations within that region are not identical for the two modalities. For example, it is possible that posterior superior temporal cortex performs somewhat different computations during sign versus word comprehension. For sign languages, this region might primarily be engaged in accessing lexical semantic representations, while for spoken languages this region may be additionally engaged in mapping auditory-vocal phonological representations onto lexical semantic representations. Similarly, left inferior parietal cortex may be involved in phonological processes for both sign and speech, but may perform different functions due to modality differences in the nature of phonological units.

In fact, Evans et al. (2019) specifically investigated whether the lexical-semantic representations of signs and words overlapped within left posterior middle temporal gyrus (pMTG) in hearing native BSL-English bilinguals. The results revealed that although left pMTG was engaged during both sign and word comprehension, there was little evidence for a direct mapping between signs and words in this region, although neural overlap was demonstrated for the cross-linguistic representation of semantic categories (fruits, animals, transport) in left posterior middle/inferior temporal gyrus. Evans et al. (2019) speculated that the difference in the neural representations of words versus signs could be driven by differences in cascading activation from auditory-vocal versus visual-manual phonological forms. This review agrees with the conclusions of Evans et al. (2019) that we need to rethink the assumption of identical neural processes underlying sign and speech processing and "highlight the unique perspective that sign language can provide on language processing . . (p. 7)."

A comparison of the neural network for sign production (**Figure 1**) and comprehension (**Figure 2**) suggests that left IFG and left SMG are activated for both processes (see also Okada et al., 2016). The precise functions of this dorsal fronto-parietal circuit are unclear, but one possible role is to support lexical selection and the integration of phonological and semantic information. The posterior MTG is also engaged during both production and comprehension, and based on data from spoken language (Levelt and Indefrey, 2004), pMTG may be involved in conceptually-driven lexical retrieval and access, which is more left-lateralized for production and extends into left inferior temporal cortex (for picture-naming tasks). Also parallel for comprehension and production, the visual word form area (VWFA) supports the interface between fingerspelling and orthographic representations, but the nature of this interface requires more research. Superior parietal cortex is also involved in both sign production and comprehension, but likely performs different functions for production (e.g., planning and monitoring articulation) versus comprehension (e.g., spatial analysis of classifier constructions). Overall, the neural networks sketched in these two figures reveal that 1) the "classical model" of brain and language focused on Broca's and Wernicke's areas is woefully underspecified (just as it is for spoken language; Poeppel et al., 2012), and 2) the unique

linguistic properties of visual-manual languages need to be accounted for in a neurobiological model of sign language.

In conclusion, there is clearly much work left to be done. The neural regions that support syntactic production in sign language are largely unknown, and this question is critical given that the nature of syntactic processing may differ for production and comprehension (Matchin and Hickok, 2020). Further, we still know very little about the timing of linguistic processes or the functional connections within the neural networks for sign language. For example, what is the time course of phonological assembly and decoding for sign production and comprehension? How are linguistically-relevant parietal cortices functionally connected with temporal and frontal cortices? The summary **Figures 1** and **2** provided here contain no information about the temporal flow of linguistic information between regions or about how different regions function together. Future neurobiological models also need to account for the nature of the neural computations that are involved in sign language comprehension and production, just as researchers are building models that specify the neural computations for spoken language processes (e.g., Flinker et al., 2019).

There are also open domains of inquiry that are unique to sign languages. We know almost nothing about the neural regions that support the production of non-manual components at the phonological, lexical, or syntactic levels. In addition, almost all of the research reviewed here has been conducted with deaf native signers (i.e., those born into signing families), which constitute only 5–10% of deaf children (Mitchell and Karchmer, 2004). We know very little about how the early developmental experiences of deaf people born into hearing families impact the neural circuits for sign language processing, but see Mayberry et al. (2011), MacSweeney et al. (2008b), and Twomey et al. (2020) for some data on this question. We also know very little about the neural development of systems that support sign language and whether the developmental trajectory parallels that found for spoken language (but see Payne et al., 2019), particularly given the possible effects of early language deprivation on neural structure and function (Hall, 2017; Romeo et al., 2018; Meek, 2020).

In sum, it is hoped that over the next few decades we will enhance and deepen our understanding of the neurobiological foundations of sign language, which will not only provide further insights into the neural basis of human language, but will also provide a translational foundation for treating injury to the language system, for diagnosing language impairment in signers, and for promoting healthy brain development in deaf children.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Cripping the "Delay": Multilingualism-Related Consequences of Re-Labeling Language Deprivation Systems

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INTRODUCTION

The human capacity for communication is both stunningly innovative and resilient. These points are illustrated most effectively by the literature on homesign systems created by deaf and hard of hearing (DHH) children in the absence of usable language input. Goldin-Meadow (2012) specifies that "homesign systems arise when a deaf child is unable to acquire spoken language" due to the inability to hear speech "and is not exposed to sign language" because their hearing family does not know or use any sign language (Goldin-Meadow 2012:602). Homesigns are invariably described as gestural systems built (in part) on the *gestural* component of the language(s) used by DHH children's hearing families. However, among the estimated ~95% of DHH children who grow up in hearing families (Mitchell and Karchmer, 2004), it is likely that some are also able to access elements of the spoken language that are potentially usable for acquisition. The totality of this received spoken language input does not constitute a full, natural language, but it may nevertheless contribute to the child's initial communication system. If so, questions arise as to what exactly this system is, which is neither homesign (at least in the way it has been typically described) nor a natural language (in the way linguists and layfolk typically understand the term), and how such a system influences subsequent acquisition. These questions form the main focus for this article. We consider here the initial communicative systems created by *all* DHH children with adverse childhood communication experiences (ACCE, Kushalnagar et al. 2020), who have also been termed "language-deprived" (Hall 2017), before they acquire an established natural signed, written or spoken language. For the sake of simplified exposition, we refer collectively to these systems as simply the "initial system," a deliberately broad label that encompasses the full range of communicative mechanisms innovated by DHH people in contexts of degraded, restricted and/or delayed language input. Although such initial systems include homesign systems, the two designations are not interchangeable, as the existing literature is unclear on the extent to which all ACCE/language-deprived individuals develop the grammatical mechanisms described by homesign researchers (Goldin-Meadow, 2020).

A clear understanding of the initial system and its impact on subsequent acquisition is critical, given the many disadvantages and highly variable outcomes documented for language-deprived DHH people in the literature dedicated to "late acquisition of first language." Those studies conclude that initial systems do not provide learners with the foundation necessary for "typical" acquisition of the first- or second/subsequent language (L1 or L2/L*n*) (e.g., Mayberry et al., 2018). However, it is worth noting that many of the tasks used to illustrate language and processing disadvantages for ACCE/language-deprived DHH people are highly decontextualized from actual language use. This contrasts with the heavily interactive and contextualized communication styles observed for many

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language-deprived DHH people around the world, through which meaning is co-created between interlocutors, often extemporaneously and with recourse to extra-grammatical mechanisms (Moriarty Harrelson 2017). The recently articulated framework of *Crip Linguistics* (Henner and Robinson 2021) highlights the ableist and discriminatory implications of marginalizing the communicative practices of so many DHH people as "less than language" simply because they do not conform to expectations of languages as used by abled populations. We extend this view to the domain of language acquisition research, arguing that the common designation of language-deprived children's first conventional sign language as their "late L1" and their subsequently learned written language as their L2 prevents us from considering important contributions that their initial system may make to those languages. Recognizing the potential of the initial system as a source of transfer and/or cross-linguistic influence to subsequently learned languages is a crucial step towards understanding the notoriously variable language acquisition outcomes for DHH people (Mayer and Trezek 2020, Henner et al., 2016, a.o.). This approach also offers valuable insights to current theoretical debates, such as the recent discussion over competing models of third language acquisition (L3A), now recognized as quite distinct from L2A (Rothman et al. 2019; Westergaard 2021). Aside from the language architecture-related constructs which make L2 and L3 different, nothing much changes when one steps outside of the L1 domain of theorizing. For instance, it is well-known that L2 education (García et al. 2021 and references therein) and, more generally, the field of L2 acquisition are racialized (see the discussion in Flores and Rosa 2019, a.o.). Much of the same can be said for multilingual (L3+) discourses, see e.g. Cisneros (2019), Alvarez (2018), a.o.). We thank an anonymous reviewer for bringing this point to our attention. Most importantly, systematic examination of the initial system in the ways we describe it recognizes the diverse language practices of *all* DHH people as valid foundations for language acquisition.

Our discussion is structured as follows. In the remainder of this section, we summarize several problems related to the construct known as "late L1 acquisition" and introduce the tools that a Crip Linguistics framework provides for the re-examination of the initial system. In *Theoretical Consequences of Recognizing the Initial System Within the Crip Linguistics Perspective*, we sketch out some theoretical implications of this recognition. Rather than simply being replaced by or subsumed into subsequent languages, we discuss intial systems as existing foundations exerting specific influence on acquisition of L2 (*Consequences for the First Subsequent Language: Child L2*) and L3 (*Consequence for the Subsequent Languages: Child L3*). Finally, we conclude in *Conclusion* with a summary of the issues raised and suggest directions for further research.

Rationale for the "Initial System" as a Construct

A common assumption among linguists and lay people alike is that DHH children raised in hearing, non-signing families do not develop language unless they encounter a conventional sign language and/or have sufficient access to a spoken language (e.g., due to high levels of residual hearing or successful use of technology). In the meantime, these children communicate with their hearing families using systems that they create from the restricted input available to them. These creations have attracted a great deal of research attention but from two very distinct perspectives that appear contradictory. On one hand are descriptions of homesign systems displaying an impressively sophisticated array of language-like features that are innovated by DHH children in the absence of usable linguistic input (Goldin-Meadow 2012; Carrigan and Coppola 2017; Flaherty et al., 2021; Abner et al., 2021). On the other hand are reports of poor language outcomes for DHH adults who experienced delayed exposure to a conventional sign language; these outcomes are attributed to an initial communication system that was too impoverished to fully support subsequent language development in either modality (Mayberry and Eichen, 1991; Deng and Tong 2021). How could such seemingly opposing characterizations of DHH children's communicative practices both be true? Do they represent the extremities of a broad spectrum along which DHH children naturally fall? Or two distinct developmental stages through which DHH children pass as they grow older (Morford and Hänel-Faulhaber 2011)? We take the ambiguity above as our point of departure and argue that a systematic investigation of the full range of communicative mechanisms innovated by *all* DHH people is crucial for an accurate characterization of their subsequent language learning.

Let us consider, for instance, the "late L1 signer/learner" designation commonly applied to DHH individuals who experience delays in childhood language input, and the concurrent assessment of their initial system as an inadequate foundation for "typical" acquisition of a first- or second/subsequent language (L1 or L2/L*n*) (Mayberry and Kluender 2017). Decades of research have repeatedly documented the negative effects of degraded and/or delayed language input on DHH children's linguistic development and the persistence of those effects into adulthood (Mayberry and Eichen 1991; Newport, 1990, i.a.). Cases DHH children who receive neither early exposure to any conventional sign language nor sufficient access to the spoken language(s) of their family environment for L1 acquisition remain troublingly commonplace. Some of these children eventually encounter and acquire a conventionalized sign language, a process typically commonly described as *late L1 acquisition* (e.g., Mayberry 2007). Developmental outcomes in the context of late L1 acquisition are notable in two respects: because such individuals all endure some degree of adverse childhood communication experiences (Kushalnagar et al., 2020)/language deprivation (Hall 2017), which has been shown to correlate with poorer performance on experimental tasks involving language and processing, outcomes are 1) variable, and 2) they diverge notably from "typical" L1 outcomes of children with early and abundant access to language input, displaying differences that persist even despite extensive exposure to accessible language later in life.

The late L1 acquisition construct has also been useful for distinguishing the wide-ranging, persistent differences observed for late-exposed signers from the more "mundane" L2 effects observed for sign language learners who have a well-established L1. However, this designation also raises important questions that

have not been sufficiently addressed in the psycholinguistics literature. Chief among these is the role played by whatever resources the child initially brings to the task of language learning, e.g., the varied combination of signs, gestures and/or spoken words that many DHH children from hearing families develop in subsequent acquisition of a signed language (e.g., in the case of belated exposure to a signing community) and/or a spoken language (e.g., after activation of a hearing aid or cochlear implant); see, for example, the discussion in Kusters (2021) and references therein.

Yet, the notion of a late L1 signer reflects the traditional view that this initial system is not itself a language, so its development is not considered language acquisition. Accordingly, Mayberry and Kluender (2017) write, "In the absence or paucity of prior spoken language development, a deaf child's first exposure to a sign language marks the initial onset of language acquisition, albeit at a late age" (p. 6). Even well-developed homesign systems created by DHH children before encountering a conventionalized sign language are described as "[containing] many, although not all, of the properties of natural language" (Goldin-Meadow 2020:196), qualifying them as being *language-like*, but not actually *language*. Across the psycholinguistics literature there is a collective but implicit assumption that whatever the DHH person developed initially is simply subsumed into a sign language once they are exposed to that language, and the original system ceases to exist. Yet this is not at all how we as a field conceive of linguistic development in any other acquisition context. Instead, we carefully document the processes by which systems that existed beforehand influence those which develop subsequently. Why shouldn't we do the same for the initial systems? We submit that no matter which language properties these initial systems may lack or how much they may diverge from "typical" L1 systems, they are nonetheless actively created by DHH children to serve the linguistic function of meaningful communication and as such, potentially contribute to and participate in subsequent acquisition processes in the same way that conventional languages do.

As language acquisition researchers we have an empirical responsibility to thoroughly investigate this proposal. Doing so in no way diminishes the reality of language deprivation and the unacceptable burdens it places on DHH children. Rather, it recognizes the linguistic adaptations that these children create in contexts of sub-optimal language input and explicitly acknowledges their role in subsequent language learning. In fact, we suggest that continuing to dismiss the initial system contributes to an ableist framework common in scientific research. In contrast, according serious empirical attention to the initial system of ACCE/language-deprived children and recognizing its potential influence on subsequent language learning could offer valuable insight on the variability in linguistic outcomes for DHH people that have proven so difficult to explain otherwise.

A Crip Linguistics Perspective on the Initial System

The view of DHH children's initial system articulated above fits well with the framework of *Crip Linguistics*, introduced by Henner and Robinson (2021). This framework highlights the linguistic adaptations innovated by disabled people and the collaborative, multimodal nature of language that is created by and used among disabled individuals. Henner and Robinson urge researchers "to assume that *all* people are competent co-participants in constructing meaning" (p. 13, emphasis ours), no matter how much their language systems may diverge from "typical" norms. The authors challenge the fundamental dichotomy of typical vs disordered/atypical language discussed in fields such as linguistics, psychology, speech pathology and education, arguing that standards for optimized, typical language actually reflect normative expectations of the abled majority. The most relevant of these expectations to the current discussion are listed in (1).

1) (a) language develops spontaneously along the timeline typical for abled people with unfettered access to linguistic input
   (b) meaning is conveyed through linguistic resources (through a traditional lexicon, grammar, etc.)
   (c) communication between people is "quick, efficient, and spoken" (p. 23).

As we discuss below, none of these characteristics are generally associated with DHH children's initial systems, contributing to their exclusion from language-hood in the existing literature.

Henner and Robinson (2021) challenge the notion of anyone's language as "bad" or intrinsically disordered. They concede that language may *become* impaired as a result of environmental conditions such as language deprivation, but rather than focus on those impairments, Crip Linguistics emphasizes the many competencies that language-deprived individuals display in innovating the "flexible accumulation of languaging practices and modalities" (Moriarty-Harrelson 2019) 1) that constitute the initial systems of many DHH people. These "languaging practices" involve extensive *linguistic care work* between interlocutors (2).

2) Linguistic care work is the time taken in being patient, in supporting and providing semiotic resources, in seeking, expanding, and claiming our own semiotic resources, in calibrating to each other in seeking mutual understanding. This is not only language work but care work through languaging in being invested in collective access and belonging to create and provide optimal environments and material conditions for language (and mutual understanding) to take place. (Henner and Robinson, 2021: 25)

The communicative resources recruited during linguistic care work can extend well beyond the grammatical mechanisms traditionally recognized as "language." For instance, Moriarty Harrelson (2017) documents the communicative practices of deaf Cambodian adults considered (sometimes even by themselves) as having "no language" prior to learning one of the national sign languages in Cambodia. To communicate with those around them, these deaf Cambodians use gestures, text and signs, but also creatively incorporate graphic resources (e.g., drawings, emoticons, and maps) and technology (e.g., calculators for haggling over prices at the market), practices that contravene expectations (1b) and (1c) by being "non-linguistic," time-consuming and requiring patient engagement and multiple

exchanges between interlocutors. Yet, if these multimodal, collaborative interactions are ultimately effective in achieving mutual understanding, there must be some linguistic mechanisms underlying these practices. Translanguaging researchers have variously discussed such mechanisms in terms of 'sense making' and semiotic repertoire assemblage, which are characteristically 1) distributed, 2) individually evaluated, 3) contingent on access as well as self-conceptions, and 4) unstable and, importantly, have also been argued to be part-and-parcel of communication strategies of spoken language communities unaffected by language deprivation (see Kusters 2021 and references therein). For language acquisition researchers, the mechanisms underlying language care ought to be particularly interesting. They represent the initial system developed by language-deprived DHH people, and it is reasonable to ask how they are maintained and how they shape development of Cambodian Sign Language or any other language that these signers subsequently encounter. Crucially, however, while these systems *shape* the subsequently acquired languages, there is no good reason to assume that they actually *become* these languages, somehow morphing into their L1, albeit slowly (and typically not fully successfully). In the next section we articulate some specific theoretical consequences of recognizing the initial system as one which persists into and is active during subsequent language development.

THEORETICAL CONSEQUENCES OF RECOGNIZING THE INITIAL SYSTEM WITHIN THE CRIP LINGUISTICS PERSPECTIVE

As noted in *Rationale for the "Initial System" as a Construct*, the psycholinguistics and language acquisition literatures are notoriously vague and even contradictory in their characterization of what we have labeled the initial system. On the one hand, there is a robust literature detailing the linguistic complexity displayed by homesigns: the existence of lexical items, morphemes, and hierarchically organized structured strings/sentences with distinct word-order patterns, if not specific grammatical constructions (Goldin-Meadow, 2020). These linguistic patterns are not attested in the gestures of hearing family members, indicating that they were innovated by homesigners rather than acquired from input (Carrigan and Coppola 2017; Flaherty et al., 2021, i.a.). Such findings are powerful testimony to the resilient human ability to create certain grammatical subsystems even in the absence of those systems in the linguistic input. At the same time, several studies demonstrate that, despite all of the internal complexity, homesigners often fail the main goal of the task: successful communication hearing family members. In contrast, DHH signers of *other* sign languages can comprehend homesigner's discourse (Carrigan and Coppola 2017), perhaps DHH interlocutors more readily engage in the "care work" essential in crip linguistics and familiar to DHH people worldwide. Thus, despite input deprivation, a linguistic system emerges spontaneously after all [as in (1)]; "care work" [as in (2)] is required, but a question arises whether and in what form such "care work" must take place, and to what extent it is affected by factors outside of the narrow definition of "language".

On the other hand, even when homesigners are subsequently exposed to an established sign language, their development of that language has been argued not to resemble that of typical L1 or L2 learners (e.g., Slabakova 2020), despite similarities of their homesign system to established languages (Morford and Hänel-Faulhaber 2011). Morford et al. 1997) demonstrate this point through a direct comparison of classifier verbs elicited from the well-known homesigner David both before and after he began acquiring ASL in his late teens. The grammatical sophistication of David's homesign system is particularly well-documented (Morford and Goldin-Meadow, 1997; Hunsicker and Goldin-Meadow 2012; Cartmill et al., 2017), including his systematic use of certain handshape classifiers to represent objects with specific sizes and shapes (Goldin-Meadow et al., 1995). Yet, despite the impressive homesign system he had created as a child, which included mechanisms for encoding different types of objects through handshape, David's subsequent acquisition of this aspect of ASL was not more successful than that of other deaf late-learners (Newport, 1990; Mayberry, 1993). Indeed, Mayberry and Kluender (2017) explicitly conclude that the performance of late-exposed signers on grammatical tests in their first conventional sign language indicate that "homesign does not function as an L1 for the deaf child" (p. 10). We consider this to be a pre-mature conclusion.

The prolific "late L1 signer" literature documents significant disadvantages for ACCE/language-deprived deaf signers on various linguistic tasks, compared to deaf and hearing people who had the benefit of an early-established L1 (Mayberry et al., 2002, Ramírez et al., 2013 Mayberry 2007, a.o.). Yet the observation that homesigner's subsequent development of a signed or spoken language does not resemble "typical L2 development" in those languages begs the question of *how* that development is being shaped by the initial homesign system. Today's language acquisition literature is rich with analyses for examining cross-linguistic influence and transfer, yet application of these models to DHH people's initial systems is virtually nonexistent, blocked by the assumption that only formal/classically acquired linguistic systems (a.k.a. "languages") exert grammatical influence on subsequent language learning. In Morford et al.'s (1997) comparison of David's homesign and subsequent ASL production, his overall scores on the verbs of motion test were low, but accuracy in selecting the appropriate handshape for a given classifier depended on whether David's homesign repertoire had an established handshape for representing that particular object type. If it did, the handshape production in the elicited production task was more accurate, even if his homesign handshape differed from the conventional ASL handshape for that object. Morford et al. conclude that although David's homesign system did not allow him to acquire ASL more successfully than other deaf late-signers, David's homesign acted as a source for transfer of some handshapes from his homesign to

his ASL, in much the same way a conventional previous language would.

Morford et al. (1997) demonstrates the great potential for longitudinal examination of interactions between homesign and subsequently learned conventional language(s), but to date there are very few such studies. We propose that for practical purposes (and theoretical ones as well, as we will see), the initial system that an ACC/language-deprived child creates serves as an existing foundation on which any subsequent language is built, whether signed or spoken, or both. Whether that initial system displays sufficient linguistic sophistication or systematicity deemed a "proper language" does not diminish the fact that this system has been created by the DHH child to serve the purpose of language and displays properties of conventionalized languages. As such, a comprehensive investigation of that DHH child's overall language development should include consideration of how that initial system contributes to subsequent language acquisition. Explicit examination of this interaction can tell us if cases typically discussed as late L1 acquisition are actually more akin to L2 acquisition, displaying errors in the L2 grammar that are traceable to features of the child's initial system. Likewise, cases typically categorized as DHH signer's L2 development (most commonly of written language) may actually be instances of L3 acquisition. L3/L*n* acquisition is rarely discussed in the context of sign language users of any category (either deaf or hearing), but recent recognition of the prevalence of multilingualism among signers (Guiberson and Crowe, 2018; Zeshan and Webster 2019) suggests that the L3 literature offers useful tools for new insights on what is currently discussed as homesigner's second language learning of a spoken or written language.

Let us summarize in the interim. Within the framework of Crip Linguistics, we have argued directly why cripping "late acquisition" is necessary (3 and 4 below). (5) and (6) then follow.

3) Any child who has been deprived of a natural language input is expected to create a communicative system that recruits multiple modes of sense-making, i.e., it is multimodal.
4) This system (which we have provisionally labeled the "initial system", although it should be named and elaborated, given how many people begin their communicative lives with it) needs to be taken seriously by researchers in terms of structure. We should turn to the exploration of this system in *all types of cases* because it has ramifications for subsequent language development.
5) Despite immense individual variation, the initial system is the first building block of communicative intent on which all subsequent language learning will rely for language-deprived DHH children; accordingly, the field of language acquisition should be applying constructs associated with L1 development to it directly.
6) All of the *other* and, in particular, *subsequent* languages of the learner should thus be considered L2, L3, . . . L*n*.

In particular, 6) emerges from the epistemological conundrum of inaccurate labeling (vis-a-vis cognitive success, e.g., in Schurz, 2014 and references therein), as well as a growing L3 acquisition literature that raises additional problems with treating a learner's linguistic system as an L2 when it is in fact their L3. We proceed to that point next.

CONSEQUENCES FOR THE FIRST SUBSEQUENT LANGUAGE: CHILD L2

Theorizing about multilingual experiences necessarily involves considerations of language minoritization, since s languages, even national ones, are minoritized (De Meulder et al., 2019). This phenomenon is, unfortunately, well documented in the literature, as are its effects on multilingual language acquisition. Skutnabb-Kangas and colleagues (see Skutnabb-Kangas 2020 for an overview) have argued that linguicide is commonly committed against indigenous and linguistically minoritized communities. According to these authors, removing the indigenous language from the indigenous person also results in language deprivation as the majority language tends to dominate not only language attitudes but also acquisitional trajectories of the children who are surrounded by it. Here, however, the parallels between hearing and DHH children end. Hearing children always have the dominant language of the community to turn to for communicative functions (though often at the expense of linguistic and cultural loss associated with their L1), which they often acquire (near-)natively. Matters are potentially different for DHH children: even with additional training and/or augmenting technology, (full) access to this majority language and, thus, native(-like) acquisition remains out of reach. But if what they *do* acquire is not a L1 as typically defined, then what is it? We explore this question in more detail for the context of DHH children who have experienced language deprivation, but the general process should hold for spoken languages as well.

On any theory of multilingualism (simultaneous or sequential), a language learner is expected to demonstrate language interaction, to which we have already alluded in our discussion of David (Morford and Goldin-Meadow, 1997). The typical approach to such interaction is conceptualized as transfer and/or cross-linguistic influence between languages (Vainikka and Young-Scholten, 1996, Eubank 1993, Platzack and Clahsen 1996, White 1989, Schwartz and Sprouse 1996; Hulk and Müller, 2000, a.o.). The specific systems that should be expected to transfer to/influence subsequent language learning varies from case to case. For a DHH child of deaf parents they will likely acquire a sign language first, which will interact during (pre-) school ages with the written (version of the spoken) language they then acquire as L2. This situation is replicable for a DHH child of hearing parents placed at a very young age into a sign language-based early intervention program (Sass-Lehrer 2014). However, the reality is different for the vast majority of DHH children who do not receive natural language input before they begin school (ages 3.5–8). While researchers studying DHH L1 acquisition might still consider children in this age-range as "early acquirers" (Mayberry 1993; Cormier et al., 2012), the same cases would be categorized by many L2 acquisition researchers as *child L2 acquisition,* which begins at approximately 3–4 years of age (Schwartz, 2004; Unsworth 2005; Meisel 2008; Chondrogianni et al., 2018) and ends before age 7; 0 (Abrahamsson and

Hyltenstam, 2009; Meisel 2013). The child L2 literature also tracks effects of the quality of input (Chondrogianni and Marinis, 2012, Paradis 2011) especially when caregiver fluency in the L2 is low (Hammer et al., 2014), protracted "default" acquisitional patterns are involved (Hulk and Cornips, 2006), and asynchronous development occurs in different domains (e.g., significantly quicker learning of phonology than vocabulary and morphosyntax; McCarty 2013; McCarty 2014). In other words, the child L2 literature offers immediately applicable predictions for the majority of DHH children's language acquisition, once we are explicit about the role of their initial system.

We should thus be open to considering the pre-school learning of a natural sign language by DHH children who are not exposed to that language from birth as potential cases of child L2 acquisition. For instance, Cormier et al. (2012), indicate that age of acquisition effects in prelingually DHH signers from hearing families exhibit several of the aforementioned effects between the ages of 2–8, just as predicted by the child L2 literature. The authors report that prelingually DHH signers from hearing families (whom they categorize as *early learners,* distinct from *native signers*) exhibit age of acquisition effects in their grammaticality judgments on their first sign language (British Sign Language/BSL). In particular, among the 2–8 year-olds, 1) age of acquisition correlates with more target-like performance on the grammaticality judgment task, 2) younger children perform more target-like on some grammatical structures but not on others, demonstrating the aforementioned "asynchronous development". According to the authors, 2–8 year-olds exhibit a growth effect, in contrast to other groups. We expect the early learners in Cormier et al. to *eventually* settle on the native-like BSL patterns in several domains (rather than performing immediately in line with child L1, adult L1, or adult L2 norms, Chondrogianni et al., 2018; Unsworth et al., 2019, a.o.), a prediction that arises from the child L2 literature. This research also shows "richness of L2 input" *vs*. proficiency to be crucial in predicting target structures. Note that, in the case of signers, research has leaned towards the same conclusion (Holcomb et al., 2021; Lieberman et al., 2021, and references therein). Following this line of argumentation, we can also expect some direct outcomes of different languaging distributions in child L2 configuration, such as have been reported by Puskás 2017 for young children learning Swedish as child L2/L*n*. This study shows that what Henner and Robinson label "care work" may be reformulated as "high level of trust between children and their teachers" (Puskás 2017:313).

In turn, as we have argued, we can test the null hypothesis that the previously unnamed initial system of the majority of DHH learners will participate in subsequent language learning in the manner observed for child and adult L2 (see Unsworth 2005 for extended discussion). In our examination of linguistic patterns of any multilingual learner we should expect to encounter structures that come from a system *other than* the signed (e.g., ASL) or spoken/written languages (e.g., English); namely from what we have thus far been calling the initial system. In this way we remain open to attributing language interaction effects to that initial system, in addition to acquired signed or written/spoken languages.

CONSEQUENCE FOR THE SUBSEQUENT LANGUAGES: CHILD L3

We have articulated our position that the *first subsequent* language beyond the initial system of a ACCE/language-deprived DHH person will not *become* a ("delayed") L1, but rather should be considered as a child L2, a theoretical construct with its own predictions for development and mastery across modules. We now move to the next language of the learner which they are likely to be learning in school *as an L3*. This language may be either signed (especially if the L2 was a spoken one, developed through intensive auditory training and/or utilization of various technologies) or written, reflecting the dominant language(s) of the country: e.g., Spanish in Spain, Japanese in Japan; and so forth. Because the tenets of L3 acquisition are new to many language researchers (including ourselves), we first offer first a brief overview of the basic concepts we consider the most relevant to the current discussion.

L3/L*n* research is a fairly young field just over 15 years old or so, rooted in the L2 theoretical frameworks but with a strong contribution of its own, engaging several types of audiences. As we understand it, the main foci of this field are 1) the sources of interaction between the languages of the multilingual, and 2) the details of this mechanism. While these questions belong to the domain of L3 theorizing proper, we argue that sign language acquisition research offers potential answers where spoken language research falls short. Principally, theoretical models of L3 acquisition are modality independent; it should not matter whether the third language is signed or spoken, and whether learners access it via the aural/oral, visuo-gestural, or even print channels.

Despite the relative youth of the field, several L3 theories have been articulated that distinguish between contributions of the learner's previous linguistic systems to cross-linguistic interaction. A few of the most prominent theories are listed below.

7) A selection of L3 theories describing contributions of a previously-acquired language:
   (a) L1 (Jin 2009, Na; Ranong and Leung 2009; Hermas 2014).
   (b) L2 (Bardel & Falk 2007).
   (c) L1+L2 (Cumulative Enhancement Model, Flynn et al., 2004; Scalpel Model, Slabakova 2017; Linguistic Proximity Model, Westergaard et al., 2017)
   (d) L1 *or* L2 (Typological Primacy Model, Rothman 2011).

These theories all rely on the previous linguistic experiences and, thus, make strong predictions about the contribution of the initial system with which most DHH children begin their linguistic journey. For the models in 7), whichever new language is being acquired is simply expected to be affected by the initial system, though *how* and *to what degree* remain a matter of debate.

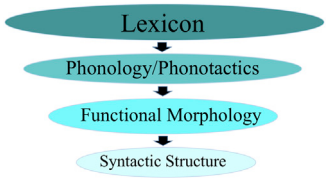


FIGURE 1 | | Implicational hierarchy of input cues Adapted from (Rothman et al., 2013; Rothman et al., 2015).

A contested issue in L3 acquisition literature is whether to characterize the mechanism of language interaction as transfer/cross-linguistic influence, or more accurately, whether the two are independently attestable (RSherwood-Smith (2017)). For instance, Rothman et al. (2019) refer to *transfer* as literally a "reduplication of a representation from previously acquired linguistic representations," a "copy" of the grammar of a previously acquired language. In contrast, cross-linguistic influence is a temporary "bleeding" of one language into another (p. 15). On this approach, transfer occurs only at the initial stage of acquisition, when the learner, or rather, the learner's linguistic mind, first "decides" which language to (fully) copy (Schwarz and Sprouse 1996). That is, *transfer* happens only once and affects the entirety of the grammar ("wholesale"). The use of the term by Rothman et al. (2019) is literal. In turn, for Slabakova (2017) and Westergaard (2020, 2021) "(full) transfer" is a metaphor; "transfer" itself does not exist *per se*. Instead, cross-language interaction occurs due to co-activation of all of the languages of the multilingual and is expected at several junctures. Under this view, L3 learning is incremental, proceeding "property-by-property," regardless of the order of acquisition of the previous languages or (psycho-) typological similarities between languages. The only requisite context is input that co-activates shared structures in the previously acquired languages (Westergaard 2021). We do not currently know of any work exploring the application of any of these models to DHH children with delayed input to natural language, but let us consider what such research might look like. Here we focus on two recent models for reasons of exposition, but similar argumentation can also be applied using other models.

The Typological Primacy Model (TPM, Rothman 2011, et seq.) argues that at the initial encounter with L3, the parser (a "grammatical analyzer" or sorts) "makes a decision" based on a psycho-typological assessment of similarity between the L3 and the learner's L1 and L2. The parser "ranks" contributions of similarities according to a set hierarchy: lexical items > phonology > morpho-syntax. This sequence is shown in **Figure 1**, adapted from Rothman et al. (2015).

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Let us illustrate with a hypothetical example of a DHH native signer of Catalan SL (LSC) whose (child) L2 is Spanish Sign Language (LSE), and who has just embarked on L3 acquisition of ASL. The first assessment their parser makes is to check whether they recognize (or rather, *think* they recognize) the same signs in ASL as in LSC (L1) *or* LSE (L2). If the answer is "yes" for either LSC or LSE, then exactly (and only) that language will become the source of transfer; that is, a copy of the grammar of that language will serve as the starting point for L3 development of ASL. If neither the LSC nor the LSE resembles ASL on a lexical level, the parser will turn next to phonology. If the phonological patterns of one of the learner's previous languages are perceived to be more similar to those in ASL, then that previous language will become the source of transfer. However, if no such perception is obtained, the parser turns to evaluating morpho-syntactic similarity.

Now let us apply this analysis to a more common DHH learner, who experienced delayed exposure to a sign language (say, LSE), typically (though not always) before approaching a spoken language. This is the first place where the TPM requires further elaboration. What immediately complicates matters is whether this learner has had any amount of input in spoken Spanish, through residual hearing or training, that is usable for construction of a Spanish grammar, albeit clearly a different one from "standard Spanish." If the answer is "yes", we expect this new system produced by the learner to also include co-speech gesture. If the gestural system underlying homesign and L3 Spanish correspond, then we should expect the parser to consider this lexicon, and the evaluation procedure should proceed very similarly to what we articulated above for the LSC/LSE learner of L3 ASL, where all of the languages were in the same visuo-gestural modality. By the same token, the parser "sees" and considers the phonology of the co-speech gesture associated with Spanish. If that phonology is not deemed similar enough to that of a previous language, the parser then considers the morpho-syntax of Spanish against the initial system and the L2 LSE. If the syntax of this initial system *appears* closer to what is observable in Spanish, we should expect to see evidence of transfer from that system rather than from LSE in the Spanish of language-delayed DHH learners. The crucial question thus is whether access to spoken input/speech (in any amount) was a part of the child's initial system. An affirmative vs. negative answer to this question leads to direct predictions for whether the grammars in each of the modalities will be considered by the parser as the source of transfer.

Another concrete example: for a DHH child growing up in a hearing environment with *no* access to sound, the initial system typically consists of 1) pointing, 2) lexical items that are iconic, invented by the child to be understood (but not necessarily used) by the caregiver(s), and 3) gestures borrowed from the co-speech gestures used by the caregiver(s) (Goldin-Meadow, 2007; Torigoe and Takei 2002, a.o.). Let us imagine such a child growing up in a Spanish-speaking household, having established what we have been calling the initial system for communicating with the family that is directly label-able as "homesign," learning a sign language in an intervention program (e.g., LSE), and now attempting Spanish (potentially spoken and also written). What will the parser do in this case? We assume that the parser does not decide based on modality, but does it do so based on iconicity? For instance, sets (a)-(b) above offer predictions related to this particular characteristic of sign languages, which has not yet been discussed in the spoken language theories of L3 acquisition, but one can imagine how such argumentation would proceed

(Sanchez 2019). Otherwise, the sequence of evaluation proceeds as before, with the parser evaluating for similarity based on psycho-typology, starting at the lexical level, followed if necessary by the phonological then morpho-syntactic levels. The "winner" of that comparison becomes the source of transfer for Spanish.

However, another complication arises, associated with a common educational practice of placing the "spoken words on the hands" (Gustasonn et al., 1982) through sign supported speech (SSS) or invented signed systems. This practice arguably creates an acquisition problem for the learner because it is neither 1) a sign language, since it violates basic structural principles of natural sign languages, 2) a spoken language, since it is not spoken and because it omits a variety of morphological components that are part of the spoken language, nor 3) homesign, since homesign is a communicative system devised by the learner based on gestures of the community while SSS are invented by educational authorities. Yet, SS is precisely the strategy often used for instruction of the written language for the DHH children. In this situation, identifying the source of transfer should proceed as described above, but given the artificial nature of invented sign systems, it is less obvious to us where the parser will find sufficient overlap between the previous languages and the written L3.

An interim conclusion arising from Rothman-style (2011) theorizing is that DHH signers who received a natural sign language early and therefore bypassed "the initial system stage" will move reasonably seamlessly into learning of another sign language, in that we expect to see run of the mill L1/L2 transfer at the initial approach to L3. In contrast, children who experienced language deprivation in childhood and thus had to create an initial system for communication will entertain either this system (as designated L1) or an actual sign language (as L2) when they approach an L3, be it spoken/written or signed. If the L3 is spoken/written, perceived similarities between the initial system and L3 may outweigh the similarities between the L2 and L3 in the creation of the new grammar; restructuring of the newly copied grammar will follow.

In contrast, models that feature grammatical representations growing in real time, such as Westergaard et al., 2017 Linguistic Proximity Model, abandon wholesale transfer, relying instead on the parallel activation of previously acquired languages. In the words of Westergaard (2021) "any property can be shared but what is actually shared will depend on the outcome of competition between candidates." On Westergaard's model: 1) the learner first scans her previous grammars; 2) if she finds corresponding structures, they are activated; if she does not, she resorts to universal grammar (UG). In this system then, nothing "transfers"; rather, cross-linguistic effects arise due to co-activation of shared structures. This particular feature of the model makes certain prediction for DHH learners of other languages: on the one hand, it highlights the "instability/variability typical of early L3 grammars" prior to "setting"/stabilization (Westergaard 2021); on the other, it suggests that depending on the modality of the languages involved, the pre-stabilization stage may be protracted due to reduced inhibition/coactivation.

As before, we illustrate the workings of this model by starting with a simpler, albeit less typical, case of a unimodal L3 learner with LSC as their L1, LSE as their L2 and ASL as their L3. At various points during the acquisition stage, upon encountering new data-points in ASL, the learner is expected to scan her LSC and LSE grammars, building ASL representations in real time out of the candidate representations that win among the competitors. The same prediction holds for cases when the L1 is an initial system rather than a conventional sign language. That is, if at any point the representations in the initial system and the L3 are shared, the linguistic mind of the child will adopt that representation for the L3. Further, we expect that the DHH learner with access to a written or spoken language will engage in the inhibitory processes to a different extent (Dias et al., 2017, a.o.). Effects on the learner's comprehension/production of the written (and spoken) language should follow. Thus, similar to the research on bimodal *vs.* unimodal bilinguals (Lu et al., 2019; Schaeffner and Philipp, 2020; Kaufmann et al., 2018, i.a.), research on unimodal vs. bimodal L3A learners should produce different patterns of acquisition, at least under the Westergaard (2021) model. Finally, to date, L3 literature has not yet arrived at a final measurable conclusion as to whether any contributing language is ever fully abandoned/discarded after transfer into L3. This type of "abandonment" is well-known as language attrition (Schmid 2011). The process remains under empirical scrutiny (see various resources at https://languageattrition.org/), with the current conclusion being that it is unlikely to completely "erase" the L1 from the mind of the learner (cf. Bayram et al., 2019; Westergaard 2020). We thus predict something similar for the initial systems: despite the many developments of the communicative strategies and practices, what we have called "the initial system" is expected to persist in the linguistic mind of the learner, yet may subsequently be subject to attrition at various junctures.

We hope the introduction to the L3 models of acquisition outlined above demonstrates the concrete predictions they offer for examining the contribution of the initial system to DHH children's subsequent language development. In return, including DHH learners in L3 research has potential to not only test the models themselves but also increase their empirical coverage. Thus, irrespective of one's theoretical allegiances, we believe that the fields of L3 acquisition, Deaf Studies and sign linguistics stand to mutually benefit from this new line of inquiry. As originally advanced in Morford et al. (1995) (and discussed in *Theoretical Consequences of Recognizing the Initial System Within the Crip Linguistics Perspective*), we should expect a variety of properties from a child's homesign to surface in their subsequent languages but with the following amendment: only to the degree that the parser finds appropriate. Rothman (2011, et seq.) predicts that the initial stage of L3 acquisition will involve wholesale transfer of one of the previous linguistic systems (i.e., the homesign system or a subsequently acquired language), which will subsequently undergo restructuring to match L3 input. The decision of which system will be copied lies solely with the parser and is based on psycho-typological (learner perceived) proximity of a previously acquired language to the target L3. In contrast, according to Westergaard, the linguistic mind of the learner may "transfer"

some but not all parts of previous languages to the target L3, offering a promising (albeit currently hypothetical) behavioral account for why DHH learners exhibit such variable outcomes in their subsequent language acquisition, particularly with regard to spoken language(s) and literacy (Crowe and Cupples, 2020; Scott et al., 2021, and references therein).

Another set of predictions directly arising from the L3 literature is neurolinguistic in nature: to the degree that the initial system is usable by the parser as the "L1", it will be co-activated during L2 and L3 tasks (Westerdgaard 2019; et seq). Until now, we have set aside any questions that can be broadly construed as "language and brain," although of course such questions are critical in theorizing about language of the population under discussion, as has been argued before (Mayberry and Kluender 2017; Twomey et al., 2020; Cardin et al., 2020, a.o.). We have focused on the language itself, and the practices associated with it, both on the part of the signers, their caregivers, and crucially, the researchers examining them. However, our approach to the initial system within Crip Linguistics suggest that we should see the presence of this system in empirical works probing multilingual neural networks in various domains (Emmorey et al., 2020; Hofweber et al., 2020, a.o.). This brings potential advantages (for the disambiguation among the L3A theories) of multimodal *vs.* unimodal ways of languaging. Theories which rely on co-activation of structures in both languages (Westergaard) *vs.* incremental restructuring of the grammar (Rothman) offer explicit predictions for DHH learners whose initial system may contain certain *representations* for spoken/sign languages. In addition, research on sign languages in general and languages of the DHH, with and without initial system experiences, can enrich the predictive power of models of L3 acquisition: currently, these models all assume "native language knowledge," although both Rothman and Westergaard and colleagues have published extensively on bilingual acquisition by Heritage Language learners and have made strong claims about "nativeness" of such systems, as well as their (in)compatibility with other varieties of the same languages (see, Lohndal et al., 2019, a.o.). Yet, in their discussions of L3 acquisition, both authors (and colleagues) assume the inherent complexity of the system. The question, however, is whether this complexity is necessitated by either of the theories. In principle, it is not, which harkens to the discussion of the core properties of language in Lohndal et al. Thus, the homesign/initial system data challenge the L3 theorists to the same question: are there minimal requirements for the initial system before it can be expected to participate in L3 processes? Today, this is an empirical question that deserves careful examination.

There are many potential consequences of our proposed re-examination of labels, as well as an important caveat: the simple fact that the initial system is utilized/utilizable for language acquisition does not imply that it *ought* to be utilized. Existing research has so clearly demonstrated the importance of early access to natural language input for healthy development in so many domains (not only language, cognition, and education, but also physical, emotional and mental health; Hall 2017) that depriving children of natural language input has been rightfully labeled a violation of human rights (Skutnabb-Kangas and Phillipson 2010, i.a.). Given the very well-documented harms of language deprivation on DHH children's development, Henner and Robinson (2021) concede that it may still be accurate to label the initial systems developed in the face of such deprivation as *impaired*. Such a system will not be the optimal foundation for subsequent language acquisition, yet for reasons that we have outlined above, it may still end up transferring to L2 or L3. In cases where a DHH encounters an invented sign system, perhaps at school in conjunction with a written language, the very fact that such a target is artificially constructed makes it less acquirable than natural languages (Supalla and McKee, 2002). Therefore, the learner could find themself facing the following dilemma: their "designated L1" is a system that is itself not a full-fledged natural language and does not serve all the same linguistic functions of natural languages, and their potential L3 is an artificially constructed system that is also not a natural language, but rather a representation of a natural language. Further, as soon as the L3 moves to orthography (i.e., off the hands), a new problem arises: new learning must be accomplished, an additional learning task for the language user who began with an "incomplete" system and whose L3, as it has been represented until now, is not a natural language. It is no wonder that a variety of complications arise. In our view, however, these complications are all the more reason to pursue this line of work, both from theoretical (e.g., Crip Linguistics, L3/L*n*) and applied perspectives (e.g., Deaf Education, L2 teaching, etc.).

CONCLUSION

In this paper we re-examined the well-established notion of "late L1 signer" and the attendant assumption that language-deprived DHH people's initial system is not a language, and thus does not participate in processes of language acquisition (L1 or beyond). We hope to have illustrated instead that initial systems (including homesigns) used for building subsequent languages are part and parcel of the linguistic experience of the majority of DHH people. Thus, we advocated for the explicit examination of the initial system of *any* DHH child who does not receive timely linguistic input. Offering arguments from various angles, we alluded to the fact that there may not be any principled reason to contrast *homesign* systems as traditionally used in descriptions of communicative practices of Nicaraguan, Turkish, Taiwanese, and American ACCE/language-deprived children (Goldin-Meadow 2020; Flaherty et al., 2021) and the initial systems—communicative strategies of other DHH children who are born to hearing families and grow up without exposure to a sign language.

Throughout the paper, we have covertly suggested that like established sign languages, initial systems may be argued to be categorical insofar as homesigns may be argued to be categorical. This, of course, remains an empirical question. We have argued that systematic examination of the mechanisms by which DHH people's initial system (including homesigns) shapes subsequent language learning through transfer and cross-linguistic influence

is not only theoretically important, but also consistent with the call by Henner and Robinson (2021) to "crip linguistics" in order to "reintegrate languaging with all bodies" (p. 4), not just those fortunate enough to have received early access to a natural language. We hope to have illustrated the connection between the topic of our examination here and the main theses of Henner and Robinson, summarized below:

8) 1 A Crip Linguistics is necessary for analyzing human languaging, lest we reproduce inequities.
2 A Crip linguistics recognizes that languaging is multimodal.
3 A Crip linguistics embraces disabled ways of being in producing language: sensory orientations, interdependence, mutual-aid and world-building, carework, and the ways that time interacts with the bodymind and language. (Henner and Robinson 2021).

We view sign language linguists, especially those focusing on grammatical development (including ourselves), as especially well-placed to re-examine how cultural interaction, disability, and language deprivation lead to multilingual competencies and grammatical development, since these issues are so prevalent in the communities in which we work.

A crip linguistics view may recognize *impaired* language, but impaired language should not be dismissed as *"bad language," intrinsically disordered language,* or, especially, *non-language*. As Henner and Robinson point out, such perspectives are fundamentally ableist and do not further equitably representative science. Setting aside the issue of human rights, we hope to have shown that dismantling the privilege of "native L1 normalcy" observable in signed as well as spoken languages (Quer and Steinbach 2019; Haug et al., 2021) not only makes for ethically responsible academic work, it also brings together strands of research that have not traditionally benefited from each other's expertise, simultaneously extending the empirical reach of all involved. It is well-known that language is used to oppress, to create and maintain inequalities well beyond disabled individuals and has arguably also been observed in racialized and poverty-affected communities (see, e.g., Rickford and King 2016, a.o.). Henner and Robinson (2021) remind us that such inequalities must be addressed from all directions, i.e., every linguist should consider adopting crip linguistics framework.

We thus close by passing along a call to action from our colleagues to the rest of our field: "The cripped linguist highlights the linguistic adaptations used by disabled people, including their relations and world-making, and illuminates structures of ableism that govern how we perceive language" (Henner and Robinson 2021:3). While we are not the first to take on this enterprise in terms of either L1 or subsequent languages, our approach explicitly places the process of language acquisition by DHH homesigners in the pantheon of theories of *multilingual* language development, recognizing the initial system as a linguistic system (if not an L1) that contributes to an emerging L3/Ln grammar based on a particular set of parser "decisions" (Rothman et al., 2019; Westergaard et al., 2017; Slabakova 2017, a.o.). Thus, given that at least on standard assumptions the learner is drawing on their previous language experiences (L1 and L2) before creating new grammars, the heart of the problem then becomes, "What exactly constitutes "L1" (and L2>>L3) for the learners of SLs?" Rather than limiting the scope of inquiry to acquisition of just L1 (Mayberry and Eichen 1991) or L2 (Morford et al., 1995; Hoffmeister and Caldwell-Harris, 2014) for predictions about how DHH with history of language deprivation acquire signed and spoken languages, the field should expand consideration to recent well-articulated theories of L3, thereby acknowledging the entirety of DHH learner's linguistic experiences.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Exploring Networks of Lexical Variation in Russian Sign Language

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When describing variation at the lexical level in sign languages, researchers often distinguish between phonological and lexical variants, using the following principle: if two signs differ in only one of the major phonological components (handshape, orientation, movement, location), then they are considered phonological variants, otherwise they are considered separate lexemes. We demonstrate that this principle leads to contradictions in some simple and more complex cases of variation. We argue that it is useful to visualize the relations between variants as graphs, and we describe possible networks of variants that can arise using this visualization tool. We further demonstrate that these scenarios in fact arise in the case of variation in color terms and kinship terms in Russian Sign Language (RSL), using a newly created database of lexical variation in RSL. We show that it is possible to develop a set of formal rules that can help distinguish phonological and lexical variation also in the problematic scenarios. However, we argue that it might be a mistake to dismiss the actual patterns of variant relations in order to arrive at the binary lexical vs. phonological variant opposition.

Keywords: lexical variation, phonological variation, Russian Sign Language, lexical database, graph theory

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INTRODUCTION

Sign languages, like all natural languages, are variable, with variation present at the phonological, lexical, and grammatical levels. The choice of variant can depend on the region of the signer, their age, and other sociolinguistic factors, including ones specifically relevant to sign languages, such as the type of school, and the presence of signing family members (Sutton-Spence et al., 1990; Schermer, 2004; Schembri and Johnston, 2012; Stamp et al., 2015; Palfreyman, 2019; Chen and Gong, 2020). Many studies focus on investigating these factors that explain the choice of variant. However, before exploring these factors, researchers need to conduct a more technical step of defining what constitutes different variants, and determining which level of variation is concerned. In this paper, we specifically discuss the problem of distinguishing phonological and lexical variants of signs.

The Puzzle of Lexical and Phonological Variation

When studying variation in signs of sign languages, researchers usually distinguish between lexical variants and phonological variants (Johnston and Schembri, 1999; Lucas et al., 2001; Schermer, 2004; Stamp et al., 2014; Fenlon et al., 2015; Chen and Gong, 2020). The two cases that need distinguishing are:

1. For concept X, there are two signs 1 and 2 that are formally related. 1 and 2 thus represent a single lexeme with different phonological realizations.
2. For concept X, there are two signs 1 and 2 that are distinct in their shape (unrelated). 1 and 2 are thus separate lexemes that are variant expressions of a single meaning.[1]

Consider the following simple example. In Russian Sign Language (RSL), the concept FATHER can be expressed by the following signs (**Figure 1**). The signs come from the lexical database of variation in RSL, which will be introduced in detail in Section "The database of lexical variation in RSL" below. The two signs are clearly formally related: they share the handshape, the orientation, the locations, and the type of movement; only the direction of movement is different between the two signs: in FATHER-1 the hand moves from the forehead to the chin, and in FATHER-2 from the chin to the forehead.

Compare this to the following two RSL signs, expressing the concept of EDUCATOR (the sign for the person working typically at a boarding school for deaf children who is more responsible for the discipline than for education), **Figure 2**. These two signs have no formal overlap (and the second one is probably a compound), so it is logical to treat them as completely separate lexical items (lexemes).

The criterion for distinguishing lexical variants from phonological variants that is most often used in published research and in existing dictionaries and lexical databases of sign languages is the following:

(1) If two signs for the same concept differ in one major phonological parameter (handshape, orientation, movement, location), then they are phonological variants of the same lexeme. Otherwise, they belong to separate lexemes.

Several additional notes are in order. First, if two signs for the same concept use different iconic bases (informally, they draw a different picture), they are considered separate lexemes, even if they only differ in a single phonological parameter (Lucas et al., 2001; König et al., 2008). Second, handedness (one vs. two-handed realization) is often not considered a distinguishing feature because both adding and removing the second hand is a very common phonetic/phonological process in sign languages (Johnston and Schembri, 1999; Fenlon et al., 2015). Third, whether mouthing is used to distinguish lexemes is questionable because the status of mouthing itself is contested (see a discussion in Fenlon et al., 2015). These additional considerations are important issues, but we do not discuss them in this paper.

One obvious drawback of this criterion is that it is quite arbitrary. Why would signs sharing three out of the four, but not two out of the four parameters considered related?[2] Furthermore, the notion of the major phonological parameter itself is theoretically questionable, as many theories of sign language phonology argue for a different (hierarchical) representation of phonological structure of signs (see Brentari, 2012; van der Hulst and van der Kooij, 2021 for an overview).

Another problem concerns relying on these phonological (also known as sublexical) parameters in sign languages, as discussed by Mudd et al. (2020) and Lutzenberger et al. (2021): in order to make a judgment whether, e.g., movement in two signs is the same or different, it is necessary to know which movement differences are phonological, and which are phonetic in the specific sign language. For most sign languages, phonological inventory has not been described in enough detail, and for some sign languages it has been claimed that phonology and thus phonological categories are only emerging (Israel and Sandler, 2011).

However, even if we accept the validity of the criterion, and settle on a common solution for the additional complications mentioned above, when we analyze the actual possible relations between multiple variant signs used to express the same concept, we are faced with contradictions. These contradictions will be the focus of this paper, and the possible scenarios that lead to contradictions are discussed in detail in Section "Problematic scenarios".

However, as a preview, consider the following hypothetical scenario, which we call the Chain Scenario. Imagine that concept X can be expressed by signs 1, 2, and 3. Signs 1 and 2 are identical but for the handshape. Signs 2 and 3 are identical but for the movement. This means that by the criterion (1) above, signs 1 and 2 are one lexeme (phonological variants of the same sign), and signs 2 and 3 are one lexeme, but signs 1 and 3 are not the same lexeme. This is a contradiction. As we will show throughout the paper, this is not a hypothetical only scenario, but a very common occurrence, at least in RSL. Furthermore, this is the simplest of the complex scenarios that are found in the lexical variation database of RSL.

To the best of our knowledge, this issue of distinguishing phonological vs. lexical variants in the complicated scenarios we describe in this paper has not been analyzed in depth in any previous research. In most papers on lexical variation in sign languages, the focus is on connecting the choice of variant to sociolinguistic factors (e.g., Stamp et al., 2015; Chen and Gong, 2020; Mudd et al., 2020). The authors typically use the criterion in (1) to isolate separate lexical variants of signs, and then explain the distribution of these lexical variants. In some studies, the focus is on measuring variability quantitatively (e.g., Israel and Sandler, 2011; Lutzenberger et al., 2021), where both lexical and phonological variability is taken into account in order to calculate

[1] For consistency, we use numbers (1, 2, 3, . . .) to represent variants (signs with distinct shapes) and letters (A, B, C, . . .) to represent lexemes (which can consist of multiple variants).

[2] In fact, Chen and Gong (2020: 7) decided to analyze signs which overlap in at least **two** parameters as phonologically related in their study of variation in Chinese Sign Language.



FIGURE 1 | FATHER-1 (two frames, watch here: https://osf.io/u2nej/) and FATHER-2 (two frames, watch here: https://osf.io/wt8dh/).

a variability metric, but the focus is again not on distinguishing lexical vs. phonological variants, and the cases relevant to our paper are not analyzed.

Why Distinguish Lexical and Phonological Variation

It is prudent to ask why it is necessary to distinguish lexical and phonological variation at all. In principle, it is possible to solve the puzzle outlined above as well as further problems by simply abandoning the distinction, and treating all minimally formally distinct expressions of the same concept equally. However, there are some arguments in favor of trying to salvage this distinction.

First, for the purposes of lexicography it is necessary to distinguish lexemes from phonological variants, because dictionaries are typically organized around lexemes, and the phonological variants are discussed within entries devoted to specific lexemes (Johnston and Schembri, 1999; Kristoffersen and Troelsgård, 2010; Fenlon et al., 2015; Hochgesang et al., 2018).

Second, it is plausible to hypothesize that two lexemes for the same concept and two phonological variants of the same lexeme would be represented differently in the mental lexicon. While some might question the psychological reality of this difference, it is an empirical question whether these categories are psychologically real, and before we investigate it experimentally, we need to descriptively settle on the boundaries of these categories.

Finally, the distinction can also be relevant for other linguistic questions. For example, in our preliminary research on RSL we discovered that signs from different semantic fields are different with respect to the type of variation. Specifically, kinship terms and color terms in RSL typically have a large amount of phonological variation, while lexical variation is lower than for signs related to school and education. There is an intuitive explanation for this pattern: school-related signs are developed in specific deaf schools (Schembri and Johnston, 2012), and thus completely different unrelated variants emerge and are preserved, while color terms and kinship terms are less school-dependent, and thus the different variants either have a common source or interact and converge more easily. However, it is not possible to even describe this pattern if we abandon the two categories of variation.

For these reasons we consider it valuable to discuss the distinction further using novel data from RSL. Our final argument, however, will be in favor of acknowledging that the possible relations between variants go beyond the binary distinction of lexical vs. phonological.

MATERIALS AND METHODS

The Database of Lexical Variation in Russian Sign Language

The current paper is based on the initial stages of the analysis of a database of lexical variation in RSL[3]: https://rsl-research-explore.garagemca.org/. It was created by the Garage Museum of Contemporary Art in Moscow, with participation of sign language linguists. The database was collected using a website where participants were asked to record themselves signing isolated signs from several semantic fields[4]. The participants were specifically instructed to record multiple variants if they could recall them, starting with the one they themselves used most frequently. Data collection took place in the summer of 2020. Participation was on a purely voluntary basis.

The concepts selected for the questionnaire came from the following semantic fields: kinship terms, color terms, school-related lexicon, numerals. Kinship terms and color terms have been widely investigated for other sign languages, including investigations of lexical variation for these fields (Lucas et al., 2001; Schembri and Johnston, 2012; Stamp et al., 2014; Mudd et al., 2020). School-related lexicon was chosen because we assumed that such concepts would indeed vary considerably between different regions due to the important role deaf schools play in sign language emergence and transmission (Schembri and Johnston, 2012). Finally, anecdotal reports said that numerals in RSL do not vary across different regions, so we wanted to empirically test these reports. The total number of concepts included was around 90, excluding the numerals. We expected that filling the questionnaire would take 20-30 min.

[3]The website's interface is only in Russian at the moment of publication (December 2021), but the English interface is planned to be added in near future.

[4]https://rsl-research.garagemca.org/

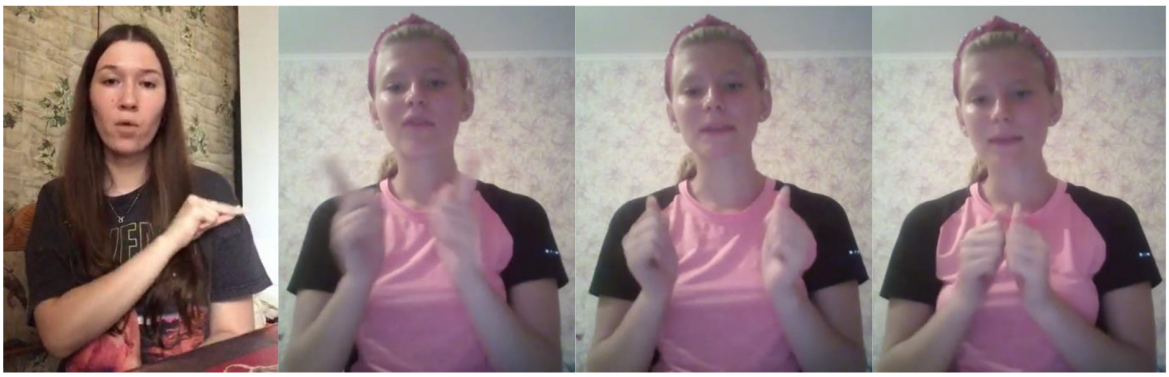


FIGURE 2 | EDUCATOR-1 (1 frame, watch here: https://osf.io/8y2dn/) and EDUCATOR-2 (3 frames, watch here: https://osf.io/5aygc/).

The explanation of the purpose of the research, the instructions, and the questions in the sociolinguistic questionnaire (see below) were presented in both RSL and Russian. However, the stimuli in the questionnaire were words in written Russian. While it is well known that using written language as stimulus is not optimal (van Herreweghe and Vermeerbergen, 2012), this method is unavoidable in a large-scale online data collection study of lexical variation. We could not use video recordings of the signs as stimuli as this would obviously influence the participants, and many of the concepts we were interested in are not easily representable by pictures. Since we only collected isolated lexemes, we consider direct influence of written language to be restricted to mouthing. However, for this reason, this database cannot be used to analyze mouthing accompanying the signs.

In addition to collecting the recording of the signs, we collected socio-linguistic data about the participants, namely their dates of birth, gender, place of birth and places where they lived for a considerable period of time, age of acquisition of RSL, and deaf and hard-of-hearing relatives.

While more than 600 people started filling out the sociolinguistic questionnaire, 279 recorded two or more signs (it was possible to stop recording at any moment in the questionnaire). More than 19 000 videos (one video per concept per participant) were recorded. Due to the on-line format of the questionnaire, the participants do not constitute a representative sample of the population: the majority of them were in the 18–35 age range, and almost half of the signers coming from Moscow. Nevertheless, the database contains a large amount of variation that needs future linguistic and sociolinguistic analysis.

In this paper, we do not describe or analyze sociolinguistic factors that can explain variation and focus on the specific task of the linguistic analysis of variation in terms of the phonological vs. lexical opposition. This will thus serve as the basis for further annotation of the database, and the necessary first step for future sociolinguistic analysis. Furthermore, the majority of data analyzed so far concerns color terms and a few kinship terms. The video recording of all the signs discussed in this paper can be found here: https://osf.io/7h3f6/.

Data Annotation

We annotated the data manually by describing each variant sign for a concept and assigning it a label (e.g., FATHER-1, FATHER-2, etc. assigned in order of occurrence in the database). In determining what constitutes separate variants, we used the following principles.

First, if one signer produced two signs in one video, these two signs are clearly perceived as separate variants by the signer, and we annotate them as such. This was especially useful for some controversial cases. For example, it is possible to analyze the variants of FATHER in **Figure 1** not as two separately represented variants, but as a result of applying metathesis based on context[5]. However, such variants were in fact produced together by the same signers, and thus they are analyzed as distinct variants.

Second, we considered variants distinct if they were clearly different in at least one of the major parameters (handshape, orientation, location, movements). For the reasons discussed in Section "The database of lexical variation in RSL," mouthing was not analyzed at all. Finally, we acknowledge that the decision of what constitutes the same or different major parameters (e.g., the same or different handshapes) in two variants is a subjective judgment. Our annotation was guided by our knowledge of the phonology of RSL based on many years using, studying and researching RSL,[6] but not on a published formal inventory of phonological units, as such an inventory for RSL does not exist at the moment. As discussed above, this is a common methodological concern for studies of variation for most sign languages (Mudd et al., 2020).

For this study, we do not consider fingerspelling (although fingerspelling should probably be analyzed as separate lexemes), and we do not consider compounds. Compounds sometimes have parts which also serve to express the same meaning as a single sign and thus also complicate the system considerably. We leave this issue for future research.

[5]It is, however, unlikely that such a process would apply for our data set, because the signs were produced without any context, and with the same stimuli for all the signers.

[6]Two of the authors are hearing CODA signers of RSL, all of the authors are fluent RSL signers.

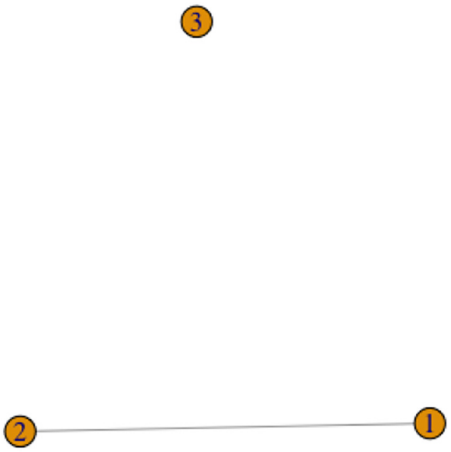


FIGURE 3 | A graph with two components.

Note that even if some of our annotations turn out to be erroneous (e.g., two variants should in fact be analyzed as a single variant, or vice versa), this can only invalidate some of the specific examples in the rest of the paper, but not the theoretical arguments about possible variant networks.

Graph Theory

In the remainder of the paper, we will discuss the hypothetical and actual networks of variants. We argue that it is useful and insightful to represent these networks graphically, as such presentation makes the relations we are interested in intuitively clear. In order to do so, we need to use some basic notions from graph theory (Wilson, 1996). We introduce them here, and explain how they relate to the possible relations between variants of signs expressing a concept.

Graphs consist of vertices and edges that connect pairs of vertices. In our case, variants are vertices, and edges represent the relation of phonological relatedness between vertices/variants. Two vertices that are connected by an edge are called adjacent vertices. In our case, this means that two phonologically related variants [by (1)] are always adjacent vertices in the graph representation[7].

For example, recall the signs for FATHER in **Figure 1**. These two variants are phonologically related, and thus would be represented as two vertices connected by an edge in a graph representation (for example, as vertices 1 and 2 in **Figure 3** below).

Graphs might have components, where components are connected parts of the graph that are not connected to each other. For instance, the graph in **Figure 3** has two components: (1,2) and 3. In the case of graphs for sign variants, it is clear that separate components must belong to separate lexemes. However, the difference between separate lexemes and phonological variants is not reducible to the difference between components and vertices within a component, as the Chain Scenario discussed above shows. We will thus focus on exploring possible configurations within components.

A cycle is defined as a part of the graph that can be represented as a sequence of edges that are all distinct and that join a sequence of vertices such that this sequence starts and ends in the same vertex while no other vertices are repeated. In Section "Problematic scenarios" we show why this notion is relevant to analysis of sign variants (see also the figures there).

Graph theory has been used in linguistics in several domains. The most common applications of graph theory are to analyze semantic (Sigman and Cecchi, 2002, review in Borge-Holthoefer and Arenas, 2010), phonological (Vitevitch, 2008), and orthographic (Trautwein and Schroeder, 2018) lexical networks. The main approach here is to construct a large network representing a considerable part of a lexicon in a language, and then describe these networks in quantitative terms from graph theory, such as the average path length and clustering coefficient. The actual network under study is compared against a random network of the same size, in order to assess whether, e.g., the aforementioned average path length and clusterting coefficient are non-random. For instance, it has been shown that such lexical networks possess small-world characteristics, where the average path length is comparable to random networks, but the cluster coefficient is much higher. These properties of lexical networks seem to correlate with psycholinguistic evidence, e.g., on the role of phonological neighborhood density (Vitevitch, 2008). A study that applied a community detection technique, the Louvain method in particular, to language data (Siew, 2013) used a giant component of 6,508 words from the phonological network used in the Vitevitch (2008) study to identify communities within the network and then compare lexical and phonological characteristics of words in these communities. The Louvain method, commonly used in such studies, is tailored specifically for large networks (Blondel et al., 2008).

Another domain of application of graph theory is in computational linguistics, where different types of graph representations have been used to represent linguistic data and to perform various NLP tasks (see Kuhlmann and Oepen, 2016 for an overview of linguistic resources using graph representations). This domain is also closely connected to another related field of algorithmic community detection (Fortunato, 2010). Community detection algorithms are usually applied in cases of very large networks in order to discover the underlying structure of the network (Girvan and Newman, 2002; Fortunato, 2010). One example of applying community detection is represented by Jurgens (2011), where this technique was used to induce word senses from corpus data by detecting communities (interconnected parts of graphs) in a word co-occurrence graph.

One study that is in spirit similar to ours in that it focuses on relatively small graphs, albeit in a completely different linguistic domain, is Piperski('s (2014) proposal to use graph theory to analyze linguistic complexity. In this study, the author proposed to measure linguistic complexity (in terms of form-meaning mappings) by applying some measures from graph theory.

Concerning lexical variation in sign languages, Chen and Gong (2020) used clustering, which is a statistical technique related to graph theory, to detect dialects in lexical signs in

[7]More than two variants can also be mutually adjacent, forming what is known as a clique.

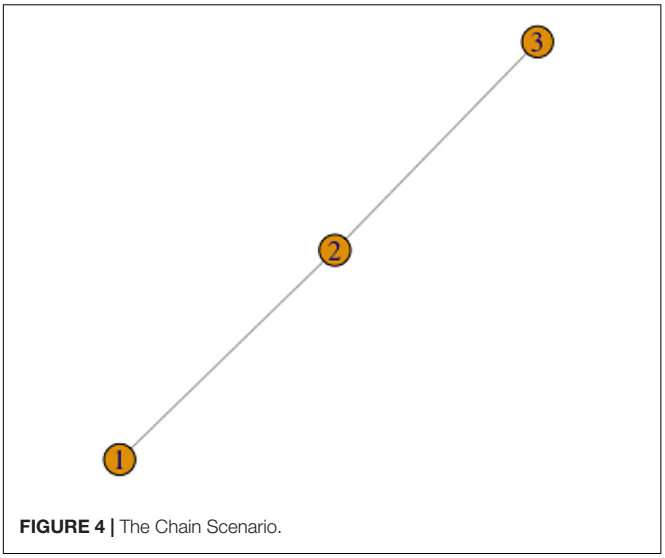


FIGURE 4 | The Chain Scenario.

Chinese Sign Language. However, they only looked at what they considered to be lexical variants, for which they used the same criteria as elsewhere in the literature, and did not explore the question of the boundary between lexical and phonological variation. Similarly, Mudd et al. (2020) calculated lexical distance between Kata Kolok signers using lexical variation as basis for calculation; this also creates an underlying graph representation of signers in the community. However, they also did not analyze sign variant networks, as this was not part of their research question.

To sum up, while graph theory and community detection has been used in various domain of linguistics, it has not been applied to the phenomenon that we consider in this paper, namely analyzing variant networks to distinguish lexical and phonological variants. Given the relatively small sizes (in terms of the numbers of vertices and edges) of the networks considered here, we focus not on quantifying various measures over these graphs (such as average path length or clustering coefficient) or detecting communities algorithmically, but on describing the specific configurations that we find in the data in relation to the question of distinguishing lexical and phonological variants.

PROBLEMATIC SCENARIOS

In this section, we explore five scenarios where some variants are phonologically related to some other variants, which leads to contradictions or at least difficulties in distinguishing phonological and lexical variants. These scenarios are the Chain Scenario, the Cycle Scenario, the Overlapping Cycles Scenario, the Shared Vertex Scenario, and the Connected Component Scenario.

The list is not exhaustive: it is based on examples we found in the data. Thus, for each of these scenarios, we give actual RSL examples from the database of lexical variation. Afterward, we discuss some examples of complete variant networks for color terms demonstrating that, in actuality, multiple problematic scenarios can concern even a single concept.

The Chain Scenario

We introduced the Chain Scenario in Section "The puzzle of lexical and phonological variation," but we repeat the description here. Imagine that concept X can be expressed by signs 1, 2, and 3. Signs 1 and 2 are identical but for the handshape. Signs 2 and 3 are identical but for the movement. This means that by the criterion (1), signs 1 and 2 are one lexeme (phonological variants of the same sign), and signs 2 and 3 are one lexeme, but signs 1 and 3 are not the same lexeme. This situation can also be represented as a graph in **Figure 4**.

This scenario is a very common phenomenon in the RSL database. Consider the following example. The concept DARK.BLUE in RSL has many variants (as we will further discuss in Section "The Connected Component Scenario"), but we will focus on three of them in this section, **Figure 5**. The first variant has the C handshape, making small repeated downward movements in the neutral space. The second variant has the same handshape and location, but the movement is the rotation of the wrist. The third variant has the A handshape, and the same movement and location as in the second variant.

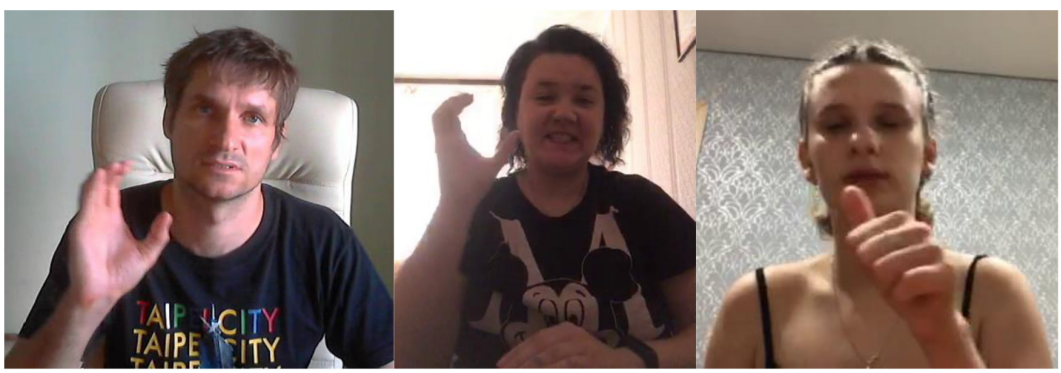


FIGURE 5 | DARK.BLUE-11 (repeated downward movement not depicted), DARK.BLUE-12 (repeated wrist rotation not depicted), DARK.BLUE-13 (repeated wrist rotation not depicted). Watch the video recordings here: https://osf.io/7h3f6/.

The three variants thus exactly exemplify the Chain Scenario from: the first and second variants are only distinguished by one parameter (the movement), and the second and third are distinguished by one parameter (the handshape), but if we compare the first to the third, we observe two major parameter differences. How are we to analyze these variants in terms of the number of lexemes, and which variant should belong to which lexeme? We offer a solution in Section "A possible system of rules."

The Cycle Scenario

In section "Graph theory," we defined cycles in graph theory. A cycle is a sequence of edges that are all distinct and that join a sequence of vertices such that this sequence starts and ends in the same vertex while no other vertices are repeated. A simple example is that a concept X is expressed by variants 1, 2, 3, 4 and 5, such as the following pairs of variants can be defined as being phonologically related: (1,2), (2,3), (3,4), (4,5), (5,1) (**Figure 6**).

This scenario is also a common occurrence in the database, and is best illustrated by the variants for the concept "father" (see also the color "white" in **Supplementary Materials**). This concept has six distinct realizations in RSL (**Figure 7**). Variants 1 and 2, variants 3 and 4, and variants 5 and 6 are all distinguished by the same component, namely variants 1, 2, and 3 have the movement from the forehead to the chin, and variants 4, 5, and 6 have the movement from the chin to the forehead. At the same time, variants 1 and 2 share the handshape (flat hand), and so do variants 3 and 4 (palm bent), and variants 5 and 6 (the H handshape).

How are we to analyze this system in terms of lexemes? First, variants 1 and 2 should belong to one lexeme, variants 3 and 4 should belong to one lexeme, and variants 4 and 5 should belong to one lexeme. The variants in these pairs are distinguished by movement direction only. Second, variants 1, 3, and 5 should belong to one lexeme, and variants 2, 4, and 6 should belong to one lexeme. The variants in these triplets are distinguished by handshape only. However, also by the same logic, variants 1 and 4, 1 and 6, 2 and 3, and 2 and 5 should not belong to the same lexemes, because they are different with respect to both movement and handshape.

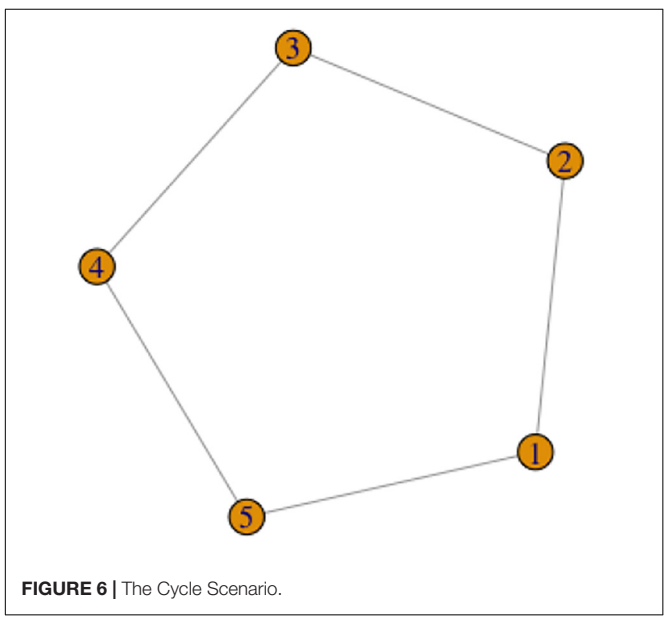


FIGURE 6 | The Cycle Scenario.

The relations between the variants are graphically represented in **Figure 8**.

The Cycle Scenario is intuitively different from the Chain Scenario because of the high degree of interconnectedness of the variants. While in a simple chain two variants on the ends of the chain are only connected to one other variant, in a cycle each variant is connected to at least two other variants. Intuitively, then, it becomes difficult to separate any of the variants into one lexeme without the rest of the variants that are so tightly connected to them.

The Overlapping Cycles Scenario

Sometimes a network of vertices is interconnected, but does not form a single cycle, as there is no path through all the vertices such that the edges are distinct, and each vertex except for the first one is repeated. One such case is represented in **Figure 9**, left. Note that if one vertex is removed (vertex 9), the remaining graph is a cycle, as in **Figure 9**, right.

Thus, technically this is a different scenario from the Cycle Scenario above. However, in this scenario each vertex is still connected to at least two other variants within the component, and as such, we might want to include all such variants into one lexeme.

This scenario is manifested in the signs for GRAY, which we discuss in Section "Examples of actual networks of variants" below.

The Shared Vertex Scenario

It is possible that two complex parts of the variant graph share a variant: two or more cycles of variants or a cycle and a chain can share one variant. For example, a concept X can have variants 1, 2, and 3, which form a cycle, and variants 3, 4, and 5, which also form a cycle (**Figure 10**).

A real-life example of this scenario is illustrated by the network of variants for the concept "pink" (see the **Supplementary Materials** for a full illustration). In fact, this concept is expressed by 11 variants, six of which are completely unrelated to the other variants, and the remaining five are related exactly in the way depicted in **Figure 10**.

As discussed in the previous section, intuitively it makes sense that all the variants within a cycle belong to the same lexeme. However, if two cycles share one variant, does this mean that they should both belong to the same lexeme? The answer to this question is less intuitive. On the one hand, the two connected cycles are overlapping in one vertex, and the shared vertex is connected to at least two variants in both cycles. If the variant shared between the two cycles is to be removed such that the graph turns into two separate components, these components can in some cases cease to remain to be cycles (e.g., if we remove the variant 3 in **Figure 10**). On the other hand, the connections within the cycles seem to be stronger than between the cycles.

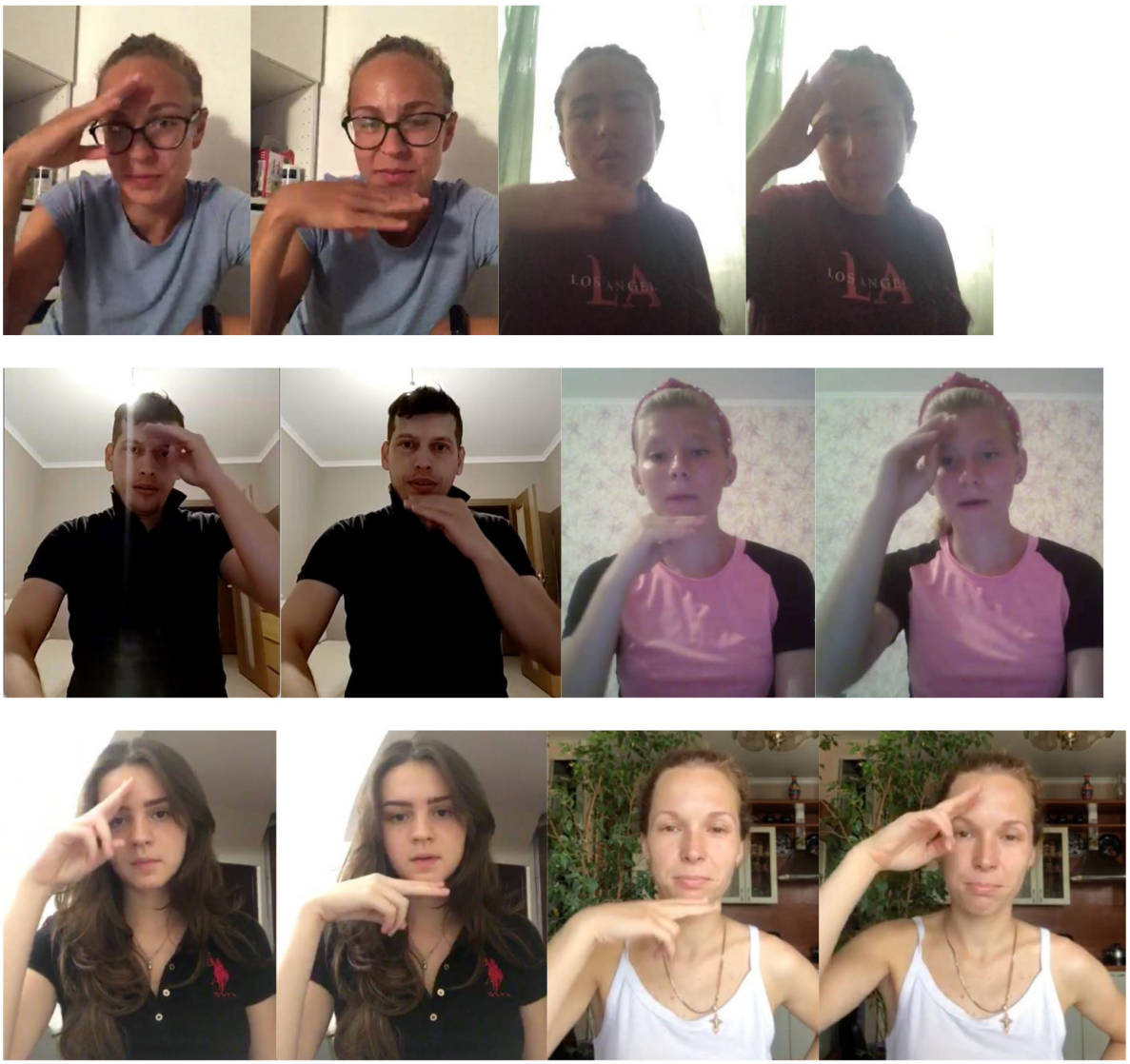


FIGURE 7 | The six variants of FATHER (two frames each; in signs 1, 3 and 5, the hand moves from the forehead to the chin, in signs 2, 4 and 6, the hand moves from the chin to the forehead; watch the video recordings here: https://osf.io/7h3f6/).

The Connected Component Scenario

The final possibility is that multiple cycles and chains form a connected component of the variant graph, but without vertices shared by several cycles. The simplest example is represented in **Figure 11**: there are two fully connected cycles (123 and 456), and one variant in each cycle is connected to one variant in the other cycle (3 and 4). Basically, any connected component in graph theoretical terms (any part of the graph where there is a path from each variant to each other variant) falls under this scenario. A real-life illustration of this scenario is the variants of ORANGE in RSL, which will be discussed in the next section.

Note that the four scenarios from the previous section can all also be classified as the Connected Component Scenario – they are all examples of connected components with some additional restrictions. The Connected Component Scenario is thus the loosest scenario in terms of connections between variants, only requiring that all the variants are connected somehow – through some other variants. Furthermore, in this scenario, removal

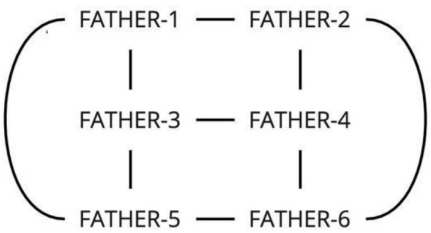


FIGURE 8 | A graph representation for the variants of FATHER.

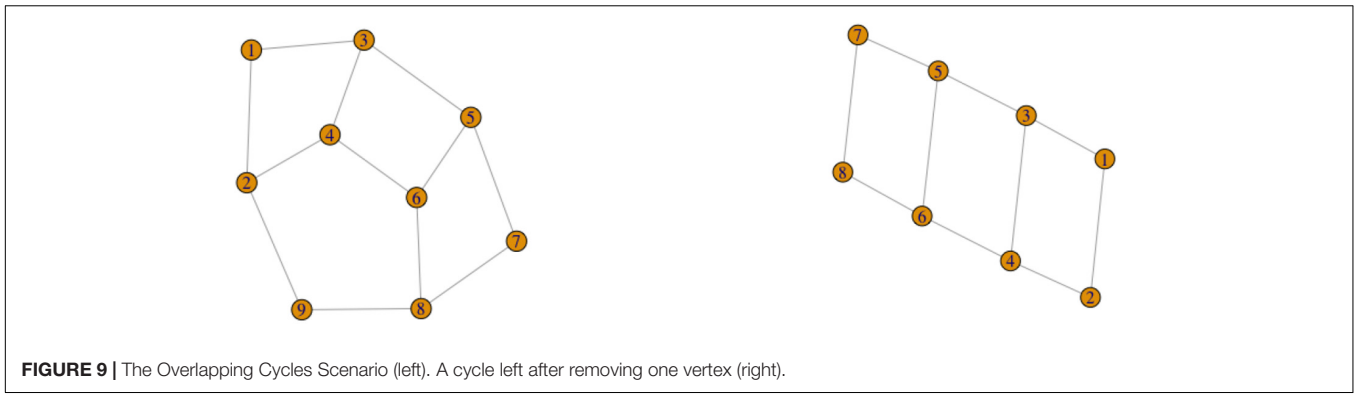


FIGURE 9 | The Overlapping Cycles Scenario (left). A cycle left after removing one vertex (right).

of some variants or connections between variants might not change the occurrence of cycles and chains within the remaining components. For instance, if in **Figure 11** the variants 3 and 4 turn out to be phonologically unrelated, the cycles 123 and 456 would still remain. This shows that the more connected subparts of the graph are less dependent upon the presence of all the vertices and edges than in the Shared Vertex Scenario.

Thus, unless we decide that, in all four scenarios above, we should analyze all the variants as belonging to the same lexeme, we could not argue the same for this scenario either. Intuitively, the fact that two variants belong to a connected component might not be enough to classify them as belonging to the same lexeme. On the other hand, there is still a clear difference between variants belonging to the same component, and variants that do not belong to the same component, and thus are completely unconnected.

Examples of Actual Networks of Variants

One example of actual networks of variants has been presented above: the variant signs for FATHER represented in **Figures 7**, **8** are all the variants for this concept found in our database. Thus, this is an example of a concept that has a cycle of variants, and no variants that are completely isolated. The same system of variants is also present for the concept MOTHER, where the only difference with the signs for FATHER is that the hand moves horizontally, between the right and left sides of the face (or vice versa).

Looking at color terms in RSL, we can observe large and interesting variation in the network complexity (the number of vertices and edges involved). For instance, RED has only two variants, which are only different in the handshape used, and thus they represent a single lexeme without complications. An example of the concept with a simple network of variants (but quite a large number of variants) is VIOLET (**Figure 12**).

As **Figure 12** shows, variants 1, 2, and 3 are all phonologically related to each other, and thus they can be analyzed as a single lexeme. Variants 4 and 5 are phonologically related, so they represent another single lexeme. Variants 6 to 10 are unrelated to the other variants, so each is a lexeme.

However, most of the color terms manifest complex networks of variants, and illustrate the problematic scenarios identified above. This is the case for the concepts "white," "black," "yellow," "pink," "dark blue," "light blue," "gray" and "orange."

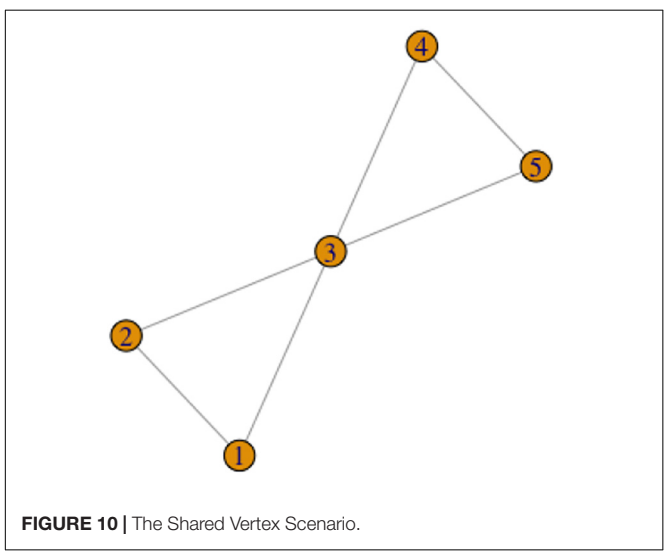


FIGURE 10 | The Shared Vertex Scenario.

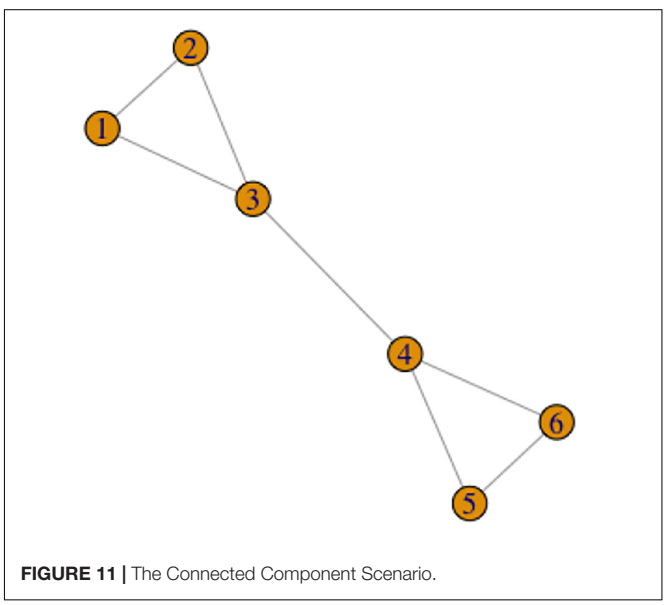


FIGURE 11 | The Connected Component Scenario.

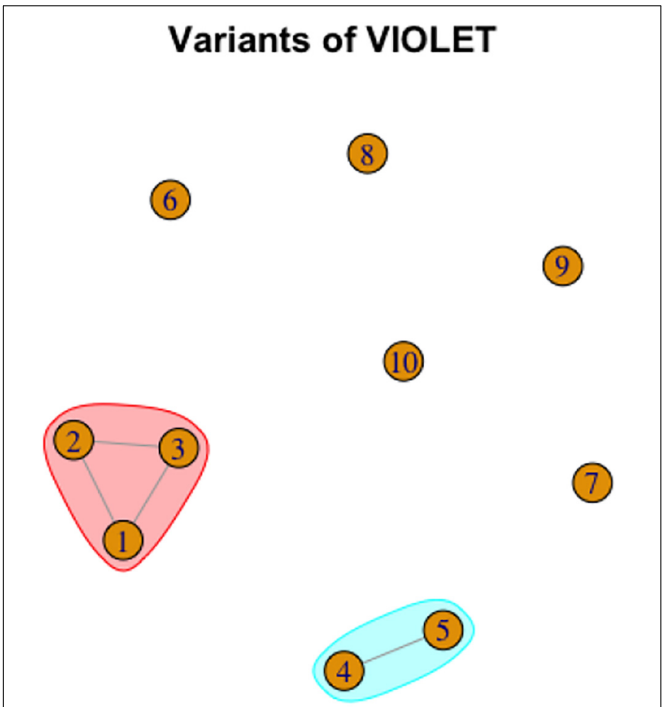


FIGURE 12 | Graph representation of variation in VIOLET. Color shading represents lexemes.

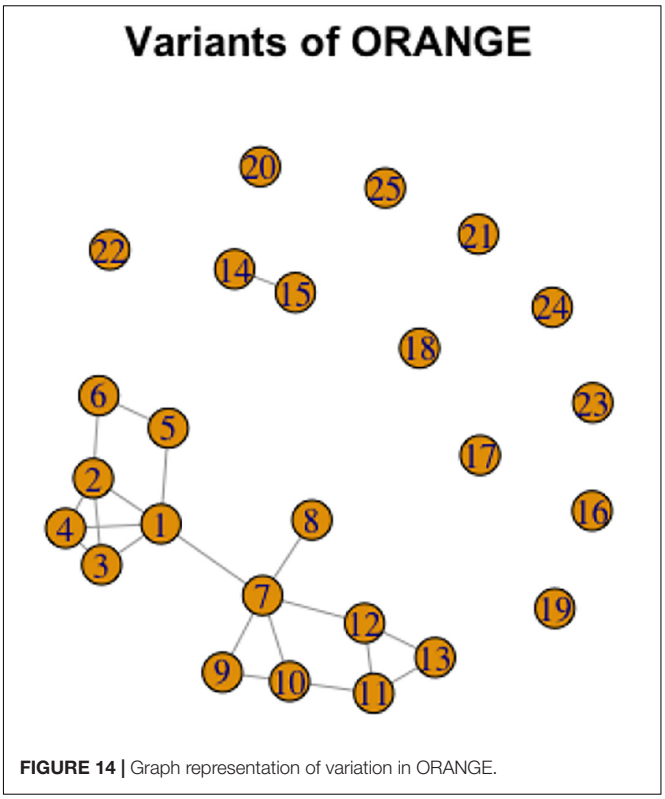


FIGURE 14 | Graph representation of variation in ORANGE.

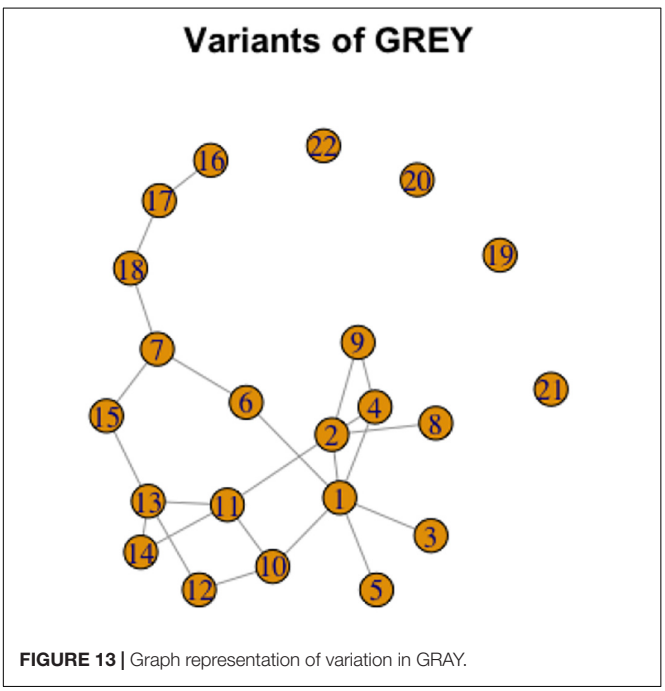


FIGURE 13 | Graph representation of variation in GRAY.

To illustrate possible complexity, consider a graph representation for GRAY, **Figure 13**. This case illustrates the Overlapping Cycles Scenario. Specifically, variants 1,2,4,9,10,11,12,13,14 can be analyzed as a cycle; however, variants 6,7, and 15 are also all connected to this cycle, but in such a way that they do not form a single cycle together. In addition, there are variants 5, 3, and 8 each connected to one other variant in the same component, and variants 7, 18, 17, and 16 form a chain, thus illustrating the Chain Scenario. Finally, there are variants 19 to 22 which are unrelated to the other variants.

For another example of complexity, consider a graph representation of the variant network for ORANGE, **Figure 14**. This figure illustrates three of the five scenarios discussed above (for the Shared Vertex Scenario, see the representation for PINK in the **Supplementary Materials** for illustration).

ORANGE has 10 variants unrelated to the others, and thus comprising 10 separate lexemes. In addition, variants 14 and 15 together are phonologically related and thus form a lexeme. Looking at the connected part of the graph, we can see two cycles. The first one, represented by variants 1–6 is almost completely interconnected. The second cycle consists of variants 7,9,10,11,12. In addition, the two cycles are connected via the relation between variants 1 and 7 (the Connected Component Scenario). Abstracting away from the cycles, variants 1, 7, and 8 can be analyzed as a chain.

It is interesting to observe the pattern of variation here by looking at the specific forms of the signs. Variants 1 to 6 are all conducted in the neutral space, and while they vary in handshape and movement, they are interconnected enough to form a cycle. Variants 7 to 12 (excluding 8) are all conducted near the cheek, and also vary in handshape and movement. The two large groups have a connection via variants 1 and 7 which share the handshape and movement, but not the location. Thus, intuitively, each

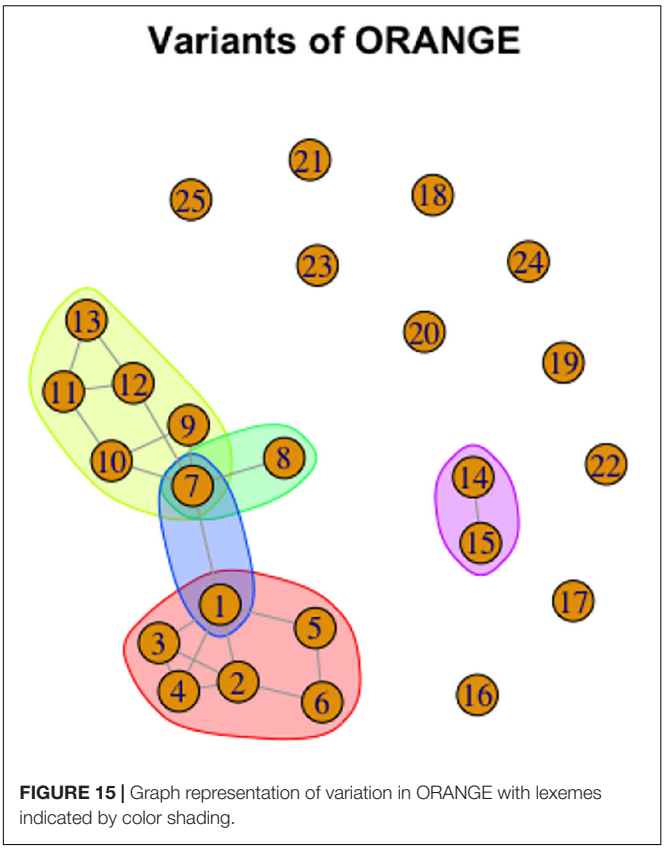


FIGURE 15 | Graph representation of variation in ORANGE with lexemes indicated by color shading.

variant in each of the cycles belongs to a separate lexeme, but there is also a connection between the two lexemes that has to be acknowledged.

In the **Supplementary Materials** for this article, one can find graphical representations for all the color terms in the database analyzed so far and the video recordings for each variant of each concept.

DISCUSSION

The variability of the variant networks presented in the previous section makes it clear that the problem of distinguishing separate lexemes in such networks is non-trivial. It is definitely possible to develop a system of rules that will unambiguously identify lexemes even in the complex cases (Section "A possible system of rules")[8]. However, with such a system of rules in place, we still need to ask whether the binary distinction between lexical and phonological variants is really something to strive for.

A Possible System of Rules

Starting with the Cycle Scenario, as discussed above, we have the intuition that all variants that are part of a cycle, should belong to a single lexeme. Recall the case of FATHER (**Figures 7**, **8**). The signs for "father" vary along two dimensions (handshape and direction of movement), and all possible combinations of the three handshapes and two directions of movement are possible. It is possible to arbitrarily choose one of those dimensions as primary, and say, e.g., that FATHER consists of three lexemes (same handshape within each lexeme), or of two lexemes (same movement direction within each lexeme). However, first, we see no reasonable way of choosing one of the dimensions over the other. To sum up, we suggest the following rule:

(2) **The Cycle Rule:** Let X be the set of variants {1, 2, 3, etc.} for a concept. Let us represent the phonological relations between the variants as an undirected graph where the variants are vertices, and the variants that are distinguished by a single phonological parameter are connected by edges. If some subset of variants forms a cycle, we consider all of these variants belonging to the same lexeme.

We suggest that the Overlapping Cycles Scenario (**Figure 9**) can be analyzed in the same way by attributing all the variants in the overlapping cycles to one lexeme. This can be achieved by the following addition to the Cycle Rule in (3):

(3) **The Overlapping Cycles Rule:** Any variant that is connected to at least two variants within a cycle of variants belong to the same lexeme as the variants within the cycle.

We now move on to the Chain Scenario (**Figures 4**, **5**). In this scenario, variants 1 and 2 are related, and so are 2 and 3, but not 1 and 3. We need to decide how many lexemes are manifested here, and which variants belong to which lexemes.

First, let's handle the question of the number of lexemes[9]. For a chain of three variants 1, 2, and 3, we can propose one, two, or three lexemes. Proposing three lexemes is equivalent to removing the difference between lexemes and phonological variants completely, so we do not pursue this option further. Proposing that all the variants belong to the same lexeme might be acceptable, but this means violating the main criterion in (1), because now variants 1 and 3 belonging to the same lexeme are distinguished by more than one parameter. This leaves the option of the three variants belonging to two separate lexemes.

We propose that it is in fact possible to analyze a chain of three variants as two separate lexemes, and at the same time obey the main criterion, if we allow for one assumption: a single variant can belong to two separate lexemes. This means that in chains of variants, if variant 1 is related to 2, and variant 2 is related to 3, then 2 belongs to a lexeme together with 1, and 2 belongs to a lexeme together with 3. We then have two lexemes: Lexeme-A (1,2) and Lexeme-B (2,3).

In the case of the three variants of DARK.BLUE above (**Figures 4**, **5**), this means the following: there are two lexemes, DARK.BLUE-A and DARK.BLUE-B. The first lexeme has two phonological variants: DARK.BLUE-11 and DARK.BLUE-12. The second lexeme also has two phonological variants:

[8]After identifying lexeme boundaries, a separate step necessary in dictionary creation is determining the citation form, when factors such as frequency and iconicity of the candidate variants are taken into account (Cormier et al., 2012). We do not further discuss this aspect, focusing on the initial step of determining the number of lexemes and attributing the variants to these lexemes.

[9]This analysis is inspired by treatment of dialectal chains proposed by Hammarström (2008) with regards to determining the number of languages in situations of dialectal chains.

DARK.BLUE-12 and DARK.BLUE-13. We thus solve the question of where variant DARK.BLUE-12 belongs by stipulating that it belongs to two separate lexemes.

This solution might seem counterintuitive, but we argue that it is the best solution for the problem. First, in absence of other clues, it is usually impossible to decide where the "middle" variant in a chain should belong, as it is phonologically related to the two other signs to an equal extent. Second, having the same form belonging to different lexemes is a mechanism that is required in other scenarios anyway.

Consider homonymy: if we have concepts X and Y which are not related to each other, but both are expressed by the same form, we would say that this form indeed belongs to two different lexemes separately. To make an even more relevant example, imagine that we have two unrelated concepts X and Y, and both have two phonological variants. X can be pronounced as 1 or 2, and Y can be pronounced as 3 or 4. It so happens that the shapes of 2 and 4 are identical, but because the meanings they express are different, they are simply homonymous variants of different lexemes. Finally, the idea that the same form can belong to different lexemes has been applied in analyzing near synonyms in sign languages by Fenlon et al. (2015: 28–30), so our proposal only extends this idea to full synonyms (= lexical variants).

Note, however, that this solution does have a practical drawback in applied research. If we allow variant 12 to belong to two separate lexemes (DARK.BLUE-A and DARK.BLUE-B) in a lexical database, there will be two separate entries for the two lexemes, but they should both contain variant 12 as a phonological variant, which is cumbersome. Even more problematic is the fact that, if we then gloss a text where DARK.BLUE-12 occurs, there will be no way of deciding which of the two lexemes it should be identified as. A technical solution would be to use a double label (DARK.BLUE-A/DARK.BLUE-B), but again, this is not ideal. However, at the current moment, we do not see a better solution for the Chain Scenario.

With these solutions for the Cycle and Chain Scenarios, we also get the solutions for the Shared Vertex and the Connected Component Scenarios. For the former case (**Figure 10**), where a vertex is shared between two cycles, we can now easily say that the two cycles are two lexemes, and that the shared variant belongs to both lexemes.

For the Connected Component Scenario (**Figure 11**), again, each cycle within a connected component is analyzed as a separate lexeme, and if there is a chain, it is analyzed as consisting of several lexemes by the rules above, where variants can be shared between various chains and cycles.

To give a specific example, consider again the graph representation of ORANGE, repeated here in a modified form as **Figure 14**. 10 variants are unrelated to the others, and thus manifest 10 separate lexemes. In addition, variants 14 and 15 together are phonologically related and thus form a lexeme. There are two cycles: variants 1–6 form a lexeme, and variants 7,9,10,11,12 form a lexeme. In addition, 1 and 7 together form a lexeme, and 7 and 8 together form a lexeme. The proposed lexemes are represented by color shading (for lexemes with more than one variant) in **Figure 15**.

Problems With the Proposed System and Future Directions for Research

The system of rules proposed above has several problems, including technical and linguistic issues.

As discussed in the previous section, the decision to allow a single variant to belong to several lexemes introduces technical problems for lemmatization for dictionaries (Hochgesang et al., 2018), but especially for lemma-based glossing of corpus data (Mesch and Wallin, 2015). For such variants that are attributed to multiple lexemes, technical solutions exist. One solution already mentioned above is to use glosses in which both (or all) lexemes that share this variant are named. Another solution is to arbitrarily assign the shared variant to one of the lexemes, which is not problematic as long as this assignment is clearly registered in a protocol.

Linguistic issues are more serious, in our opinion. The proposed system of rules is built in order to preserve the binary opposition between separate lexemes and variants within a single lexeme. However, as we have seen, empirically the variety of relations between variants is more rich. Specifically, we observe the following cases of relations between pairs of variants:

(1) Two variants can have no relation to each other, not even through other variants (e.g., 20 and 21 on **Figure 14**). Clearly, such variants belong to separate lexemes.
(2) Two variants are not directly phonologically related, but there are some intermediary variants such that one can form a path (chain) of phonological relations between the two variants (e.g., 6 and 8 on **Figure 14**).
(3) Two variants are not directly phonologically related, but they form a part of a connected network of variants (they are part of the same cycle or overlapping cycles, e.g., 10 and 13 on **Figure 14**).
(4) Two variants are directly phonologically related (e.g., 1 and 2 on **Figure 14**).

Based on existing research, cases (1) and (4) above are clear. In (1), the pairs of variants clearly belong to two separate lexemes. In (4), the pairs of variants clearly belong to the same lexeme. The intermediary cases (2) and (3), however, need to be acknowledged, and probably analyzed separately in linguistic and psycholinguistic research. It might be the case that instead of having a binary opposition of lexemes vs. phonological variants, we need to have at least four categories (corresponding to the list above): **separate lexemes, connected variants, variants within cycles/overlapping cycles, phonological variants**.

In order to test the validity of these categories, we suggest the following steps:

- Analysis of networks of variants similar to the one presented in this paper should be applied to other signs in RSL and to other sign languages in order to explore and discover the possible configurations. More complex scenarios can be discovered that we have not yet identified. It might be possible to use existing databases of lexical variation for such research, for instance, the database for

Chinese Sign Language (Chen and Gong, 2020) would be very suitable for this type of analysis.
- It would be interesting to explore how various phonological processes (van der Hulst and van der Kooij, 2021) affect the configurations of variant networks[10]. For example, a weak hand drop, if phonologized, might lead to an emergence of a phonological new variant, and this variant can be incorporated in already complex network of existing variants and disturb or modify its structure. Both theoretical and actual scenarios should be explored.
- Sociolinguistic properties of the different categories should be explored. For example, it might be the case that the choice between separate lexemes and connected variants are explained by a factor which does not explain the choice of variants within a cycle or phonological variants, etc. In other words, it should be tested whether the four categories are distinguished in actual use.
- Psycholinguistic experiments should be carried out in order to explore whether the different categories we identify are distinguished in production and perception by native signers.

Furthermore, it can be useful to try and enrich the graph representation of networks by incorporating other factors:

- Frequency of variants should also be analyzed if possible. For example, it might turn out that some variants are much less frequent than others that they are phonologically related to (see, e.g., Chen and Gong for such findings for Chinese Sign Language); this information might be used to enrich the graph representation of the networks, and provide insights into the typology of configurations.
- Representations can be further enriched with phonological information. For example, one can add some indication of what the common components are between the variants that are phonologically related in order to study whether different components typically occur in different types of graphs (e.g., in cycles vs. chains).

Finally, it might be worth testing community detection algorithms on these variant networks (Fortunato, 2010). It would be interesting to see whether automatically detectable communities correspond to lexemes in our definition and to intuitions of native signers, at least for larger networks. As we have mentioned above, community detection algorithms may not be effective in detecting lexemes in such small networks, but some specific community detection methods offer interesting approaches that may allow us to explore structures of variant networks as weighted graphs using phonological information to calculate a numerically specific degree of overlap between different variants.

SUMMARY

In this paper, we demonstrated the patterns of lexical variation in sign languages in terms of phonological relatedness between the variants. In order to do so, we analyzed kinship terms and color terms in a newly created database of lexical variation in RSL. We proposed the use of a graph representation as a tool of visualizing relationships between variants.

We discussed that the usual approach to distinguishing phonological and lexical variants of signs does not work in some cases (the problematic scenarios). These scenarios turn out to be well attested in RSL. Further, by studying these configurations, we therefore developed a system of rules to handle such cases. While the system is somewhat complicated, it allows to fully handle the extent of the variation at play.

At the same time, we conclude that the actual patterns of possible relations between variants has to be acknowledged. Instead of focusing on the binary distinction between lexemes and phonological variants, it might be necessary to distinguish at least four categories: separate lexemes, connected variants, variants within a cycle, phonological variants. However, further linguistic and psycholinguistic research is necessary to establish psychologic reality of these categories.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/**Supplementary Material**.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

VK wrote the manuscript with contributions from the other authors. All authors participated in designing the study, developing data collection, annotation of the database, and analyzing the data.

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[10]We thank a reviewer for this suggestion.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.740734/full#supplementary-material

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REVIEW
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Big Things Often Have Small Beginnings: A Review on the Development, Use and Value of Small and Big Corpora for Flemish Sign Language Linguistic Research

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In 1990, Vermeerbergen started the first larger-scale corpus study with (semi)spontaneous language data from adult signers on the morpho-syntactic aspects of Flemish Sign Language (VGT). After this, a number of lexicographic projects, including the collection of a 90-h corpus, led to the launch of the first online bilingual Dutch/VGT—VGT/Dutch dictionary in 2004. Since then, researchers have developed several corpora of variable sizes, with the greatest realization being the VGT Corpus. The main focus of this chapter is twofold. On the one hand the run-up to, the development and the use of the VGT Corpus will be discussed, while on the other hand smaller specific research corpora will be highlighted such as the corpus on early parent-child interaction and the multifocal eye-tracking corpus. The current chapter will discuss the research and community value of the corpora and future directions. Finally, it will elaborate on the need for corpus research, the associated advantages and disadvantages, and the obstacles faced in smaller deaf communities.

Keywords: Flemish Sign Language, corpus linguistics, grammar, lexicography, sociolinguistics, automated sign language recognition, parent-child interactions, multifocal eye-tracking

INTRODUCTION

This article focuses on corpus developmental and documentary approaches to sign language research. It gives a major overview of the different Flemish Sign Language (VGT) projects utilizing various corpora in the past decades, with the main achievement being the VGT corpus (Van Herreweghe et al., 2015). The current state of affairs in Flanders and what we have learned from the development in sign language research will be discussed by looking at past, current and on-going projects. Prior to this, the chapter starts with a background description of Flemish Sign Language, the Flemish Deaf community and the main corpus project initiators. We are aware of the fact that in the past any set of data on which a linguistic analysis was performed was called a corpus but that with the advent of computer technology and corpus-based linguistics, use of the term "corpus" has become more and more restricted to any type of collection of texts in a machine-readable form. Nevertheless, we prefer to also label these older "datasets"

corpora since we have the associated metadata and they were transcribed and/or annotated in machine readable text files—usually in Word -, be it not in an integrative way, i.e., not by means of a computer program that links the video data to transcription/annotation tiers as for instance the ELAN annotation software (Wittenburg et al., 2006).

After a unanimous vote, Flemish Sign Language was officially recognized by the Flemish Parliament in April 2006. The Flemish Government recognized VGT as a minority language used by the Deaf community in Flanders, for whom VGT possesses an identifying role (Vermeerbergen and Van Herreweghe, 2008; Van Herreweghe et al., 2016). Keeping in mind that not all deaf children acquire VGT and that not all signers are born deaf [e.g., interpreters, hearing children of deaf adults (CODAs)], Loots et al. (2003) estimated that there are 5,000–6,000 deaf Flemish Sign Language users. About 95% of them have hearing parents—i.e., who do not know how to sign at the time of their child's birth. The vast majority of deaf people have acquired their sign language at the deaf school they attended.[1] Hence, there are five distinct VGT regiolects corresponding to the areas around each Flemish deaf school which more or less coalesce with the Flemish provinces. Apart from regional variation, some gender-related differences—this inter-gender variation is especially visible in the older generations—can be noticed due to the existence of separate schools for boys and girls until the 1970s (De Weerdt et al., 2003; Vanhecke and De Weerdt, 2004; Jonckers, 2013). The Flemish Deaf community has formally rejected an imposed standardization and has instead openly stated to support and promote the ongoing spontaneous standardization process of the language (Van Herreweghe and Vermeerbergen, 2009). Therefore, inter- and intra-regional variation needs to be taken into account in every analysis of VGT.

The largest share of work focusing on the description of Flemish Sign Language has been continuously carried out by researchers now affiliated with Ghent University, KU Leuven and/or the Flemish Sign Language Center (VGTC). The VGTC, a non-profit organization, was founded in 1997. Later, in 2006, it was stipulated in the decree on the recognition of Flemish Sign Language that structural funding would be provided to the VGTC to develop as an independent center of expertise with respect to VGT (Van Herreweghe et al., 2016). Over the years, these three VGT research hubs have shared and supported each other in their own and in joint projects. However, the overall number of active researchers remains scarce.

SMALL CORPORA: PAVING THE WAY TOWARD THE FLEMISH SIGN LANGUAGE CORPUS

This section discusses the development of early small corpora, the data collection process, and their results. It highlights the main studies on grammatical (2.1) and lexicographic research (2.2) since the start of VGT research in the 1990s until the establishment of the VGT Corpus in 2015.

Grammatical Research From 1990 to 2015

The First Large Scale Study

When it comes to descriptive grammatical research, groundbreaking work was carried out by Vermeerbergen in the early 1990s, culminating in her PhD dissertation (1996). She collected and transcribed a corpus consisting of 6 h of spontaneous sign language data—4 h of dialogues and 2 h of monologs—produced by 10 (near-)native signers, at the time of the study between 30 and 83 years old. This spontaneous data was complemented with additional data, including narrative retellings as well as the elicitation of declarative (locative and non-locative) sentences from 14 informants (aged 22–86) based on the Volterra et al. (1984) picture task.

First, the full corpus was used to try and define VGT's "basic word order," i.e., the word order of simple declarative, active clauses. However, for VGT, a combination of one verb with two arguments (whether SVO or SOV) was less common than a combination of two clauses, each representing a subject/predicate structure (mostly as SVSV). The first part of the sentence constitutes the framework for the second part, which allows the combination to be seen as a topic/comment structure.

Second, with regard to Vermeerbergen's other main research theme, i.e., the expression of the relationship between the verb and its arguments, her research shows that word order only plays a minor role (1996). Rather, VGT signers most often use one or more other linguistic mechanisms and constructions to indicate this relationship, including verb agreement, "classifier predicates," the use of loci and pointing signs, role shifting (a.k.a. shifted attribution of expressive elements) and reference shifting, manual simultaneity and dominance reversals. Many of these mechanisms and constructions had already been described for other signed languages but had not yet been studied for Flemish Sign Language. In the following years, the main corpus, i.e., the 4 h of spontaneous dialogues, 2 h of monologs and 30 min of elicited narrative retelling, was used for several studies, e.g., on the use of space, non-manuals, classifiers and the productive lexicon, and simultaneity (e.g., Vermeerbergen, 1998, 2001, 2006; Vermeerbergen and Demey, 2007; Vermeerbergen et al., 2007a).

Other Grammatical Studies

Later, in the early 2000s, Van Herreweghe and Vermeerbergen (2003) jointly engaged in a new contrastive VGT—Dutch study focusing on reference tracking. The participants were asked to watch an animated cartoon, i.e., "Quatre à Voyager," containing four main characters, all male (Faton and Theunen, 1983). The cartoon lasts about 7 min and does not contain any spoken interactions, nor subtitling. All the participants watched the cartoon twice and were asked to then narrate the story in written Dutch or in VGT. For the written Dutch stories there were 119 school-aged participants (these were collected by Van Herreweghe as part of her PhD research; Van Herreweghe, 1996). Eight signers participated in the production of the VGT narratives of whom six were native signers (four adolescents and

[1]This might, however, be different for the current generation of deaf children. These pupils integrate more regularly into mainstream education compared to the older generations.

two adults) and two were near-native signers (both adults). Van Herreweghe and Vermeerbergen (2003) showed that in VGT the protagonists could be referred to by means of full noun phrases (which was quite rare), pointing (in various ways), role and reference shifting, null arguments with (spatial) verb agreement or by simply deleting the subject (which is only possible in connected signing).

Shortly afterward the same researchers collaborated in a descriptive study on interrogatives and negatives in VGT (Van Herreweghe and Vermeerbergen, 2006). This time they used three small corpora: (1) parts of the corpus which was used by Vermeerbergen for her PhD, (2) nine versions of the "Quatre à Voyager" story (i.e., six versions by native signers and three by near-native signers), and (3) a game with two pairs of (near-)native signers who asked each other questions to which they expected a negative answer while none of them were allowed to simply sign YES or NO. In this way, more elaborate affirmative or negative utterances were elicited (this is a common children's word game in Flanders).

In 2008, De Weerdt and Vermeerbergen further explored the expression of possession and existence in VGT. This study was part of a larger project coordinated by Ulrike Zeshan's Sign Language Typology Group (Zeshan and Perniss, 2008). The researchers' descriptions and the detailed number of examples were based on a questionnaire and additional data elicited from three near-native VGT-signers (De Weerdt and Vermeerbergen, 2008).

In the same year, the Flemish Sign Language Center initiated its first two research projects, namely on the topics of formation of plurals and the use of classifiers for the concepts "car," "person," and "bird" (Heyerick et al., 2011, 2014). The research data was primarily collected in the context of their study on plural formation (Heyerick and Van Braekevelt, 2008). The elicitation material used for these studies were 156 pictures of one object, two objects, multiple countable objects, and multiple uncountable objects (Kubuş, 2008; Zwitserlood et al., 2012). In addition to pictures, the participants were also exposed to two videos related to the researchers' specific research questions, i.e., an advertising film for cars (duration 1:01) and the cartoon Birds (duration 2:38). Considering the (inter-)regional, gender and age variation, a total of 40 deaf VGT signers agreed to participate, i.e., 20 as active signers and 20 as interlocutors or recipients. This yielded 12 h of video data. Through this approach researchers were able to describe some mechanisms behind the formation of plurals and the formation of classifiers of those three specific referents, i.e., car, person, and bird. However, they stated that additional research is desirable and could include—among other suggestions—the recording and analysis of more spontaneous conversations (Heyerick et al., 2011).

Through cross-linguistic research, Vermeerbergen and Van Herreweghe also contributed to a further understanding of the degree of similarity between (un)related sign languages. The projects include the description of constituent order and verbal predicates in VGT and South African Sign Language (SASL) (Vermeerbergen et al., 2007b; Van Herreweghe and Vermeerbergen, 2012b). For this, a corpus driven by the Volterra et al. (1984) picture elicitation task was collected consisting of similar VGT and SASL-data, i.e., 4 signers per language producing the 18 sentences. The same type of data was collected for a cross-linguistic study including elicited declarative sentences from VGT, Irish Sign Language (ISL), and Auslan (Johnston et al., 2007). These studies showed that for non-locative sentences Flemish signers use both SVO and SOV order, with a preference for SOV in sentences with non-reversible arguments and SVO in sentences with reversible arguments. Whereas lexical verbs more often result in SVO order, productive "classifier predicates" appear in the final position. Furthermore, the analysis shows that, especially in the case of sentences with reversible arguments, Flemish signers often build more complex multi-clausal sentences or add elements such as an additional (main or light) verb resulting in split sentences, serial verb constructions or verb sandwiches.

Lexicographic Research

From 1999 onward, several VGT lexicographic projects were conducted, which eventually led to the launch of the first online VGT/Dutch—Dutch/VGT dictionary in 2004 (see Van Herreweghe et al., 2004).[2] This dictionary was based on the collected data of 30 informants, 6 per regional team. Each team consisted of deaf men and women between the ages of 20 and 50, all having a thorough proficiency in their regional VGT variety which they used in their daily lives. The informants had been educated at a deaf school and they all identified as being active members of the Flemish Deaf community. Within each regional team a deaf native VGT-signing moderator was appointed. These moderators received some prior training on eliciting and collecting the required data correctly. The full deaf team engaged in 6 thematic meetings, which eventually resulted in 90 h of recorded language data (see Vermeerbergen and Van Herreweghe, 2018 for a detailed overview of the thematic lists, the procedure, and the analysis). Since then, some studies have been conducted using the dictionary as their primary source of analysis. For instance, Demey's doctoral dissertation is the sole extensive description of the phonological structure of VGT (Demey, 2005). This in-depth study includes a detailed phonetic transcription of 2,424 lexical signs, fingerspelling, and numbers. The results indicate that not only considerations of a phonological and phonetic nature are important when describing the form of signs, but also that the role of iconicity should not be underestimated. Further, contrastive research based on these transcriptions and analyses, and the phonological structure of the Sign Language of the Netherlands (NGT) demonstrates striking similarities, i.e., neighboring regions sharing the same spoken language, viz. Dutch (Vermeerbergen et al., 2013). Apart from a few frequency differences and additions to phonetic or semantic implementation rules, there is only little variation found among the two languages on a phonological level.

As part of her bachelor's studies, De Putter (2016) used the VGT and NGT dictionaries to compare the signs for 100 basic concepts in both languages. She compared the manual parameters of the selected signs and found that the two languages have more signs classified as being different than similar or identical. The hand configuration proves to be the most language-specific parameter. The analysis of the non-manual parameter,

[2]https://woordenboek.vlaamsegebarentaal.be

however, reveals that the mouthing, derived from spoken Dutch in both languages, was identical in 85% of the cases and thus supports mutual intelligibility among these two sign languages.

THE DEVELOPMENT OF A PUBLICLY ACCESSIBLE FLEMISH SIGN LANGUAGE CORPUS

The previously described early grammar and lexicographic projects have several things in common. Their results are based on the VGT productions of a limited number of deaf signers, recorded in a variety of different settings. Moreover, there is a rather small group of deaf VGT signers actively engaged within the Flemish Deaf community who have often been asked to participate in research. As a consequence, some of them regularly recur in several of these studies. In that way, the patterns that were identified in the different datasets might not be representative for the entire Flemish Deaf community. It should be noted that in most of these studies, the participating signers had to perform different elicitation tasks linked to a specific research question. Apart from Vermeerbergen (1996), these tasks often did not include free conversations, for instance. Moreover, these smaller corpora were never made publicly accessible since the informants had not been asked to consent to that. Consequently, the video data usually remained on different types of (analogous) videotapes or more recently on DVDs in the offices of the researchers. Only the transcriptions of the VGTC projects were carried out in the ELAN annotation software (Wittenburg et al., 2006), while the transcriptions of the other studies were mostly done in a separate text file. What's more, the transcriptions were usually not complete since they only focused on the item to be studied. Also, the metadata collected were frequently of a different nature and therefore not always comparable. For all these reasons the demand for a representative corpus of Flemish Sign Language became more pressing.

Eventually, from 2012 to 2015 several VGT researchers collaborated in the development of an open access VGT Corpus (Van Herreweghe et al., 2015; Verstraete et al., 2015).[3] The corpus was established to function as a core data source for any research effort aimed at analyzing VGT or comparing VGT with other (signed) languages. The machine-readable digital corpus of naturalistic and elicited Flemish Sign Language data includes more than 140 h of face-to-face interactional video data with a frame rate of 50 per second and a resolution of 960 by 544 pixels. Over the stretch of a number of years the research team collected data of 119 signers, i.e., native and near-native signers, men and women, with deaf parents and with hearing parents, between 12 and 91 years old. Overall, the corpus establishes a permanent and representative record of all VGT varieties, enabling the formulation of new observations on the use and structure of VGT. Moreover, it has a documentary function since the informants recount stories of their own schooldays, of activities in the Deaf community etc. The reference corpus of VGT can also be utilized for cross-linguistic purposes since part of the elicitation materials is used in research of other (sign) languages too (e.g., Sallandre et al., 2016).

Along with the collected metadata—personal background, patterns of language use, degree of bilingualism in VGT and Dutch, the corpus consists of elicited data, elicited and spontaneous narratives, conversational data as well as on-topic interviews (name sign, language attitudes, daily life during WWII etc.). In pairs, participants were asked to retell stories [e.g., "Frog where are you?" (Mayer, 1969) and "Quatre à Voyager" (Faton and Theunen, 1983)], to engage in free conversations, to sign the Volterra sentences (Volterra et al., 1984), to give road directions to the interlocutor, to explain the meaning behind their name signs, etc. The corpus is further enriched with ID glosses using the ELAN software (Wittenburg et al., 2006). The VGTC is currently working on a link with the VGT Signbank to incorporate ID-glossed signs into a lexical database and the dictionary.[4] Since the start of the project 40 h of the data have been transcribed, i.e., for established lexical items with ID-glosses and for productive signing with a basic semantic annotation (both in written Dutch). As part of certain smaller research projects, some data in the corpus have been enriched with more detailed annotations on several aspects of the lexico-grammar of VGT. Several narratives have, for instance, been segmented and annotated for depicting signs and other types of depictive tokens, constructed action and role shifting, but also mouthings and eye gaze (e.g., Van Herreweghe and Vermeerbergen, 2012b; Beukeleers, 2015, 2016, 2020; Vaes, 2015; Pattyn, 2016; Beukeleers and Vermeerbergen, 2017; Braes, 2019; Van de Velde, 2019; De Vos, 2020; Goris, 2021). More recently, several researchers have also started annotating some of the conversational data in more depth while focusing on a certain aspect. As part of her bachelor's paper, Aerts (2021) analyzed the data for PALM-UP and Jenard is—as part of an ongoing doctoral research project (MUST, 2020–2024)—analyzing the data for stance taking.

Finally, a small part of the data has been subtitled in Dutch—mostly explanations of people's name signs—and therefore so far only these excerpts can be made available to and understood by a broader audience.

RESEARCH USING THE FLEMISH SIGN LANGUAGE CORPUS

The VGT Corpus has frequently been consulted for educational and research purposes in recent years. This section provides a brief overview of studies that used the VGT Corpus—going from short-term projects in the context of Students' research to larger PhD and long-term projects—and discusses the added value of these studies. We discuss how the corpus has been used to re-test previous claims in the VGT literature (4.1), to fill in particular research gaps (e.g., lexico-grammatical and sociolinguistic variation) (4.2), and as a source for the development of automatic

[3]http://www.corpusvgt.be

[4]The VGT Signbank—part of the Global Signbank (Crasborn et al., 2018)—has currently about 20 000 entries of which 9959 are already accessible through the online dictionary. Every entry in the dataset receives a unique code referring to the corresponding ID gloss.

sign language recognition software (4.3). Finally, the status of the VGT Corpus will be explained (4.4).

Re-testing Previous Claims on a New Corpus and Documenting Language Change

As a consequence of natural language evolution, a constant revision of Flemish Sign Language linguistic research and outcomes is necessary (Vermeerbergen and Van Herreweghe, 2018). Moreover, as stated above, previous research was often carried out based on small and on-topic corpora with frequently recurring informants. Therefore, several researchers have repeated previous analyses on a new and more diverse corpus. In this way, they were not only able to re-test previous claims in the early VGT literature, but they could often also shed light onto language change in this particular language. Most reproduction studies were part of Students' BA and MA papers, all supervised by at least one of the authors. Vandewalle (2016), for instance, used the corpus to re-test previous claims about the expression of negation in VGT reported on in Van Herreweghe and Vermeerbergen (2006, 2011). In his bachelor's thesis, he analyzed data from 80 selected tasks produced by 82 participants, including both men and women across ages and regions. Results of the analysis of 599 tokens of negation show that manual negation signs do occur without an accompanied head movement. In this way, Vandewalle thus refutes the mandatory character of the head shake or negative hold in the expression of negation in VGT described in previous research (Van Herreweghe and Vermeerbergen, 2006, 2011). The "why" and "how" behind the findings are, however, still under investigation, as these questions are hard to answer on the basis of corpus data only.

In a similar vein, Braes (2019) echoed the work of Vermeerbergen (1996) to investigate word order and a possible evolution or change in VGT word order since the late 1990s. In the context of her bachelor's thesis, she analyzed the Volterra declarative sentences (Volterra et al., 1984), taken from the VGT Corpus, which were produced by 6 informants (3 male and 3 female, 19–25 years old). Braes (2019) found that SVO still is the most commonly used sequence for sentences with reversible arguments. However, for sentences with non-reversible arguments no clear pattern stood out as SOV, SV and SVO were all found, indicating a large word order variation. Thus, Braes (2019) showed many similarities with the findings of Vermeerbergen (1996) and—however, based on fewer participants—carefully suggests that there is no distinct evolution or change in the word order of Flemish Sign Language.

Filling in Some Research Gaps

As mentioned in the introduction, research on the lexico-grammar of VGT started only in the early 1990s. Moreover, there are not many researchers actively analyzing VGT. As a consequence, many aspects of the language have not yet been studied (in great detail). Therefore, some researchers have been using the corpus to address some research gaps. In this way, the VGT Corpus has paved the way for some initial studies on, for instance, the influence of elicitation materials on the use of signing space (Beukeleers, 2015, 2016; Beukeleers and Vermeerbergen, 2017), the functions of the sign TO-HAVE (Sampson, 2016), repetitions (Notarrigo et al., 2016), mouthings and mouth gestures (Pattyn, 2016; Van de Velde, 2019; De Vos, 2020), constructed action (Beukeleers, 2020; Goris, 2021), and the functions of PALM-UP (Aerts, 2021).

As researchers have transcribed and partly annotated the corpus data in ELAN, the corpus is developing into a full machine-readable corpus, which not only simplifies the analysis of the data, but also facilitates the exportation of the data to other software. As a result, most recent studies—including the studies mentioned above—now report on the exact frequencies behind the patterns and more quantitative research has been initiated. In this regard, the development of a machine-readable corpus of VGT language use has enabled, for instance, some first studies on lexical frequency (Sampson, 2017; Bruynseraede, 2018). Analyzing 8 and 20 narratives, respectively, Master students Sampson (2017) and Bruynseraede (2018) found that fully lexical signs, i.e., established form-meaning pairings, are the most frequently used signs in the data. These conventionalized forms are followed by signs from the productive lexicon, i.e., classifier constructions and constructed action. Pointing signs and gestures occur less frequently.

Quantitative studies like the ones above are not only highly relevant for a more thorough and comprehensive description of the lexico-grammar of VGT, but also for the field of applied linguistics (Johnston, 2010). Based on the frequencies of signs and formulations, teachers can provide L2 learners with the most frequent vocabulary and formulations first. Less frequent signs and formulations can then be integrated later in the L2 training program. In this way, insights from studies based on the VGT Corpus can—in the long run—be integrated in the curriculum of VGT training programs.

When reviewing the literature on Flemish Sign Language, it also becomes apparent that since the development of the VGT Corpus, more researchers have carried out sociolinguistic research. Vermeerbergen and Van Herreweghe (2013), for instance, analyze 12 retellings of "The Horse Story" (Hickmann, 2003). They selected participants from 3 generations of signers: 17–25 years old, 40–50 years old, and + 75 years old. For each generation, Van Herreweghe and Vermeerbergen selected 2 native and 2 non-native signers. Results reveal age-related variation in the choice for a particular sign type. Whereas older signers (+75 years old) use elements of the productive lexicon, i.e., classifier constructions and bodily enactment, more frequently, younger signers rely more heavily on the frozen lexicon, i.e., on established form-meaning pairings.

Other topic-specific sociolinguistic research on VGT, carried out by BA and MA students, includes a study on internal and external linguistic factors influencing the variation of the two-handed sign COW (De Putter, 2019), on age-based lexical variation in the choice for signs that refer to the days of the week (Swennen, 2018), on register variation (Vandewalle, 2018), on gender-based variation in simultaneous constructions (Van Deuren, 2019), and on regional variation in the expression of negation (Hollevoet, 2021).

The Flemish Sign Language Corpus as a Source for the Development of Automatic Sign Language Recognition Software

Finally, the VGT Corpus is also being used in sign language recognition studies (SLR). Several doctoral researchers have used the data to develop Automatic Sign Language Recognition software. Pigou (2018), for instance, focused on deep neural networks. To overcome the relatively small size of the already transcribed sections of the VGT Corpus at the time, other data such as transcribed interpreted Flemish TV news broadcasts and the NGT Corpus (Sign Language of the Netherlands; Crasborn et al., 2008)—which included more annotated data—were also included in the study (Pigou, 2018). De Coster's PhD research focuses on video transformer networks with hand cropping and pose flow (De Coster et al., 2021). As there are still many open research questions regarding SLR, two new promising interdisciplinary research projects have been launched since. These European SLR projects—that is SignON (European Commission, 2020b) and EASIER (European Commission, 2020a) funded by Horizon 2020—aim to facilitate the exchange of information among hearing and deaf individuals across Europe, each including several spoken and signed languages. In this light, the VGT Corpus is not only used for the purpose of theoretical language description, but also as a data source for the development of, for instance, automatic translation of VGT into written/spoken Dutch.

The Current Status of the Flemish Sign Language Corpus

In sum, this section has shed light on the added value of the VGT Corpus in the study of Flemish Sign Language. In doing so, we have shown that the corpus has allowed researchers to re-test previous claims in the early literature on new (and often more) data, to fill in particular gaps in our knowledge about the structure of VGT, to document sociolinguistic variation and in the development of automatic sign language recognition and translation software. Although the corpus has proven to be an important asset in the study of VGT in the last 6 years, it should be noted that the development of the corpus itself is in many ways still in its infancy. Due to the limited number of researchers working on VGT large parts of the corpus have not been transcribed and/or annotated (in great detail). Consequently, the size of the datasets of current studies on VGT still remains rather small and thus many of the findings and conclusions in the studies reported on above, are still rather preliminary. We will return to this in the discussion of this paper (see section "Discussion").

BEYOND THE FLEMISH SIGN LANGUAGE CORPUS

In the context of several doctoral projects, two small corpora have been developed over the years focusing on other aspects of Flemish Sign Language. The first corpus is based on early dyadic parent-child interactions (Loots, 1999; Mouvet, 2013) and a second one, the multifocal eye-tracking corpus, combines the use of static cameras with mobile eye-tracking devices to study the role of eye gaze in triadic VGT interactions (Beukeleers, 2020).

A Corpus for the Study of Early Parent-Child Interactions

The first corpus, based on early parent-child interactions, calls on the data collection of the doctoral projects of Loots (1999) and of Mouvet and Matthijs (2010–2013).[5] This full corpus—compiled with data collected at two different points in time—is innovative for VGT in many ways. It includes an age group not studied before, interlocutors of different ages, different language backgrounds, spontaneous conversations etc. The corpus includes infants aged 6 months up to 2 years old. The video recordings contain parent—child interactions of when the children were 6, 9, 12, 18, and 24 months old. The researchers aimed to fully reflect the heterogeneity of the general population of deaf children, e.g., language background and auditory support. Overall, 90–95% of the deaf children are raised in a hearing family with no prior knowledge on deafness or the visual modality. Therefore, the corpus includes many hearing parents and a handful of deaf parents. All children were deaf or hard of hearing (DHH). Researchers of both projects made sure that all regions in Flanders were represented in their corpus. The initial corpus consisted of 20 parent-child dyads, with 13 originating from hearing families and 7 from deaf families. Data collection included mothers and fathers interacting with their DHH child. These interactions were recorded in a therapeutic setting. Mouvet and Matthijs based their work on the early interactions of DHH children in 12 hearing families and 1 deaf family. All interactions were recorded in the home setting. Depending on children's age and concentration span, and the initial research purposes these recordings vary from 7 to 45 min of dyadic interactions.

The corpus has been analyzed by Loots (1999); Mouvet (2013), Matthijs (2018), and Wille (2018) for different research purposes and has given us a first and profound insight in the early interactions and language environment of deaf infants. Loots, for instance, concluded that parents who do not communicate visually and in a sequential manner with their deaf child stagnate in the transition from existential to symbolic intersubjectivity between the ages of 18 and 24 months (Loots and Devisé, 2003a; Loots et al., 2005a). Mouvet (2013) later showed that the functional development of the deaf children of hearing parents in her study was clearly delayed, showing individual developmental patterns with respect to language(s) and/or modality(ies). She continues by stating that these deaf children, regardless of the type of auditory support, do not perform on par with their hearing peers nor is their signed lexicon comparable to that of their deaf native signing peers, potentially resulting in semilingualism. In addition, Wille et al. (2018), who analyzed data collected by Mouvet and Matthijs, were the first to describe the VGT development of a deaf child growing up in a deaf signing family, with respect to dyadic face-to-face

[5]Mouvet and Matthijs collected their data together during the period 2010–2013, resulting in two PhD dissertations (respectively, in 2013 and 2018).

interactions. Along with a more extensive corpus analysis, using data from Loots (1999), and Mouvet and Matthijs (2010–2013), this research provided the basis for the development of early interaction guidelines for professionals; including deaf children's early visual milestones (Wille et al., 2019, 2020a,b). The studies above, emphasize the benefits of a bimodal bilingual approach which can facilitate language development and may form a supportive basis for the children's full language potential.

The corpora further also formed the base of research on early communication strategies used by deaf and hearing parents (mothers and fathers) in interaction with their DHH children. Through their analyses, these researchers have been able to show the influence of parents' hearing status, gender, and language choice on their use of these strategies (Loots and Devisé, 2003b; Loots et al., 2005b; Wille et al., 2019). In line with these findings, Matthijs (2018) highlights the role of *good quality* parental communication strategies within deaf children's development of intersubjectivity in mother-child interactions. The researchers above all highlight the insufficient visual support hearing parents receive and indicate that deaf parents can be seen as role models for all hearing parents when it comes to efficient early communication with a deaf child, independent of children's auditory support and parental language choices.

A Multifocal Eye-Tracking Corpus

Most recently, a new corpus for the study of the role of eye gaze in VGT interactions was developed. Beukeleers PhD project (2020) investigated the role of eye gaze in VGT interactions focusing on its functions regarding turn management and its various functions in the lexico-grammar. When reviewing the sign language linguistics literature, it became apparent that many topics related to the functions of eye gaze in interaction management have not been studied in great depth. Moreover, most of the existing studies analyzed only a limited amount of data (i.e., 2–13 dialogues, see Baker, 1977; Lackner, 2009) and focused merely on the analysis of dialogues, where there might be less competition for the floor compared to triadic and multi-party interactions. Moreover, most researchers have mainly analyzed these functions of eye gaze in video data that were only recorded with (a) static camera(s). It is, however, not straightforward to analyze interlocutors' gaze behavior in this type of datasets, because the videos do not allow researchers to determine the exact point of fixation, i.e., to determine where the participant is exactly looking at. Researchers rather have to estimate participants' gaze directions by relying on their head and eye movements. To overcome these limitations, Beukeleers et al. (2020) opted to build a new corpus using a multifocal eye-tracking approach (see Brône and Oben, 2015). This corpus contains 10 unscripted triadic VGT interactions, including both conversations on a topic of the participants' choice and brainstorm sessions on a given topic. Each conversation lasted about 20 min and in total 2 h55 of data were collected. Altogether, 12 fluent signers—male and female—have engaged in the interactions. The participants come from the 5 different regions in Flanders and vary in age (22–75 years old). Participants were grouped per 3 and seated in a triangle to ensure that they had equal visual access to both co-participants. The interactions were recorded with 3 static cameras and participants were also equipped with mobile eye-tracking devices which record the environment from each participant's perspective and simultaneously measured their eye movements (Beukeleers et al., 2020; for more technical details see Beukeleers, 2020).

This dataset has made it possible for researchers to analyze unaddressed participants' gaze behavior during question-response sequences in triadic interactions. By timing the unaddressed participant's gaze shift in relation to the end of the question of the signer and to the beginning of the next signer's response, Beukeleers (2020) and Beukeleers et al. (2020) have used ratified participants' gaze shifts as an empirical measure of anticipation in face-to-face signed discourse. In this way, they have contributed to a better understanding of turn processing and anticipation in interaction (Beukeleers, 2020; Beukeleers et al., 2020). Moreover, the eye-tracking data allow for an analysis of signers' gaze behavior in the construal of multimodal depictions and in turn management, i.e., two functions that have gained only little scholarly attention within the field of sign language linguistics. Beukeleers (2020) has, for instance, shown how these functions can co-occur and compete in spontaneous conversation. Whereas previous studies have often assumed that signers systematically look at depictions when creating them, Beukeleers (2020) has shown that gaze patterns rather differ according to, for instance, the type of turn (depictions in a question vs. non-question turn) and the position of the depiction in the turn (e.g., turn-medial vs. turn-final position). Hence, she argues that eye gaze plays a prominent role at different levels of social interaction and that its function is dependent on the context it occurs in and the social action that is being performed (see also Rossano (2012) and Kendrick and Holler (2017) for spoken Italian and English, respectively). Parallel corpora are available, thus it is not only possible to further explore other social functions of eye gaze and their interplay in VGT discourse, but also to initiate comparative studies on the use of eye gaze, and even more broadly, the multimodal nature of face-to-face interaction and the tight integration of gesture and language.[6]

DISCUSSION

This section contains a critical reflection on the need for and the use of corpus research. It will elaborate on the associated advantages and disadvantages of corpus development, and the obstacles faced in smaller deaf communities.

Corpus linguistics goes hand in hand with the possibilities offered by more and more advanced computer technology. These advancements have allowed us to store large amounts of digital data, and to develop time-aligned annotation software such as ELAN.[7] Indeed, Johnston (2009: 18) argues: "Corpus linguistics is based on the assumption that processing large amounts of annotated texts can reveal patterns of language use and structure not available to lay user intuitions or even to export detailed

[6]See, for instance, Vranjes (2018) for a multifocal eye-tracking corpus of interpreter-mediated spoken Dutch-Russian conversations, Jehoul (2019) for a multifocal eye-tracking corpus of spoken Dutch conversations and Vandemoortele (2020) for a multifocal eye-tracking corpus of musical interactions.

[7]https://archive.mpi.nl/tla/elan

linguistic analysis of particular texts." In corpus linguistics, "quantitative analysis goes hand in hand with qualitative analysis" (Leech, 2000, p. 49). The same obviously holds for sign language corpora. The research value of the collected authentic language data for VGT has proven to be undeniably high. Since the 1990s individuals' intuitions have been gradually supplemented by concrete linguistic evidence from smaller scaled specific corpora. The more recently developed and (partly) searchable VGT Corpus allows for a large-scale approach and in-depth analysis of almost all language patterns. Through this new data collection and analyses, initial statements have been and will be rejected, confirmed, or broadened. New statements have also been formulated on targeted questions linked to region, gender, age, register, and task variation. Nevertheless, even though more and more signed language corpora emerge, we still feel that for certain types of research, it is recommended to adopt an integrated approach in sign linguistic research as was stated in Van Herreweghe and Vermeerbergen (2012a, p. 1033). Such an approach could involve analyzing corpus data (quantitatively and qualitatively), making hypotheses on the basis of this analysis and checking these hypotheses against native signers' intuitions. The latter comes with risks as Pateman (1987, p. 100), for instance, argued: "it is clear and admitted that intuitions of grammaticality are liable to all kinds of interference 'on the way up' to the level at which they are given as responses to questions. In particular, they are liable to interference from social judgments of linguistic acceptability." However, we feel that the combination of corpus data analyses and subsequently tapping into native signers' intuitions can to a large extent mitigate this kind of interference. What is more, certain rare constructions may not occur in the corpora at hand and negative information (i.e., ungrammatical or unacceptable utterances) cannot be inferred from corpora. That is why native signers' intuitions, grammaticality judgment tasks, and experimental studies should remain complementary to corpus research.

The open access nature of the videos included in the VGT Corpus allows all of us to witness how language is used in different contexts by different signers, as it includes many different tasks and is balanced for age, gender, and region. This data should then be accompanied by transcriptions which convert it into a machine-readable and searchable corpus, to facilitate more complex analyses, instead of a static archive. Researchers working on the VGT Corpus project have so far mainly focused on the transcription of the manual production, i.e., of established and productive signs. Fully annotating a signed corpus is extremely labor intensive and time consuming. Crasborn (2014) mentions that "glossing in annotation software can take as much as 200 times real time to do consistently—assuming there is already a full lexicon with ID-glosses available for reference," such as a Signbank. In the future this might change due to the current efforts toward automatic sign recognition (see section "The Flemish Sign Language Corpus as a Source for the Development of Automatic Sign Language Recognition software"). At the moment the most frequently occurring signs in the VGT corpus, for instance, can be transcribed with a relatively accurate automatic sign recognition tool using a drop-down menu with five suggestions of the most likely automatically recognized sign (Pigou, 2018; De Coster et al., 2021). It is expected that quite a lot of progress can still be made in this area and VGT annotators impatiently look forward to this. After several years of varying work intensity, the transcription and annotation process is still not finished for the VGT Corpus, so that researchers continuously transcribing and annotating the collected data are necessarily engaged in long-term work. Many countries face a similar slow annotation process, not only because of the technical aspects related to annotation, but also because of financial reasons. It is often impossible, once the video data for a corpus is collected, to find additional funding to add the much needed annotations to the corpus. As a result, annotations are often done in the context of student theses or doctoral projects. This precisely contradicts some of the initial aims of building a corpus, i.e., direct use and facilitation of (complex) linguistic research with the help of a fully machine-readable corpus, where researchers would not have to put so much time into annotation anymore. Consequently, the size of the datasets that have been annotated and analyzed in light of these projects still remains rather small and mostly topic specific. Thus, large parts of the VGT Corpus are still not machine-readable. Additionally, most of the studies that use the VGT Corpus data consider analyses of retellings of narratives and do not include conversational data (with the exception of Notarrigo et al., 2016; Aerts, 2021). These limitations imply that many of the findings and conclusions in the studies reported on above (see sections "Re-testing Previous Claims on a New Corpus and Documenting Language Change and Filling in Some Research Gaps"), are to a certain extent preliminary and they thus should be ratified with analyses of larger, and more representative samples of VGT data. This is exactly the main reason why the VGT Corpus (like many other sign language corpora) was built.

However, once (part of) a corpus has been transcribed (and annotated) its value is undeniably great and comes with many advantages such as its representativity, the readily availability of the language data, and the possibility of carrying out new, large frequency and variation studies. This is, for instance, how we build a better understanding of early Flemish Sign Language acquisition, language access to deaf children and the tight integration of early gestures and sign language development (see section "A Corpus for the Study of Early Parent-Child Interactions"). The most recent corpus—including innovative eye tracking—has also provided an insight in online turn processing, the construction of depictions and the role of eye gaze (see section "A Multifocal Eye-Tracking Corpus"). The descriptions of linguistic patterns can then be converted into detailed language and teaching materials for prospective linguists, interpreters, speech- and language therapists, and teachers.

Within the deaf community, studies based on corpus data can also support the creation of a broader understanding and greater awareness of Flemish Sign Language. Research can further be integrated in education, social valorization projects and on-topic workshops to continuously disseminate new research findings. In this regard, it remains important to add new data to corpora—such as the VGT Corpus—on a regular basis, especially from younger signers who were too young during earlier recording

moments. A corpus is a documentation of language use, but one cannot lose sight of new language evolutions. The past years, researchers have described several changes related to VGT use and practices, e.g., the recognition of VGT, societal and educational values of VGT, access to (tertiary) education, technological advances, internationalization (Van Herreweghe et al., 2016). It seems that VGT is going through an accelerated development, involving an exponential growth of the lexicon, the development of a formal vs. informal register, and the introduction of "new" signs and structures (e.g., the VGT sign APPARENTLY; Vermeerbergen, 2020). Therefore, researchers should proceed to collect new data and thus constantly maintain and expand the database so that research on and the teaching of sign language structures, and the documentation of signs used in the language continue to evolve with the language and its context. So, it is obvious that a solid corpus requires constant attention and a hands-on active approach.

AUTHOR CONTRIBUTIONS

BW, MVH, and MV conceived and planned the project. BW took the lead in writing the draft manuscript. BW and IB further shaped the presented ideas. All authors provided critical feedback and contributed to the final version of the manuscript.

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Revisiting the Past to Understand the Present: The Linguistic Ecology of the Singapore Deaf Community and the Historical Evolution of Singapore Sign Language (SgSL)

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Singapore, a young nation with a colonial past from 1819, has seen drastic changes in the sociolinguistic landscape, which has left indelible marks on the Singapore society and the Singapore deaf community. The country has experienced many political and social transitions from British colonialism to attaining independence in 1965 and thereafter. Since independence, English-based bilingualism has been vigorously promoted as part of nation-building. While the roles of the multiple languages in use in Singapore feature prominently in the discourse on language planning, historical records show no mention of how these impacts on the deaf community. The first documented deaf person in archival documents is a Chinese deaf immigrant from Shanghai who established the first deaf school in Singapore in 1954 teaching Shanghainese Sign Language (SSL) and Mandarin. Since then, the Singapore deaf community has seen many shifts and transitions in education programming for deaf children, which has also been largely influenced by exogeneous factors such as trends in deaf education in the United States A pivotal change that has far-reaching impact on the deaf community today, is the introduction of Signing Exact English (SEE) in 1976. This was in keeping with the statal English-based bilingual narrative. The subsequent decision to replace SSL with SEE has dramatic consequences for the current members of the deaf community resulting in internal divisions and fractiousness with lasting implications for the cohesion of the community. This publication traces the origins of Singapore Sign Language (SgSL) by giving readers (and future scholars) a road map on key issues and moments in this history. Bi- and multi-lingualism in Singapore as well as external forces will also be discussed from a social and historical perspective, along with the interplay of different forms of language ideologies. All the different sign languages and sign systems as well as the written/spoken languages used in Singapore, interact and compete with as well as influence each other. There will be an exploration of how both internal factors (local language ecology) and external factors (international trends and developments in deaf education), impact on how members of the deaf community negotiate their deaf identities.

Keywords: language ideology, Singapore sign language, Singapore deaf community, deaf identity, sociolinguistics of sign languages, language practice, and language management, language ideology and politics

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INTRODUCTION

The Singapore deaf community co-exists with the wider Singapore society. Therefore, language and identity issues in the Singapore deaf community are closely interrelated to and shaped by language and identity issues in the broader Singapore context. It is essential to get an insight into the multilingual ecology of Singapore and the interplay of language ideologies first, to understand the ecology of the deaf community. Language ideologies comprise people's covert and overt thoughts, ideas, attitudes, and beliefs about languages and varieties in terms of the value assigned to them, whether they are perceived as superior or inferior, and the language practices they employ (Webster and Safar, 2020; Woolard, 2021). This publication details how bi-and multi-lingualism in Singapore give rise to language ideologies which influence both hearing and deaf Singaporeans' interactions, communication, and evaluation of their own and others' language practices in Singapore in two main related sections: 1) the linguistic ecology of multilingual Singapore society and 2) the linguistic ecology of the Singapore deaf community.

The Linguistic Ecology of Multilingual Singapore Society

According to Mallikarjun (2019), the linguistic landscape refers to a static picture of a place where its language features are visible while linguistic ecology refers to the dynamic relationships and changes that occur between languages in an environment. Riney (1998) details six different types of interrelated language shift phenomena which have occurred over the past several decades because of key historical events since British colonialism from 1819 to 1961 as well as Singapore's language policy and planning initiatives. These language shifts include the following changes:

i. from Indian languages originally spoken by the Indians who were brought to Singapore by the British in the 1930s and 1940s as apprentice servants, to English and Malay,
ii. to Malay as a minority language when it was previously used as a lingua franca
iii. from Chinese dialects such as Hokkien, Teochew, Cantonese and so on originally spoken by the Chinese immigrants to Mandarin as a lingua franca among the Singaporean Chinese community
iv. to English having the status of a lingua franca and mother tongue when it was previously considered a mere 'working language'
v. from non-standard forms of bilingualism to English-mother tongue bilingualism;
vi. in progressing to literacy and biliteracy from non-literacy and semi-literacy.

Judging by the census data in 2020 (Department of Statistics Singapore, 2021), these predictions have been largely borne out. In 1965, when Singapore achieved independence as a nation, the country was situated in a multilingual ecology and attempting to move away from the influence of colonialism. Countries in Southeast Asia such as Myanmar, Thailand and Laos promoted linguistic nationalism where language policy and planning and nation-building efforts demonstrated resistance against colonialism in the form of promoting a common national language, which are Burmese, Thai and Laotian respectively (Tan, 2021). Each of these countries have similar post-colonial stories as they all went through the process of deciding on a common national language whilst grappling with their newly minted identities, including how this negotiation was going to ensue between the colonial language and the local languages. Ng and Cavallaro (2019) compared post-colonial evolution in Hong Kong, Malaysia and Singapore and pointed out that despite the similarities in colonial history and ethnic composition, the Singapore trajectory is a unique one which saw dramatic transformations in the linguistic landscape and ecology in the last 50 years.

During the entire period of the British colonialism from 1819 to 1961, English was the language of administration in Singapore (Riney, 1998). The sociolinguistic landscape in Singapore has been widely discussed and the following is drawn from Ng and Cavallaro (2019); Ng et al. (2021) and Nah, et al. (2021). In the 1950s, Singapore designated English, Mandarin, Malay and Tamil as the official languages and implemented English as a lingua franca to encourage social cohesion and racial harmony among the Chinese, Malays and Indians, which were the three main ethnic groups in the country. English was perceived as a neutral language and effective for interethnic communication since it did not belong to any of the local speech communities and its use would not privilege one ethnic group over another and would promote equality (Tan, 2021). Furthermore, the Singapore government felt that English was necessary for pragmatic and economic reasons, especially for the country's survival as a nation since it facilitated access to the wider world (Wee, 2003). This pragmatism, also referred to as linguistic instrumentalism, views language/s not just as integral to the maintenance of an individual's cultural or ethnic identity, but also as commodifiable resources in a community because of its value and ability to achieve national goals. This philosophy is reflected in three key language campaigns: 1) the Bilingual Policy, 2) the Speak Mandarin Campaign, and 3) the Speak Good English Movement. These campaigns shape the sociolinguistic reality of Singapore today and the following sections will briefly outline how these campaigns eventually exert an influence on the local deaf community and their attitudes to language use.

Bilingual Policy

The English-mother tongue bilingual school policy adopted in 1966 gives bilingualism in Singapore a meaning of its own as the terms "first language", "second language" and "mother tongue" are defined differently from those commonly seen in linguistics definitions (Saravanan, et al., 2007). Several authors have written about the impact of the bilingual policy post-independence (e.g., Ng et al., 2021; Mathews, et al., 2017; Saravanan, et al., 2007). The following is a brief discussion of the impact of the bilingual policy which requires English to be the first language of instruction in schools, with the other official languages labelled as "mother tongues" and acquired as second languages. The "mother

tongues" were assigned according to ethnic background and are Mandarin, Bahasa Melayu, and Tamil for the Chinese, Malays and Indians respectively, regardless of what the speakers' first languages are (Saravanan, et al., 2007). This association of mother tongues with ethnic backgrounds rather than the language spoken in the home means that the "mother tongues" studied at schools as second languages may not reflect the first language of the students. The mother tongues are seen to provide "cultural ballast" which are there to contain the complete dominance of English (Vaish, 2008).

According to Wee (2003), the concept of 'linguistic instrumentalism' justifies the existence and privileging of the use of the English language across all domains of Singapore society because it is viewed as a world language that facilitates greater access to economic progression, information, higher status and quality of life in society. He further argues that other languages are perceived as delaying such access or even when regarded as important, they are treated as preserving cultural heritage or "cultural repositories". Therefore, English became a dominant language due to government official language policy, its widespread use by the media and the Speak Good English Movement in 2000 (Bolton and Ng, 2014; Tan 2014; Tang, 2018). Tan (2014) argues that since English is the lingua franca among different racial groups in Singapore, the state should assign it 'mother tongue' status, as not identifying it as such, opposes the actual language practices in Singapore. Consequently, the rising dominance of English across every domain in Singapore such as business, law and education, even discussed as early as the 1980s, has led to the decline of the use of mother tongues as well as other Chinese and Indian varieties. Members of the public have voiced their concerns that the prestige of English and its ubiquitous use have caused the standards of mother tongues to decline (TODAYonline, 2013).

The Speak Mandarin Campaign

In the early 1900s, the popularity of Chinese medium schools increased, and Mandarin Chinese was adopted as the standard language of instruction, thereby demoting other Chinese languages such as Hokkien, Teochew and Cantonese to vernaculars (Riney, 1998). By 1956, Mandarin Chinese already had a strong foothold in the Chinese community, especially in the domain of education, because of the establishment of Nanyang University in the same year that adopted Mandarin Chinese as a language of instruction. Ng et al. (2021) pointed out that despite the increasing influence and prestige of Mandarin Chinese in Singapore, many Singaporeans started to show a preference for English-medium education in the 1950s. This was due to its more promising job prospects as English-educated Singaporeans were earning higher incomes and had a higher employability rate compared to those who were Chinese-educated (Kuo, 1985). This caused a decline in student enrollment in non-English medium schools until 1987 when the last Chinese medium school closed (Abshire, 2011; Ho, 2016). In 1979, the 'Speak Mandarin Campaign' was introduced by the Singapore government to facilitate Singaporeans' progress in learning Mandarin Chinese. As a result, many Singaporean Chinese have reported increasing the use of English and Mandarin in their homes as indicated by responses to census questionnaires in each succeeding decade (Liang, 2015). This has caused a significant decline in the use of Chinese regional varieties.

Singapore's multiracial policy was to ensure that Mandarin, Malay and Tamil be accorded equal language statuses and economic value in order to uphold the nation's principles of multiracial equality and egalitarianism (Wee, 2003; Schiffman, 2007). However, the acquisition of Mandarin has been promoted due to China's rising economy in the global scene, thus leading to Mandarin becoming a popular choice of language even among non-Chinese who lobbied schools to give their children the option of studying it (Simpson, 2011). Said (2019) pointed out that there remains an imbalance that indicates a preference for Mandarin over Malay and Tamil, as reflected in the Singapore government's top-down constitution processes and allocation of resources for mother tongue learning. Despite the active promotion of Mandarin Chinese as a lingua franca among Chinese Singaporeans, English still features more prominently in the discourse and continues to dominate the linguistic ecology of Singapore (Cavallaro et al., 2021). This observation is consolidated in the 2020 census, which shows a significant 6% decline in the use of Mandarin Chinese among Chinese Singaporeans (Cavallaro and Ng, 2021). This is the first downturn in Mandarin ascendency since 1979. At the same time, English use in the community has increased by 10%.

Malay has been retained as a national language or assigned "ceremonial" role that is visible on an international level for historical and policy reasons, while Tamil is deemed as politically insignificant (Kadakara, 2015). This was to establish some form of political safety net since Singapore is a small ethnically Chinese dominant nation surrounded by Malay and Muslim countries (Riney, 1998). The Malay community also comprises different dialects of the Malay language and other languages such as Javanese, Boyanese and Batak. Although the Malay community has been viewed as more successful conservators of their language in comparison with other ethnic communities, there is an apparent shift from Malay to the increasing use of English, especially among the younger generations and those from higher socioeconomic and education backgrounds (Mirvahedi and Cavallaro, 2019). This is confirmed in the 2020 census which indicates a dramatic 17.5% increment in the use of English by Singaporean Malays. The public have expressed skepticism of the government's case for the economic value of Malay because Singaporeans in general are more impressed with the economic potential of China compared with its neighboring countries such as Malaysia, Indonesia and Brunei (Wee, 2003). As English is one of the working languages in Malaysia, it is possible for business transactions in the country to be accessible in English. However, it is imperative to know Mandarin to access similar economic opportunities in China. Therefore, this weakens the necessity of learning Malay. Malay, however, retains a more important position than Tamil because the Malays are demographically stronger and are symbolically seen as the indigenous occupants of Singapore.

The Indian community constitutes approximately 7% of the overall population of Singapore. It consists of a Tamil majority and speakers of northern Indian languages such as Bengali,

Malayalam, Punjabi, and Hindi, as well as a small percentage who acquired Malay. In the 18th century, Tamil was introduced into Singapore by Indian immigrants from Tamil Nadu and only 3–4% of the population currently speak the language (Singapore Department of Statistics, 2000; Saravanan, et al., 2007; Singapore Association for the Deaf, 2020). This is essentially about half of the Indian population. As monolingual Tamil speakers were perceived as "uneducated", the Tamil elite increasingly enrolled their children in English-medium schools instead of Tamil-medium schools until Tamil-medium education ceased completely in 1982 (Riney, 1998). There is also a lack of language maintenance of Tamil in the homes as those who are better educated tend not to use it as a home language (Schiffman, 2003). Between 1980 and 2000, the use of English dominated the homes of Indian families and increased, while the use of the Tamil language in homes dwindled (Saravanan, et al., 2007). The fact that Tamil is not necessary in business dealings and work contexts, accelerated its decline in use (Wee, 2003).

The Speak Good English Movement and the Singlish Debate

Due to the intermingling among the different ethnic groups over time and the different languages in contact with each other, a local vernacular called Singlish or Singapore Colloquial English, which interweaves English with Mandarin, Malay, Tamil and Hokkien words, and adopts Chinese grammatical structures, became a fixture in local communication within and across ethnic groups, mainly in informal settings and sometimes even in formal settings (Kramer-Dahl, 2003; Wee, 2013; Tan, 2015l; Cavallaro and Chin, 2014). As Singlish differs from the grammatical conventions of Singapore Standard English, the Singapore government introduced the Speak Good English Movement in 2000, to promote the use of Singapore Standard English or "proper English" and to discourage Singaporeans from using Singlish. This sparked off the "Singlish debate" which is dominated by the voice of the Singapore government (Bokhorst-Heng, 2005). The debate occurred between politicians who promoted standard English, "expert voices" of linguists and academics who claimed Singlish to be a marker of the Singaporean identity, and voices of the public in the press (Bokhorst-Heng, 2005; Tan, 2016). Cavallaro and Ng (2009) and Cavallaro, et al. (2014) found that sentiments of Singaporeans toward Singlish including those who support its use, remain deeply divided. On the one hand, they found overt positive affirmation for Singlish that is not supported by the matched-guise findings. As matched guise studies measure covert attitudes, they explained this schism in the findings by positing that Singaporeans may see the use of the colloquial variety as something that is more appropriate for private domains.

The findings that Singapore Colloquial English was rated lower in both status and solidarity traits in comparison to Singapore Standard English, contradicted preconceived perspectives and expectations of Singapore Colloquial English as a marker of strong solidarity in Singaporeans. This was a surprising result as this is in contrast with several similar studies which indicate that the speaker with the regional or colloquial accent or variety was rated more positively on solidarity traits than the speaker of the standard accent (Cheyne, 1970; Giles, 1971). These studies show that Singlish has a low status and is stigmatised in Singapore society while Singapore Standard English is associated with prestige and high status. Ng, et al. (2014) further attested this through a language accommodation study which found that speakers that had diverged to Singapore Standard English were given more positive ratings compared to those who used Singapore Colloquial English in a sales context. The Singaporean participants firmly prefer sales assistants to maintain the use of English even in situations when it is customary for shop assistants to accommodate to the language choice of the customers.

Singapore's nation-building agenda is rife with debates surrounding language meanings and language practices, resulting in different perspectives on definitions of Singlish and which definitions are correct (Bokhorst-Heng, 2005). At the heart of the debates are the tensions resulting from "glocalism" that involve two distinct constructs of national language ideologies: "internationalism" versus "national identity", representing different perspectives of how an ideal Singapore and citizenship is defined. The case of Singlish and the ideology of a standard language has resulted in intra-language discrimination, as evident by the varying perspectives of interlocutors in the Singlish debate where there is devaluation of the non-standard variety by one camp and the defense of Singapore Colloquial English by the other camp (Wee, 2005).

The three main ethnic groups—Chinese, Malay and Indians, have seen an increasing use of English over time, indicating a gradual move to homogeneous bilingualism or English-dominated bilingualism as evident by English-mother tongue repertoires of Singaporeans (Riney, 1998). This lends support to Tan's (2021) argument that multilingualism in Singapore is a "myth". She made an interesting interpretation of Singapore's highly promoted bilingual policy and that multilingualism is actually a façade for a *de jure* monolingual Herderian language policy. The Herderian ideal aspires to maintain the "one nation, one language" philosophy or linguistic homogeneity (Bauman and Briggs, 2003). This is achieved through "hierarchical multilingualism" within the official languages as well as "controlled multilingualism" where the mother tongues function as "control languages" for the three main ethnic groups to discourage each ethnic community from using several languages. Therefore, the Singapore government's intentions clash with how realities play out in language policy. The policy was ostensibly for societal multilingualism but not individual bilingualism as Prime Minister Lee (1984) stated in his speech at the opening of the Speak Mandarin Campaign on 21 September that:

"Few children can successfully master two languages plus a dialect. Indeed very few can speak two languages equally well. The reason why most societies are monolingual is simple: most human beings are equipped by nature to cope with only one language.

If we want our bilingual policy to succeed, we must lighten our children's learning load by using Mandarin as the mother

tongue in place of dialect. Studies show that students from Mandarin-speaking families consistently do better in their examinations than those from dialect-speaking homes. It could be the parents of such students are better educated. It must also be because they have no extra load of dialect words and phrases to carry" (p. 1).

The Linguistic Ecology of the Singapore Deaf Community

The above linguistic backdrop in the Singapore multilingual ecology set the stage and sent ripples through the Singapore deaf community, where a similar trend echoing what is happening elsewhere in Singapore is observed. Perceptions and attitudes among hearing Singaporeans towards the official languages have also infiltrated the Singapore deaf community and has influenced their language practices and ideologies toward SgSL, other spoken/sign languages and sign systems. These language ideologies have been influenced by factors described earlier such as language policy in the education system as well as nation-based initiatives such as linguistic instrumentalism and official national recognition of languages. External factors such as the influence of deaf education trends from the United States on deaf education in Singapore have also shaped language ideologies and language practices. Given the different statuses of the official languages in Singapore, it is hardly surprising that SgSL although considered by the Singapore Deaf community to be part of Singapore's linguistic diversity, has yet to attain official recognition as a national sign language (Lee, 2016).

For a deeper insight into the language and identity issues confronting the deaf community to date, it is necessary to trace the origins and the evolutionary trajectory of SgSL. This necessitates a simultaneous exploration of the history of deaf education.

The Origins and Evolution of SgSL

Fontana, et al. (2017) indicate that sign language change in Italian Sign Language has been influenced by the individual background characteristics of signers, changes in how language is processed and understood, and shifting dynamics of groups who use the language as well as the contexts the languages are used in. Research into the etymology of American Sign Language (ASL) signs show how ASL originated from and is related to early French Sign Language (LSF) as well as to contemporary LSF (Supalla and Clark, 2015). SgSL seems to have followed a similar historical trajectory in its development to ASL. SgSL has its roots in Shanghainese Sign Language (SSL), which later came into contact with and was influenced by ASL, Signing Exact English (SEE), and locally developed signs (Lee, 2016). The deaf community has developed signs to represent local words such as "durian", "rojak", "Raffles", "cheongsam", "orchard road" and 'satay (Goh, 1988). This includes Singlish words such as "kaypoh" (Chinese origin) which means "busybody", and "alamak" (Malay), equivalent to "Oh my God!".

The term "Singapore Sign Language" (SgSL) was officially coined in 2007 after being called "Native Sign Language" (NSL) for many years (Project Proposal- Singapore Sign Language (SgSL) Sign Bank and Community Engagement Project (Phase II): Development of Singapore Sign Language (SgSL) Sign Bank Project, 2014). Some deaf individuals perceived SEE as sign language that was "not natural" and phased it out with SgSL classes in 2015 at the Singapore Association for the Deaf (SADeaf). The first SgSL Level 1 and 2 classes commenced in April 2015 and have been running since then. The origins and evolution of SgSL are detailed in the next section, which highlights how significant events in the history of deaf education in Singapore resulted in language change.

The History of Deaf Education in Singapore

The First Deaf School in Singapore

A review of archival sources indicates that the histories of deaf people's lives in Singapore prior to the early 1950s appear to be undocumented. Therefore, accounts of deaf people's lives when Singapore was established as a British colony as well as during the Japanese occupation of Singapore during World War II (WWII) seem to have been lost or ignored. Based on published and unpublished archival sources, the historical evolution of SgSL has spanned almost 7 decades since the inception of the Singapore Chinese Sign School in the 1950s by Peng Tsu Ying. The following biographical information about Peng is drawn mainly from (Argila 1975; Argila 1976).

Peng became deaf when he was 5 years old. His parents brought him to Hong Kong and enrolled him in the Hong Kong School for the Deaf which was an oral school but allowed the use of sign language during and outside of school hours. During the Japanese invasion of Hong Kong in Dec 1941, Peng managed to return to Shanghai in a Japanese cargo ship. When he arrived in Shanghai, he attended *Chung Wah School for the Deaf* for his secondary education.

After WWII (1948), Peng moved to Singapore with his family. He was not able to locate any deaf people, which prompted him to put up an advertisement in the Chinese newspaper advertising educational opportunities for deaf children. Many parents with deaf children contacted him to teach their children privately. As there was no deaf school in Singapore at that time, Peng taught from his parents' home.

Peng's classes indicated the advent of deaf education in Singapore and a new life for generations of deaf children. In 1954, Peng and his deaf wife, established the first deaf school in Singapore and named it the Singapore Chinese Sign School for the Deaf. They utilized the techniques and the sign languages they acquired in Hong Kong and Shanghai. The languages used as the medium of instruction in the school was SSL and written Chinese. In 1953, Mrs E. M. Goulden, a British lady, started an oral class that had nine deaf children. This led to the establishment of the Singapore Oral School for the Deaf where English was adopted as the medium of instruction (Lim, 1977).

In 1963, The Singapore Chinese Sign School for the Deaf merged with the Singapore Oral School for the Deaf (Singapore School for the Deaf 50th Anniversary Celebration 1963–2013, 2013). It was renamed the Singapore School for the Deaf, which had an oral section and a sign section.

Other Deaf Schools Established in the 1950s

In 1956, the Canossian School for the Deaf was established by two Italian nuns to teach hearing impaired children English via oral methods (Lim n.d; Canossian School, 2020). It also used the Total Communication philosophy for a period starting around the 1970s before gradually preparing to transition to oralism between 1986 to 1988 (Canossian School for the Hearing Impaired, 1993). The school switched completely to a full oral approach by 1994 (Ho, personal communication, 2021).

In 1957, the Singapore Deaf and Dumb Art Institution was founded by Joseph Koo Ming Kang, a deaf man, who had moved to Singapore from Shanghai (Deaf and Hard of Hearing Federation Singapore, 2016). He had acquired his craft at the Deaf and Dumb Art School in Shanghai. At the Singapore Deaf and Dumb Art Institution, painting classes were conducted from Mondays to Thursdays, while Fridays were allocated to teaching Chinese writing and SSL. The institution closed in 1982 (Teo, personal communication, 2021).

The Advent of the Total Communication Philosophy and the Spread of SEE

The history of Deaf education, language and communication modes in Singapore seem to follow closely the shifting trends in Deaf education in the United States . The developments that occurred in the United States spread to Singapore about a decade or more later. The introduction of Signing Exact English-II (SEE-II) courses at Gallaudet College in Washington DC were influenced by trends in Deaf education in the United States in the 1960s that were started by deaf individuals (Holcomb, 2014). A new approach called Total Communication (TC) by Roy Kay Holcomb known as the father of TC, had started to spread in 1968 because a full oralism approach used in deaf schools was not always working (Holcomb, 2014). At that time, the TC philosophy was perceived to be child-centered and aimed to cater to the individual communication needs of the child and how he or she learned best. This could include a combination of speaking, hearing, signing, fingerspelling, reading, writing, drawing or any other strategies for communication that made information accessible to deaf children and catered to their individual learning style. According to Tevenal and Villanueva (2009), the term TC became interchangeable with simultaneous communication (SimCom), which refers to the teaching method of producing a sign for every single word in a spoken utterance.

Around the same period that TC was introduced, a few versions of Manually Coded English such as Seeing Essential English I (SEE-I) by David Anthony and Signing Exact English II (SEE-II) by Gerilee Gutason were created with the objective of improving deaf children's literacy skills by making English visible on the hands. (Coryell and Holcomb, 1997; Zak, 2005). Both these sign systems incorporate the grammatical markers of English such as articles, determiners, auxiliary verbs and conjunctions, visually where every single word in a sentence is signed. It provides a visual representation of English grammatical markers as it was believed to enable Deaf children to acquire English better (Zak, 2005). The difference between SEE-I and SEE-II is very slight–SEE-II has ASL signs for compound words such as butterfly while SEE-I has two separate signs for the individual words in compound words. "SEE-I and SEE-II are different as "SEE-I utilizes signs for all morphemes (prefixes, roots, and suffixes) and some are further divided (e.g., the word "motor" is signed with two signs)" whereas in "SEE-II each English word is signed differently, and those words for which there are no signs are fingerspelled" (Luetke-Stahlman, and Milburn, 1996, p. 30). For some words in the past tense, the sign for the free morpheme for REACH or NICE is produced first and the bound morpheme or suffix markers "–ed" or–ly respectively is fingerspelled and added at the end of the free morpheme. Later on, the TC philosophy, SEE-I and SEE-II spread to other parts of the world.

According to Moriarty (2020), the proliferation of ASL signs, particularly in Indonesia and Cambodia, was caused by key historical events and sign language ideologies through deaf education projects, international development initiatives and tourism. In Indonesia, the TC philosophy was adopted and focused on spoken Indonesian and accompanying signs from Signed Indonesian (Branson and Miller, 2004). Signed Indonesian comprises a set of frozen signs including signs for suffixes and prefixes that resembles the written and formal conventions of the language and is devoid of the fluidity and flexibility that natural sign languages possess. The implementation of similar colonial methods incorporating TC and ASL/SEE in deaf education which displaced indigenous sign languages are also evident in other global south countries such as Trinidad and Tobago as well as Guyana (Ali, et al., 2021). In Singapore, there is a similar historical trajectory of ASL/SEE-II colonialism via deaf education initiatives.

The TC philosophy and SEE was brought to the Singapore School for the Deaf by Lim Chin Heng, a former student at the Singapore Chinese Sign School for the Deaf and who studied at Gallaudet College in Washington DC in the 1970s. The following biographical information about Lim Chin Heng is drawn mainly from Integrator (1995), Tiger (2008), Yeow (1995), Lim (1977), and Parsons (2005).

Lim was enrolled in the Singapore Chinese Sign School for the Deaf in 1955 and graduated from the school in 1965. When Lim completed his primary education in 1965, which was the year Singapore attained its independence, there was no secondary school for the deaf and none of the regular schools accepted any deaf students due to lack of appropriate resources to cater to their individualized needs. Consequently, Lim's family sent him to the American School for the Deaf to pursue his high school education. Upon graduation, Lim went to Gallaudet College in Washington DC where he earned a degree in mathematics (1970–1975) and a master's degree in education (1979–1981). He had full access to and participated actively in social, cultural and sporting activities while at Gallaudet College. During this time, he developed leadership skills and a desire to advocate for deaf people in Singapore.

In 1974, Lim volunteered at the Singapore School for the Deaf and SADeaf during his summer holidays. During this time, he decided to give up his plans to settle in the United States and

resolved to return home for good. Upon his return to Singapore in the mid-1970s, Lim started as a volunteer tutor at the Singapore School for the Deaf upon Peng's request due to a shortage of teachers at the school. After seeing evident progress in his students, he became motivated to become a full-time teacher for the deaf and returned to Gallaudet College to get his master's degree in education.

Since young, Lim used 'natural' signs from SSL that he acquired from interaction with his peers at the Singapore Chinese Sign School for the Deaf before he went to the United States (Tiger, 2008) He claimed that it was an eye-opener for him when he saw students at Gallaudet using the Simultaneous Method to communicate. From his perspective, it was intelligible and the most effective way to learn English. He took up a course in SEE-II during his graduate education course at Gallaudet College and learned that fingerspelling after signing each word was an efficient way of reinforcing letters of the alphabet that were not visible solely by lipreading.

Deaf students at the Singapore School for the Deaf who were taught via the oral method or SSL, were struggling and not doing well in the Primary School Leaving Examinations (PSLE). The older deaf students appeared to perform better academically after Lim introduced American signs, the TC method and SEE-II as these methods helped them to comprehend their classes better. Lim attempted to convince some teachers of the effectiveness of this method, but they did not believe his claims initially.

One deaf adult suggested tracking the deaf children's progress in English, Mathematics and Science to prove that TC was the best way to educate deaf children. A group of deaf adults voted in favor of TC being the best method for educating deaf children. They passed the SEE measure with government acclaim. From 1976, the whole school adopted the TC approach in alignment with the SADeaf's official policy (Chua, 1990). When TC was fully implemented at the school, the oral section was renamed the "English section" while the sign section was renamed the "Chinese section" (Lim, personal communication, 2021).

From several accounts (Singapore Disabled People's Association, 1995), Lim was a dedicated and committed teacher. The students not only saw him as a tutor but also as a mentor and a role model. Lim was also serving as the Honorary Treasurer on the Board of Management of the Disabled People's Association. Renowned for his significant contributions to the Singapore deaf community especially for introducing ASL, SEE, and the TC philosophy to Singapore in 1975, Lim was awarded the title of *Outstanding Deaf Citizen* for the year during SADeaf's 40th anniversary in 1995.

Frances Parsons–World Traveller and Advocate of TC Philosophy in Different Countries

Frances Parsons, a deaf professor at Gallaudet College, set out on a 10-years trip around the world in 1971 to several countries to advocate for the use of the TC philosophy in Deaf education after visiting schools in South America (Traveler Says: Americans Are Spoiled, 1981; Parsons, 1976). The following biographical information about Parsons is drawn mainly from (Parsons, 1976; Reilly and McIntire, 1980; Parsons, 2005).

Parsons went to *Argentina*, Iran, South Korea, Thailand, Burma, India, Malaysia, the Philippines, Ethiopia, Kenya, Madagascar, Hong Kong, Indonesia, Singapore and so on. In 1976, Parsons, who was touted as the global ambassador of TC by that time, arrived in Singapore. Parsons described how oralism and lip-reading presented barriers to the development of deaf children in education and stated that:

"The solution to this problem is the use of structural signed language. For years oral-trained deaf children stop talking, verbally, the moment they leave the classroom and revert to gestures. These natural gestures, unlike structural signed language, have no grammar, syntax and tense. That retards mental and educational development. Since hand gestures are the natural expression of the deaf, a scientific controlled language form like structural signed language should be accepted and taught to ensure that the communication of the deaf has the same language structure of the hearing people. Concept gestures are very limited in contrast to proper structural signs. Structural signed language can be used with equal ease and understanding not only among the deaf but also between the deaf and the hearing" (Parsons, 1976, p. 3).

As aforementioned, changes to Deaf education in Singapore began in 1975 when Lim, introduced SEE-II and TC to the Singapore School for the Deaf after graduating from Gallaudet College. In 1976, Parsons was invited to train educators of the Deaf in Singapore how to use TC by demonstrating the combined method where sign and speech were used simultaneously. During the teachers' meeting, Parsons compared "unstructured signs" (natural gestures) from SSL with SEE-II, perceived as structured signs that represented English grammar, tense and syntax, with the support of Mr Lee, an officer at SADeaf. Consequently, Peng decided to do away with SSL and implemented the use of SEE-II. Observations that the students were using what was perceived as "unstructured" signing constantly and had only a few hours of classes of reading and writing in Chinese at school, led to this decision. Therefore, the Singapore School for the Deaf began to incorporate SEE-II signs with spoken English in 1977 by fully implementing the TC approach and phased out the Chinese Sign Section by 1978 (Gertz and Boudreault, 2015). This move was also in conformity with the Singapore government's implementation and objectives of an English-bilingual policy for education in 1966 (Ng et al., 2021).

Other Deaf Education Developments

The English-bilingual policy implemented prevailed throughout the 1960s until today. However, the Deaf community was not integrated into this planning. In 2019, the Ministry of Education extended the Compulsory Education Act to students with disabilities making it compulsory for them to attend special education schools (Teng and Goy, 2016). Therefore, prior to 2019, students with disabilities were exempted from compulsory education and they did not enjoy the same privileges of compulsory education afforded to non-disabled students. This constrained deaf Singaporeans' access to language and 'mother

tongue' acquisition, as well as interaction with the wider bilingual community.

As described earlier, deaf education in Singapore has undergone numerous changes since the merger of the Chinese Sign School for the Deaf and the oral school for the deaf. Later, other educational settings were established that adopted completely oral modes or integration programs. Cochlear implants were introduced to Singapore starting from the late 1980s onwards after it was invented in 1982 (Alexander Graham Bell Association for the Deaf and Hard-of-Hearing n. d.; Cochlear Ltd. 2016; Singapore General Hospital 2016). There were also mainstream secondary schools that enrolled deaf students and adopted the TC philosophy as well as others that adopted the oral-only approach. Some of the deaf children who went through the oral method of teaching, acquired SgSL later in life. Others also opted for mainstream schools with no additional teacher of the deaf support.

In 2017, the Singapore School for the Deaf closed due to dwindling enrollments (Teng, 2017). In 2018, Mayflower Primary School started enrolling deaf students. The school which is perceived as adopting a bilingual approach to deaf education provides an SgSL program in its mainstream curriculum (Ong, 2019). This is in alignment with the philosophy of the World Federation of the Deaf (2016) which advocates for bilingual education in national sign languages for deaf children, instead of sign systems. The Singapore Association for the Deaf (2018), who is an Ordinary member of the WFD, oversees the running of the bilingual program at Mayflower school. However, there remains a lack of linguistics research on SgSL to support the development of the bilingual program.

Akbar and Ng (2020) pointed out that the change from SEE to SgSL in deaf education settings in Singapore has resulted in deaf children indicating a preference to use SgSL over SEE. The parents accommodate their deaf children's language choices but experience conflicting feelings concerning the use of SgSL due to inadequate support from the government and the school. They found that a popular opinion among hearing parents was the belief that SEE is superior to SgSL as they perceived SEE as a high language variety and SgSL as a "broken" form of English or a "lazy" manner to communicate.

All these developments in education have shaped deaf individuals' identity formations, ideologies, and language practices. Additionally, the three key language campaigns that shape the Singapore multilingual ecology are intertwined with significant developments related to language policy in Deaf education. They are:

1. Bilingualism (1966)
i) English is promoted as a lingua franca across the different ethnic groups.
ii) "Mother tongues" to provide "cultural" ballast.

Singaporeans who are between 50 years old and above were born or living in the bilingual policy period.

2. Speak Mandarin Campaign (1979)
i) Promotes Mandarin Chinese as a lingua franca in the Singaporean Chinese community at the expense of the vernaculars.

Singaporeans who are below 50 years old were born during the Speak Mandarin Campaign period.

3. Speak Good English Campaign (2000)
i) Focus is on Singapore Standard English and prescription of Singlish (Cavallaro et al., 2021).

As this campaign is actively ongoing, all Singaporeans are affected by it and in particular, we can expect those who are 40 and below to be completely English dominated.

The corresponding profiles for deaf Singaporeans are as follows:

The majority of deaf Singaporeans between the ages of 15–24 years are more likely to have grown up oral with cochlear implants, with a small percentage who grew up signing as seen by the declining numbers of deaf students at the now defunct Singapore School for the Deaf over the years. Some who grew up acquiring spoken language acquired some SEE or SgSL later in life, after completing their secondary school education. Those who are between 25 and 40 years old are likely to constitute the majority of deaf Singaporeans who grew up oral and acquired signing later in life. The number of signers between 25 and 40 years old would be higher compared to the group aged 15–24 years old. For those 41–60 years old, the number of signers would be higher compared to the two younger age groups. As for those 61 and above, the number of signers would be higher compared to the three younger age groups. This is also the age group who learned SSL and Chinese at the Singapore School for the Deaf and experienced the change to SEE and English. Based on Tay's (2016) observations, the number of deaf signers increase with age and the number of deaf people who were taught via the oral approach and who have cochlear implants increase with the younger generations as most of them either attended an oral deaf school or a mainstream school.

Webster and Safar (2020) pointed out that sign languages are not always passed on through generational transmission in the same way that spoken languages are, because majority of deaf children are born to hearing parents and do not have the opportunity to acquire the national sign language from birth. This impacts the issue of language ownership. In this regard, the concept of "native" user of the language differs for sign and spoken language users (Webster and Safar, 2020). Therefore, based on the profiles of deaf Singaporeans described earlier on, SgSL is an endangered language because it is not being passed down to the younger generations. Interactional dynamics in the Singapore Deaf community restricts opportunities to acquire the language because there is limited intermingling between the younger and older deaf people.

The following timeline summarises the information presented from the discussion thus far. **Figure 1** shows the development of language policy and education in the broader Singapore context and the Singapore deaf community over the course of history.

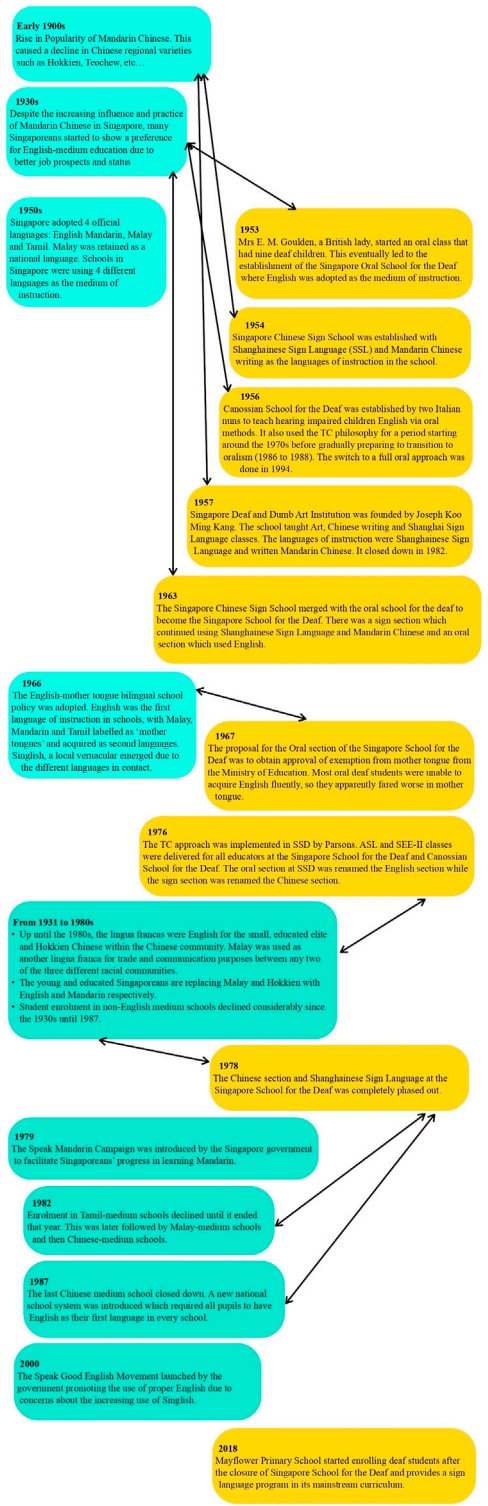


FIGURE 1 | Development of language policy and education in the broader Singapore context and the Singapore deaf community.

Language policy in deaf education was influenced by language policy initiatives in Singapore as well as external influences from deaf education in the United States. The rise in popularity of Mandarin Chinese medium schools in the 1900s in Singapore led to the decision to use SSL and written Chinese as the languages of instruction at the Singapore Chinese Sign School for the Deaf. In the 1930s, despite the increase in use of Mandarin Chinese, the language was still overshadowed by the more dominant English due to Singaporeans showing a preference for English-medium education.

The implementation of the English-mother tongue bilingual school policy eventually led to the exemption of mother tongue for deaf students at the Singapore School for the Deaf from November 1967 (Lim, personal communication, 2021). Deaf students in the oral section were struggling to acquire English and it was assumed for them that it was easier to focus on acquiring one language instead of two languages as mandated by the bilingual policy. This is in keeping with the prevalent erroneous assumption that individuals who have atypical developmental profile are not capable of learning more than one language (Cruz-Ferreira and Chin, 2010). The proposal by the Oral section of the Singapore School for the Deaf sought the Ministry of Education's approval for the exemption from mother tongue for deaf students who were trained via the oral approach. Later on, the deaf students who were educated via the TC approach in the Sign section asked why they had to be exempted from mother tongue because they were able to acquire English successfully (Lim, personal communication, 2021). Therefore, deaf children do not have the agency to make decisions on whether to learn their mother tongue as it is a decision by the school and the parents.

From 1931 to 1980s, young and educated Singaporeans were increasingly shifting to the use of English and Mandarin. Enrollment in non-English medium schools declined considerably. In 1976, the TC philosophy was implemented in SSD which saw the introduction of SEE and English. This eventually led to the complete phasing out of the Chinese section in 1978, which was in alignment with the English-bilingual policy in promoting English as a first language. In 1982, enrollment in Tamil medium schools closed, followed by Malay medium schools (Riney, 1998). The last Chinese medium school shut its doors in 1987 and a new national school system was introduced that year which required all students have English as a first language in school. Therefore, there is a clear interrelation between events that occurred in the Singapore multilingual context and the Singapore Deaf Community.

The 'Mother Tongue' Issue in the Singapore Deaf Community

Although Singapore's economic success can be attributed to the enactment of Singapore's language policies and planning, there are also negative repercussions such as English-dominated bilingualism or more homogenous bilingualism (Riney, 1998), an increasing reduction in multilingualism, suppression of local creative expressions in English, and communicative dislocation in family units and among different generations of Singaporeans (Cavallaro et al., 2014). This dislocation is even more pronounced in the Singapore Deaf

TABLE 1 | Language practices Supported in the Singapore Deaf Community.

Language practices supported in the Singapore deaf community	Percentage of interviewees (%)
Singapore Sign Language (SgSL)	37.5
Signing Exact English (SEE)	27
SEE for teaching of English in schools and SgSL for conversations in social gatherings	21
Undecided	6.2
Don't know	8.3

community. Loh (2021) describes SgSL as a "mother tongue orphan" as it cannot be associated with any specific ethnicity and "sits uncomfortably in the state's language schema" because it does not have the same prestige as English.

Despite the implementation of the English-bilingual policy which requires all Singaporeans to learn English and a mother tongue according to ethnicity, deaf Singaporeans are exempted from their second language or mother tongue (Loh, 2021). Consequently, several deaf interviewees reported experiencing "a sense of alienation" from both their mother tongue and SgSL. However, the data also reflected that the SgSL situation might be changing as more deaf Singaporeans are also beginning to embrace SgSL as their language and as integral to their deaf identity. Tay's (2018) observations reveal the contested status of SgSL, evident by the perpetual division in the Singapore Deaf community with regards to language practices. This debate is specifically between the use of SEE and SgSL and to a lesser degree, other forms of signing such as PSE. Not knowing their mother tongue has also impacted deaf Singaporeans' access to the mediascape and religion which will be addressed in the next section.

The Singapore Deaf Community's Lack of Access to the Mediascape and Religion

According to Vaish (2007), 66.7% of the Chinese children who participated in the study indicated their preference for English TV programs and movies and a quarter identified having a favourite programs in Mandarin. In follow-up studies, the Chinese children indicated that they enjoyed English movies with Mandarin subtitles or English shows dubbed in Mandarin as well as foreign cartoons dubbed in Mandarin that also had English subtitles. 76.4% of the Indian children who were surveyed stated their preference for English programs although 18% indicated that they had a favourite programs in Tamil. Findings for the Malay children were different compared to the Chinese and Indian children as the Malay children spent most of their TV time watching mainly English programs. Therefore, instead of only the dominance of English, the way in which languages are used in the 'mediascape' indicates that non-English languages and cultures are being consumed, and it is through movies, songs, and TV programs in the mother tongues that Singaporean children are provided access to wider networks and cultural capital (Vaish, 2007). At first glance, it seems that the Malay children may experience a similar sense of alienation from their mother tongue as deaf individuals based on their media consumption of English programs. However, they can still access English programs without any captions or even if the captions are in a language they do not know, because they are able to hear the audio.

In the case of deaf people, the sense of isolation is compounded further in the 'mediascape' through lack of access to programs in both their mother tongue and English. They cannot access English programs with Chinese subtitles if they did not take Mandarin Chinese as a mother tongue, nor English programs without any captions because they cannot hear the English audio. Although they can access local Chinese dramas and movies with English subtitles, they are not able to access Chinese programs with no captions or with Chinese captions. The same scenario also applies to Malay and Tamil children who are deaf. Therefore, deaf children in Singapore who have exemption from mother tongue do not enjoy the same level of access to TV programs and movies that hearing children do.

To exacerbate this exclusion, there is also limited access to live SgSL interpreters on the news. It is only provided on important occasions such as the May Day message. This is partly due to a shortage of interpreters in Singapore. SADeaf's (2020/2021) annual report indicates that there are only six full time interpreters working at the association, which also provides training for interpreters. According to The Singapore Association for the Deaf (2020), the May Day message on April 30, 2020, by Prime Minister Lee Hsien Loong, was the first to have sign language interpreters on the Channel 5 "Live" TV broadcast. Since November 30, 2012, when the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) was ratified in Singapore, SADeaf has advocated for interpreters and subtitles to be provided in all national broadcast. The National Day Rally on August 26, 2012, featured live sign language interpreters for the first time, but there was no subtitling (The Straits Times, 2012). However, since 2006, the evening news on Channel 5 has real-time English subtitles daily (Infocomm Media Development Authority, 2021), except for the 'live news report' section, but no sign language interpreters. This shows an improvement in access to the news for the deaf but it is far from adequate. Although there is some visibility of SgSL interpreters in the news, this is a far cry from the access provisions by other countries in the region such as Malaysia where Bahasa Isyarat Malaysia (BIM) or Malaysian Sign Language interpreters interpret the Malay news on a regular basis and was already in place as far back as 1986 (Ang, 2020).

The lack of access to TV programs in SgSL and ethnic languages is not the only issue facing the deaf community. They also lack access to their mother tongue in the religious domains and are excluded from such discourse. Vaish (2008) found that although English overshadows Mandarin, Malay and Tamil in the education system, in the media and public sectors as well as in family and friendship networks, the mother tongues prevail over English where religion is concerned. For the Malay and Indian ethnic groups, the

respective heritage or ethnic language is dominant for them in the religious domain as well as Arabic and Sanskrit (Vaish, 2008). However, for the Chinese, the use of English or Mandarin are predominant in Christianity and Buddhism respectively. Deaf Singaporeans from these ethnic groups are therefore, automatically excluded from participation in these religious activities due to their lack of access to the heritage languages, although a few local churches offer sign language interpreting for church services.

As aforementioned, deaf people feel a sense of alienation toward their mother tongue and SgSL which has limited their access to different aspects of life in Singapore society. This has also influenced the construction of their deaf identities and language practices which will be discussed in the following section.

Deaf Identities and Language Practices in the Singapore Deaf Community

Organizational restructuring at SADeaf along with deaf education trends have resulted in the emergence of the SgSL versus SEE debate, which has shaped deaf identities and language practices today among deaf Singaporeans (Tay, 2018). A native SSL deaf signer also revealed that those of his generation who experienced the change from SSL to SEE at the Singapore School for the Deaf still communicate among themselves privately in SSL (Neo, personal communication, 2019). However, during interactions with the wider deaf community, they switch to SgSL because they feel embarrassed to use SSL and view SgSL as superior. There is also evidence of language contact between SgSL and BIM as approximately 10 deaf Malaysians studied at the Singapore School for the Deaf and then returned to Malaysia (Chong, 2018).

Tay (2016) researched language and identity in the Singapore Deaf Community as part of a summer internship at SADeaf. She posed questions related to identity and language usage to 48 participants in the form of semi-structured interviews, of which 45 are Chinese, 2 are Malay and 1 of Indian descent. She also conducted participant observation at deaf events such as the Singapore Deaf Youth Camp. This led to discussions on identity descriptors and which language/s deaf Singaporeans supported in different contexts and the rationale behind their language choices. Some interviewees requested to have their interview in English where they typed their responses to questions on Google Hangouts while others gave consent to be filmed.

The participants identified with a range of identity descriptors. These include D/deaf, hard-of-hearing, hearing-impaired, deaf-mute, Persons with Hearing Loss (PWHL), and Non-Signing Hearing Impaired (NSHI). These labels are currently used in the discourse of the Singapore Deaf community as well as the wider Singapore society. In the press, the term "deaf and mute" was used as late as 2016, 2017 and 2020 (Chew, 2016; Tan, 2017; Chua, 2020). In 2016, the incident over the deaf cleaner being labelled as "deaf and mute" in *The Straits Times* (Chew, 2016), also sparked much agitation and discussion among the deaf community. Tay's (2016) findings also revealed a varied support for language practices in the deaf community. As seen in **Table 1**, 37.5% of participants supported the use of SgSL, 27% supported SEE, 21% supported SEE for the teaching of English in schools and SgSL for conversations in social gatherings. The remaining 14.5% were either undecided or did not know. Based on observations, the forms of signing that some interviewees used can be perceived by the deaf community as more naturalistic or "SgSL-like" or "ASL-like" and others as more English-like or 'SEE/Pidgin Signed English (PSE)-like'.

The interviewees consistently referred to SEE which is synonymous to SEE-II in the Singapore context. It is not apparent whether they knew the difference between SEE-II and SEE-I. Below are two commentaries containing excerpts from the interviews on deaf identity and language.

Excerpt 1.

Q: How would you identify yourself? As Deaf, hard-of-hearing or hearing impaired?

A: To be honest, I don't really have a strong identity in the sense that I use different words to describe myself to different groups of people. To hearing people, I call myself hearing impaired in order for them to understand me quickly. As for deaf people, it depends on who. To the older deaf, I'll say I'm hard of hearing even though I'm deaf because they understand it as deaf who can talk. To younger deaf, I'll just say that I'm deaf. I don't use the big D or the small d because they don't understand the difference. To me, I feel that I have hearing difficulties which makes certain tasks more difficult for me but with the right support, I can do many things. So, I don't have a fixed term to identify myself.

(Derrick (Pseudonym), CM062016, p. 57 Lines 1–9)

Excerpt 2.

Q: What is your perspective of SEE? Do you think it benefits Deaf children? Does it help with reading or writing skills?

A: Yes, SEE is a must! Sure, it benefits deaf children. As it enforces the sentence to be gestured out word by word in a proper flow. I see most of deafs normally writing in broken English so I believe SEE would help develop good writing skills.

Q: What about CSL[1] or SgSL?

A: CSL-Chinese Sign Language?

Q: Yeah Chinese Sign Language. that's what you grew up learning right?

A: Ah, that's by no choice, I had to communicate with my mother and siblings. For SgSL, I am not familiar with it, hence can't comment on it.

Q: Do you value CSL?

A: Not really, CSL is similar to Native Sign Language (NSL) (gesturing only important words), i.e. if you want to say you want to go to toilet, you just gesture "go toilet".

[1]*Note: During the interview, the interviewer posed the question regarding CSL which actually refers to SSL in Singapore. The interviewer should have used SSL instead when framing the question as SSL is more commonly used by the deaf instead of CSL. Therefore, it is an oversight on the researcher's part. In this instance, CSL and SSL are used interchangeably in the Singapore context but there are many varieties of CSL in mainland China.

(Jonathan (Pseudyonym), CM062016, p 53–54, Lines 17–34, Lines 1–2)

The above commentaries suggest that identity and language practices are fluid depending on context. Tay (2018) also found ideological parallels between Singlish and SgSL where both were perceived similarly and stigmatised as "broken English" and more appropriate for conversations between family and friends. "Broken English" is perceived as forms of English that do not conform with grammatical conventions of Singapore Standard English. Similar attitudes between Singapore Standard English (Wee, 2013) and SEE (Tay, 2018) are apparent, as both are considered 'proper' for use in education and more formal settings. Singapore Colloquial English and Singapore Standard English are used for different functions; Singlish is more commonly used when conversing with family and friends, while Singapore Standard English is used with educators, employers, government officials or foreigners (Echaniz, 2015). Therefore, perceptions of ideologies and features pertaining to Singlish and Singapore Standard English have influenced perceptions of ideologies and features in SgSL and SEE respectively.

Taking into account the different sign systems and sign/spoken languages used in the Singapore deaf community, findings reveal that the explanatory frameworks for relationships between language usage and identity markers were not consistent, or "fluid" across interviewees and situations (Tay, 2016). For example, SEE, ASL, SgSL and PSE were identified as forms of signing that Deaf people use and others as forms of signing that hard-of-hearing people use. The data shows a very active debate on which language should be used in the community. Interviewees do not share a common view of SgSL as the natural language of deaf people in Singapore, or even what constitutes SgSL or SEE. Some individuals view SgSL as an indication of "broken English," incomplete, and/or view SEE as good for teaching English. The data also indicated that language and identity are linked in some expectable and surprising ways. As seen in the commentary, SSL is perceived as inferior to SgSL which means that the older generation of SSL users are stigmatised and the language is dying out in a similar fashion to local Chinese and Indian vernaculars. Although SgSL is understudied as a language and stigmatised in the same way as Singlish, SSL is stigmatised to a larger extent than SgSL. Amid the SgSL versus SEE debate, SSL is almost completely overlooked by the local deaf community.

Translanguaging in the Singapore Deaf Community

While the majority of Singaporeans are moving towards individual bilingualism, bi- and multi-lingualism in the Deaf community manifest differently. Sign language communities, characterised by sign multilingualism, have "cross-signing," "sign-switching," "sign-speaking," and multimodality (Zeshan and Webster, 2019; Kusters et al., 2020). Some deaf individuals have SgSL and English as their main languages and/or a sign system like PSE, SEE or SimCom. Singaporean identity in deaf individuals is reflected in their similar ideologies toward Singlish and SgSL as well as SEE and Singapore Standard English. There are also deaf individuals who travel and know some International Sign (IS) and ASL. Therefore, ironically outside the regulatory machines of the state, Singaporean deaf signers are prolifically multilingual and this is reflected in the fluid occurrences of multiple systems and languages in their repertoire. De Meulder, et al. (2019) highlighted translanguaging practices in the context of deaf signers which focuses on sensorial accessibility and involve a wide range of semiotic resources for communication such as mouthing, speaking, signing, gesturing, writing, typing, fingerspelling, pointing, and use of technologies. The situation is in the Singapore Deaf community is very similar with additional layers of Singlish, Singapore Standard English, SEE, SgSL and other local languages.

Limitations of the Study

This study has some limitations. There were only two Malays and one Indian among the interviewees compared to 45 Chinese. Therefore, this research study has a lack of cultural representation and balance in views. Furthermore, only four educators whose contributions to deaf education and sign language evolution are mentioned. Lastly, there is a lack of historical documentation on the language situation of deaf people and their lived experiences prior to the early 1950s. Therefore, although there are existing historical sources and research on the broader Singapore context before the post-colonial period as far back as the early 1900s, the lack of historical evidence on deaf lives before the 1950s makes it challenging to draw accurate parallels between the deaf linguistic ecology and the hearing Singapore linguistic ecology in that period. A piece of the puzzle appears to be missing.

DISCUSSION

As seen from the description in preceding sections, the Singapore government's intention with regards to language policy initiatives was to promote multilingualism and recognise linguistic diversity. However, the adoption of hierarchical and controlled multilingualism promotes monolingualism in practice. This has resulted in more homogenous bilingualisms and a move toward monolingualism instead of the intended multilingualism. Schutter (2021) states that for advocates of linguistic minorities and language rights the Herderian ideal is both a blessing as well as a curse because it promotes linguistic diversity but is expressed as monism. Internal language planning and language attitudes in Singapore, significant events such as the promoting of bilingualism, the Speak Mandarin Campaign and the Speak Good English Campaign, as well as external forces in Deaf education, have shaped the language practices, ideologies and identities of the sign language community in Singapore.

There are similar trends in deaf education and ASL/SEE colonialism in global south countries that are reflected in the Singapore context. There is a nexus in the researchers' findings on the preconceived attitudes and beliefs of the status of sign languages in the primary historical sources written by Peng, Lim, and Parsons, particularly regarding the supremacy of English which

is evident by promoting the use of SEE/TC and ASL. Fontana, et al. (2017) stated that changes in language ideologies have resulted in novel linguistic practices. Changes in ideologies in the deaf community over time have shaped deaf Singaporeans' language practices. Translanguaging practices in the Singapore deaf community have revealed that deaf Singaporeans are actually multilingual although the state's definition of multilingualism indicates otherwise.

It remains unclear what the "mother tongue" of the deaf community is. Deaf people are left out of the mother tongue debate because they did not have the agency to decide for themselves regarding learning mother tongue and nor were they seriously considered in the process of deliberation. The same applies to SgSL as majority of deaf people are born to hearing parents who decide the oral route for them at birth with no exposure to SgSL until later in life. The choice of exemption from mother tongue indicates that English is perceived as more important and mother tongue as unimportant. The fact that deaf Singaporeans are using another mode, they are automatically considered to be linguistically challenged and are therefore not advised to learn another language or to be multilingual. Tay (2016) recalls when she asked an elderly deaf person what languages he knew, he only mentioned the spoken languages, not the sign languages despite him being fluent in more than one sign language. This indicates his belief that sign languages are not bonafide languages like spoken languages are. Therefore, there is a big question surrounding how language and culture is "inculcated" for deaf Singaporeans because they do not know their mother tongue and majority acquire SgSL later in life.

Considering the overall discussion, we can make the case that both hearing and deaf Singaporeans who co-exist in the Singapore multilingual ecology are "mother tongue orphans" in different ways. This is evident in the endangerment of their native tongues such as Chinese and Indian dialects as well as SSL and SgSL. We are same yet different. Snoddon and Weber (2021) posit that a bimodal bilingual approach to deaf education reaps interpersonal and cognitive benefits for deaf children because it provides them access to multilingual contexts, and this affords them the opportunity to innovate when using the multiplicity of languages and varieties in their communicative practices. They also highlight the shortcomings of language policy in deaf education across different countries which have deprived deaf children of access to a good quality sign language-based education. Through a plurilingualism and translanguaging lens, they challenge the oversimplistic notion of monolingualism, and point out the complications that accompany it especially for sign language bilingual programs. This is critical for the development of multilingual deaf identities and the active citizenship of every deaf Singaporean in accessing and participating in various facets of life in Singapore.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

PT is the first author, corresponding author and the initiator of the project. She crafted the initial draft of the paper. In 2016, PT did a research project on language and identity during an internship at the Singapore Association for the Deaf. She also collected archival data about the history of Deaf linguistics in Singapore. The findings of the interviews PT conducted are documented and analysed in the paper.

BN is PT's PhD supervisor at NTU and the second author. BN gave feedback on drafts pointing PT to relevant research for background reading on the Singapore linguistic ecology. She helped shape the discussion on multilingualism and linguistic ecology and provided feedback on the structuring of academic argument.

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Signed Languages: A Triangular Semiotic Dimension

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Since the beginning of signed language research, the linguistic units have been divided into conventional, standard and fixed signs, all of which were considered as the core of the language, and iconic and productive signs, put at the edge of language. In the present paper, we will review different models proposed by signed language researchers over the years to describe the signed lexicon, showing how to overcome the hierarchical division between standard and productive lexicon. Drawing from the semiotic insights of Peirce we proposed to look at signs as a triadic construction built on symbolic, iconic, and indexical features. In our model, the different iconic, symbolic, and indexical features of signs are seen as the three sides of the same triangle, detectable in the single linguistic sign (Capirci, 2018; Puupponen, 2019). The key aspect is that the dominance of the feature will determine the different use of the linguistic unit, as we will show with examples from different discourse types (narratives, conference talks, poems, a theater monolog).

Keywords: iconicity, indexicality, simbolicity, semiotics, depiction, signed languages

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INTRODUCTION

In 1960, William Stokoe published *Sign Language Structure* and showed that signed languages have structural properties comparable to those of spoken languages. Signed languages were analyzed as true languages for the first time, but all the effort was placed in stressing the similarity with spoken languages, minimizing all the features that make signed languages unique, such as simultaneity and iconicity. Signed language linguistics faced the challenge of describing a visual language with instruments provided by the descriptions of a spoken one, forcing American Sign Language (ASL) and other signed languages into molds created for written Indo-European languages.

Throughout most of the twentieth century, different models proposed to describe signed languages were based on a hierarchy: only the lexical units (i.e., standardized in form and meaning signs) were considered at the core of the language, while the "productive signs" (i.e., iconic constructions) were pushed to the linguistic borderline, closer to the level of gesticulation and mime.

In this paper, we will briefly review the history of signed language studies looking for the implication of the language/gesture hierarchy. We will then address how different approaches have tried to overcome this hierarchy, beginning with Christian Cuxac's semiological approach. Cuxac proposed to describe signed language starting from iconicity, seeing lexical and productive signs emerging from the same iconic and symbolic process. Based on the difference between things and processes pointed out by Langacker (1987), Cuxac distinguished between lexical units and transfer units proposing that a signer can "tell by showing" driven by an illustrative intent (Cuxac, 1999, 2000; Cuxac and Antinoro Pizzuto, 2010).

Ferrara and Halvorsen (2017) and Ferrara and Hodge (2018) applied to signed languages Clark's theory on spoken communication (Clark, 1996): speakers use their voice and body to communicate employing description, indexicality, and depiction. This theory is based in turn upon the foundational principles of categorization of semiotic signs into symbols, indices, and icons first proposed by Peirce (1994). Ferrara and Halvorsen (2017) and Ferrara and Hodge (2018) proposed a model where the attention is placed on the multiple semiotic modes of expression, and that there are very different ways to display signs according to the signer's intentions. The authors state that each way is fundamentally different from the other and those signers can use them alone or in combination.

Following a cognitive linguistic approach, Wilcox and Occhino (2016); Occhino and Wilcox (2017); Lepic and Occhino (2018); and Wilcox and Martínez (2020) proposed to overcome the supposed division between lexical signs and gestural elements in sign constructions by building a model based on assumptions from cognitive grammar and construction morphology.

In the present manuscript, we proposed going even further, stating that all these modulations are expressed on a continuum that cannot be broken up into discrete categories, nor is it possible to draw a clear border between lexical and productive signs. There are no pure icons, pure indexes, and pure symbols; that is to say, there are no boxes to categorize a specific type of sign, but rather each linguistic sign can assume all these features. Indeed, a sign will simply show a predominance of either iconic, indexical, or symbolic features, according to the context, the use, or the signer's intention.

Consequently, the signed language lexicon cannot be divided into symbolic/lexical units and iconic/productive units, tracing the border on the degree of conventionalization of the unit, as the transfer units are also highly conventional constructions. In our model, we consider indexicality, iconicity, and symbolicity as features or semiotic grounds rather than categories, and we, therefore, see them as three sides of the same triangle (Capirci, 2018). The key aspect is the feature's dominance, represented by the different proportions in the lengths of the triangle sides, with the predominant feature having the longer side. The model will therefore involve equilateral triangles or different scalene and isosceles triangles, depending on the predominance of each feature determining the length of its side.

We will evaluate the effectiveness of this model by applying it to the description of signs found in the following different language uses of Italian Sign Language (LIS): narratives, conference talks, poems and a theater monolog.

AT THE FOUNDATION OF SIGNED LANGUAGE STUDIES: WILLIAM STOKOE

Signed languages were long ignored by linguists, being considered a minor form of gestural communication similar to pantomime. In 1960, linguists still considered true language to be only speech, and as such characterized by the vocal-auditory channel, by arbitrariness and discreetness. In 1958, the linguist Charles F. Hockett, 1960 first proposed a list of key properties of language, then developed in his 1960 paper "The Origin of Speech" as the 13 design features. Hockett (1960) writes, "There is solid empirical justification for the belief that all the languages of the world share every one of these features" (1960, p. 90). The very first design feature he discusses, one he feels is "perhaps the most obvious," is "the vocal-auditory channel."

However, in the same year, William Stokoe proved Hockett to be wrong about this first design feature, showing that the vocal-auditory channel is not necessary for the development of human language.

"When Stokoe's monograph was published in 1960, the message it sent was indeed radical. The signs of the deaf, he claimed, were structured, systematic, analyzable as a human language. A revolutionary idea, indeed, that language, human language, could be in sign" (Mcburney, 2001, p.177).

As reported in Stokoe's biography (Maher, 1996), the intuition that it was possible to study the communication of deaf people through the tools of formal linguistics led Stokoe to propose to the Gallaudet College administration an ambitious research project, the first evidence of which can be found in a 1957 report «. . .structural linguistic analysis of the language of signs to see if signed languages can be studied as other languages are with a descriptive grammar and lexicon.» (Maher, 1996, pp. 56-7). The need to identify the structural properties of language, in other words, the discrete units that build the linguistic system, is at the very foundation of signed language studies.

It is well known that Stokoe was the first one to identify a cherology and to break up the sign into three formational parameters: handshape, movement, and location. However, in adopting the methods of structural linguistics, Stokoe acknowledged that he had to face the simultaneous nature of the signs when the unitary act of the sign was analyzed in sublexical units by isolating a single point of observation from time to time, an "aspect." As highlighted by the author in later works (Stokoe, 1980; Armstrong et al., 1995) the phonological analysis takes place on an ideal level "by an act of imagination" (Stokoe, 1980, p. 369)[1]. The aim to describe the lexicon and to provide the first dictionary of ASL led Stokoe to develop an annotation system, now known as Stokoe notation, as a tool for the analysis.

Before the publication of the 1960 monograph, there was no means of writing or transcribing the signs, except for the pioneering attempt of Bébian (1825). Setting aside the challenges of representing visual gestures on manuscript, it was believed that signs were unanalyzable wholes, devoid of any internal structure. Individual signs were cataloged in dictionaries by photographs or drawings, often accompanied by their written language descriptions, as in the first documentations of French Sign Language (LSF) by Sicard (1808) and Laveau (1868). As pointed out by Mcburney (2001), there is a symbiotic relationship between transcription and linguistic analysis, which is acknowledged by Stokoe himself: " the invention of a symbol system for the transcription of the sign language has had to go hand in hand with the analysis of the structure" (Stokoe, 1960, p.30).

[1]The complexity and overelaboration of signed phonology leaded Stokoe to propose in 1991 a completely different model: the semantic phonology.

Critically, the notation systems used, failed to represent all the signed language units (as, for example, the non-manual ones) and linearly transcribed them, ignoring the simultaneous nature of sign articulation. On the other hand, the widespread use that has been made of "glosses" ("translating" the signs with words of vocal languages) presents a concrete and serious risk of inappropriate segmentation; inappropriate labeling; inappropriate analysis and description of signed structures; "transferring" characteristics of the words to the signs (Antinoro Pizzuto et al., 2010; Antinoro Pizzuto et al., 2008; Antinoro Pizzuto and Garcia, in press).

Since Stokoe's groundbreaking work, signed languages started to be seen as true languages, but all the effort was put into stressing their similarity with vocal languages (i.e., an "assimilation" to vocal languages). Signed language linguists have tried to reach this goal by forcing ASL and other signed languages into molds that were made for the description of spoken languages—generally, English (Slobin, 2008). Although some early scholars such as Schlesinger and Namir (1978); Klima and Bellugi (1979); Karlsson et al. (1984); Volterra (1987) paid attention to aspects such as the use of space, iconicity, and simultaneity, quite soon the "assimilationist model" became the dominant one, and characteristics that make signed languages unique were often ignored, minimized. Signed languages were characterized by adopting vocal language tools, vocal language based linguistic theory (from a written language perspective), categories, terminology, and analyses.

ICONICITY AS A SEMIOTIC ENGINE: CHRISTIAN CUXAC

A new linguistic model was first proposed by Cuxac in 1985 attributing to iconicity a crucial, formal role in shaping signed languages discourse and grammar (Cuxac, 1985, 1999, 2000, 2004, 2013). According to Cuxac, all signed languages are grounded upon the basic capacity that signers have in iconicizing their perceptual/practical experience of the physical world and make a structured use of the shared physical-linguistic space of signed discourse.

Cuxac's research starts from a reflection initiated by Jouison in the late 1970s that was made public with a collection of his writings in 1995. Jouison soon rejected the chereology initially proposed by Stokoe, insisting on the fundamental role of the whole body in the signed discourse and on iconicity. Jouison emphasizes that the mimetic aspects of signs in no way detract from their being linguistic acts, and focuses primarily on iconic discursive structures, from which Cuxac's linguistic reflection will start.

According to Cuxac (1999, 2000) signed languages exploit the signer power to iconizing their perceptual and bodily experiences. Iconization does not reside only in the formation of the sign, at the origin of its etymology, but remains a source of creativity at the synchronic level, which the signers can draw on to structure their discourse driven by an illustrative intent.

Cuxac (1985, 1996, 2000) proposed a semiotic model in an enunciative approach for the analyses of signed discourse. This model is in line with the following works undertaken by the French research group (Garcia, 2010; Fusellier-Souza, 2006, 2012; Garcia and Sallandre, 2020) and by the Italian research group (Pizzuto and Corazza, 2000; Russo Cardona and Volterra, 2007; Volterra et al., 2019). According to these scholars, in contrast with the structuralist perspective to approach the linguistics of the signed languages, it was necessary to abandon influences and preconceptions coming from linguistics of spoken languages, especially the generativists' approach.

Cuxac argued that it is necessary to start from the internal regularity of the language to study it, without projecting analytic categories from linguistics of vocal languages. The author was inspired, among others, by the pioneering work of Jouison (1995), who draw attention to the bodily components (especially eye gaze and body movements) and to the linguistic analysis of iconic construction in LSF. Cuxac shed more light on the incidence of iconicity in grammatical structures, elaborating the model of the Highly Iconic Structures. The notion of a structure that is built on iconicity was precisely aimed at recognizing the linguistic value of iconicity as a grammatical structure of the signed languages: "These constructions are verbal (that is, linguistic) precisely because they are based on structures, that is, they are composed of constrained elements that fit into paradigms" (Garcia and Sallandre, 2020, p. 5).

Cuxac believed that the grammatical classes of signed discourse differ significantly from those used for vocal languages (Beccaria, 1994; Simone, 2008) where they are called verbs, nouns, adjectives, and conjunctions. According to the theoretical framework of cognitive grammar (Langacker, 1987), grammatical classes could be distinguished instead in things and processes, categories grounded in our cognition. Cuxac (1999) found this perspective well suited to describe LSF and later applied it to other signed languages as well. In fact, he studied different types of iconicity in the signed discourses led by different iconic/visual and lived experiences. In this way he found, identified, and distinguished different units of meaning in the signed discourses: standard signs (standard lexicon) and Highly Iconic Structures (HIS), now called lexical units (UL) and transfer structures, that generate a multitude of transfer units (UT).

"This model was progressively developed from the early 1980s on the basis of close, frame-by-frame, analysis of long spontaneous discourse corpora, recorded *in situ* (Cuxac, 1985, 1993, 1999). The methodological decision to work on corpora, setting out from a functional and therefore semantically centered perspective (a top-down approach), was unique at the time (and remained so until the 1990s), as research on other signed languages had long been focused primarily on elicited data such as decontextualized sentences" (Garcia and Sallandre, 2020, p. 5).

One of the effects of this iconization process is to endow signed languages with an additional semiotic dimension compared to vocal languages. In signed languages, there are two ways of signifying (Cuxac, 2000; Russo Cardona and Volterra, 2007; Cuxac and Antinoro Pizzuto, 2010; Volterra et al., 2019): (1) by "telling without showing" - using: (a) units that are broadly comparable to vocal languages' content words, which we will call here "lexemic units" (LU); (b) pointing signs realized manually but also visually, by re-directing the signer's gaze in the signing space -; (2) by "telling and showing," thereby producing complex

structures that can be characterized as "transfer units" (TU) and are unique of the signed modality. A most relevant feature of TU is that they can be combined among themselves, or with LU, to encode information on two (or even more) referents in a multilinear, simultaneous fashion that has no parallel in speech. Gaze patterns play a key role in distinguishing LU from TU. When producing the LU the signer's gaze is oriented toward the addressee. In contrast, when producing TU the signer's gaze is away from the addressee and their head and body posture clearly differ from those used in producing the LU.

NEW NON-STRUCTURALIST APPROACHES

The approach initiated by Cuxac and now known as the Semiological Approach (e.g., Cuxac, 1999; Fusellier-Souza, 2006, 2012; Sallandre, 2006; Cuxac and Sallandre, 2007; Garcia, 2010; Garcia and Sallandre, 2020) remained little known for a long time and still does not have a great resonance among modern-day signed language researchers. Linguistic research on signed languages continued trying to respond to two pressing practical priorities: the need to fix citation forms of signs for new dictionaries and the need to have notation systems for annotating corpora.

Throughout most of the twentieth century, linguists were busy constructing models in which discrete elements belong to discrete categories, and in which various types of rules combine those categories of elements to produce words, phrases, clauses, and sentences. In this attempt, different functionalist and cognitive approaches to signed languages tried to develop models opposing the structuralist view. Nevertheless, the need to create dictionaries and corpora pushed signed language research to continue to set clear boundaries between what was described as fully lexicalized signs, namely those which could easily enter in a dictionary. They have fixed form and meaning, as well as the transfer units, seen as more gradient and therefore gestural.

Signs at the Core and Signs at the Edge of Language

One of the first models of this kind was proposed by Johnston and Schembri (1999) and later revised by Cormier et al. (2013) in a simplified version (2013).

Johnston and Schembri's (1999) proposal is motivated by the practical need to establish which linguistic units in Auslan (Australian Sign Language) are best entered in a dictionary and which are best treated in grammar: "In the first instance, one needs to discriminate between non-linguistic visual-gestural acts (gesticulation, gesture, and mime) and linguistic visual-gestural acts (signs). The lexicographer is concerned with the latter" (Johnston and Schembri, 1999, p.115). Following this assumption, a distinction is made between "lexicalized" signs and those which are partly lexical or non-lexical.

Fully lexical signs are those defined as conventional in their form and meaning: "A lexeme in Auslan is defined as a sign that has a clearly identifiable and replicable citation form regularly and strongly associated with a meaning which is (a) unpredictable and/or somewhat more specific than the sign's componential meaning potential, even when cited out of context, and/or (b) quite unrelated to its componential meaning potential (i.e., lexemes may have arbitrary links between form and meaning)" (Johnston and Schembri, 1999, p. 126).

This "frozen" lexicon, in line with Brennan (1990), "is a list of stable forms and stable meanings (i.e., the lexemes) which is known only to a user of any particular sign language" (Johnston and Schembri, 1999, p. 131).

Johnston and Schembri thereby build a gestural hierarchy and sign typology, visually represented in an image of concentric circles in which the signs at the center, the core, are fully linguistic, while those encompassing circles are less and less linguistic, with the non-linguistic gestural forms being in the outermost circle.

The core is defined by characteristics such as full arbitrariness between form and meaning, conventionality, non-componentiality, and the stability of forms and meanings. What is "relegated" to the periphery as partially lexical or non-lexical are "Signs (lexemes) which show no obvious form/meaning relationship" (Johnston and Schembri, 1999, p. 131). The complex signs, characterized as partly lexical, have properties of gradation, while the non-lexical signs are unconventional bodily actions that show meaning, and are dependent upon context for their interpretation (Whynot, 2016).

However, the division between a "frozen" core and a "productive" edge of the lexicon can be questioned by considering if, on the contrary, the special features of linguistic signs (vocal or signed) are precisely their being "productive" and therefore unstable, vague in meaning, modifiable by speakers, iconic, compositional.

This hierarchical model proposed by Johnston and Schembri [inspired by Liddell (1995)], has been adopted by others in several subsequent works, albeit with some variations. Whilst not altering its substance they have tried to divide the components of signed languages into "core lexicon" completely linguistic, and increasingly less "linguistic" peripheries which slope outward toward the limit of the gestural or non-linguistic.

Depicting signs were regarded as both linguistic and gestural elements (Schembri, 2001; Liddell, 2003; and Schembri et al., 2005). Pointing signs have been characterized as hybrid (partly conventional, partly non-conventional) forms, and it has been suggested that points are gestural, much like co-speech gestural pointing that occurs in spoken languages (Johnston, 2013).

Johnston and Schembri (2010) propose a Table (p. 27) in which they present the linguistic universe of signed languages divided into various categorizations identifying two major types of signs in signed languages with the different names having been given to them by different authors (e.g., Frishberg, 1975; Liddell, 1977; Supalla, 1978; Liddell and Johnson, 1986): fully lexical signs (regular signs, frozen signs) and partly lexical signs (productive signs, non-lexical signs, depicting signs).

Cuxac (2000) has also been included in this "binary" vision, focusing on "standard sign" vs. highly iconic structures, but in a somewhat incorrect way, as in Cuxac's view, these categories are in no way comparable to the vision here expressed by Johnston and Schembri. According to Cuxac, transfers cannot

in any way be confused with pantomimic forms since they are based on a real linguistic structure which is an alternative to the standard lexicon; conventionality is always present. As Cuxac and Sallandre (2007) clearly point out: "among several coexisting forms of iconicity in LSF, even the most imagistic of them are organized in macrostructures on an initial level, making short work of the equation "iconic" means "unstructured" (Cuxac and Sallandre, 2007, p. 14); "Linguistically speaking, iconicity poses no theoretical problem for these structures, since the intent is deliberate. Wondering why this type of iconicity exists is as irrelevant as asking why a figurative painter will paint naturalistic subjects. The interesting question is how. With these different examples, we hope to have shown that structures and iconicity can go together" (*ibid.* p. 20).

We have said that this hierarchical approach for Johnston and Schembri (1999) was motivated by the need to establish which linguistic units in Auslan are best entered in a dictionary. Now let's see what Cormier's needs were.

Cormier et al. (2012) aim to code or annotate natural signed language data and therefore for these authors identifying the lexical signs has fundamental implications for the analysis: "there is nearly always a need to identify tokens within the signing stream which are lexical signs (in the sense of the core lexicon) versus those which are not" (*ibid.* p. 344).

These researchers were particularly interested in coding constructed actions (CAs) and proposed to evaluate the degree of gestural component of each type of construction according to the following consideration: "Cues for gestural status of handling/embodiment could be the overtness of constructed action used (as marked by the number of articulators used and/or degree to which the various articulators are active. . .), or the degree of iconicity between production and referent such that the more overt the constructed action and/or the higher the iconicity between production and referent, the stronger the character viewpoint gestural status" (*ibid.* p. 344).

In this reasoning, it seems that what underlies the distinction between linguistic and gestural is the presence of the so-called non-manual parameters, iconicity, and simultaneity (the use of several articulators at the same time). Therefore, this approach seems to suggest that the non-manual components, iconicity, and simultaneity are paralinguistic or gestural properties.

Cormier et al. (2013) proposes a simplified version of the Johnston and Schembri model (p. 373) with three concentric circles: at the "core" the standard signs (lexemes); then the productive signs that include depicting constructions (DCs) such as whole entity constructions ("non-core lexicon," Brentari and Padden, 2001); and finally to the extreme periphery the "gestures and mime," non-lexical means "*via* CA, to portray actions of referents by full or partial mapping of articulators onto actual (or perceived) actions, thoughts, utterances, or feelings" (*ibid.* p. 373).

Surely these models with concentric circles can have their usefulness for selecting the signs to be included in a Dictionary, or to annotate the corpora with identifying glosses (ID-glosses, e.g., Crasborn and Sloetjes, 2008; Johnston, 2008, 2014; Cormier et al., 2015), but are we sure that these hierarchical models that attribute values of "linguisticity" reflect the nature of signed languages (and languages in general)? Are we sure that everything that is iconic, variable according to the context, "corporeal," simultaneous, is not also conventional and arbitrary?

These scholars undoubtedly have the merit of having opened and widened the field to the study of these special aspects of signed languages, - starting for example from the impressive analysis and consideration of the non-manual components that Cormier makes in her study of CAs - but why give them a "non-linguistic" status?

Cuxac was the first to begin to investigate these highly iconic structures or transfer units and to make a division between a "telling" mode and a "telling by showing" mode. However, it must be acknowledged that he has never placed these two levels in a hierarchical way nor has he ever considered "showing" as a non-linguistic or "gestural" semiotic plane. Indeed, he has used the term "structures" precisely to underline the systematic nature of the iconic plane of "showing."

Nevertheless, over the years until today, Cuxac and the Semiological Approach continue to be little known and cited, while many of the new "models" proposed to describe signed languages seem to have internalized (almost like a dogma) this general view of language in which there is something more linguistic than the other.

Different Modes of Expression for Different Types of Signs

Hodge and Johnston (2014) make it clear that they belong to the broadly cognitive-functional construction grammar perspective. In their adoption of a perspective, that we could call *cuxachian*, they declare that signers, as well as speakers, construct their meaning using "semiotic signs of different types" and these different semiotic modes are those of telling and showing. Thanks also to the development and availability of time-aligned multimodal annotation software like ELAN that allowed building multimodal vocal languages and signed languages corpora (e.g., Crasborn and Sloetjes, 2008), according to the authors it is possible to investigate and "count" the prevalence in the signing of these two semiotic resources.

So far, the model appears as a more recent version of Cuxac's theory, but again the division emerges between a linguistic level, telling, and less than little or not at all linguistic or gestural level, showing. The authors state that while "formal and theoretical linguists have typically focused on describing how speakers and signers "tell" meaning (. . .) More recently, this focus has evolved to also consider how language users manipulate various semiotic resources to visually represent and "show" meaning to prompt conceptualizations for their interactants" (Hodge and Johnston, 2014, p. 265).

The realm of showing includes iconicity, use of non-manual components, and simultaneity. But once again the authors cannot avoid providing a hierarchy to these worlds and hierarchize between fully lexical, partly lexical, and non-lexical/gestural: "Signs vary gradiently from fully lexical, through partly lexical, to non-lexical according to degrees of conventionality, complexity and schematicity." (*ibid.* p. 267). They also specify that "Partly lexical signs have only some characteristics specified in their form

(typically handshape and orientation); all other specification emerges from mapping these forms onto the signing space." And that "Pointing signs (also known as pronouns and indexing signs in the SL literature) and depicting signs (also known as classifier and polycomponential signs) are two major sub-classes of partly lexical signs" (*ibid.* p. 267). While defining the "non-lexical signs, as "singular events" during which interactants enchronically interpret a form as "standing for" a meaning (Kockelman, 2005)" (*ibid.* p. 268). This category includes (again) CAs and DCs.

This hierarchical model, although starting from a different approach (cognitive linguistic), ends up resembling (too much) the approach of the formal and theoretical linguists, as it is presented, for example in the target article by Goldin-Meadow and Brentari (2017). At least some residues of structuralism are therefore shown. Any sort of expression in signing that cannot be analyzed in discrete, categorial terms is defined as gestural. As discussed before, this approach entails the risk of framing as language only a really small portion of signed languages, while excluding and relegating to the darkness of non-linguistic and gestural domain what does not fall into this category. That is, all the non-manual components, the transfer units (TU) or constructed action (CAs), depicting constructions (DCs), and considered as co-sign gestures. Again, a universe divided into two blocks, black and white, linguistic and non-linguistic, within rigidly closed, and separate categories.

Finally, we come to the model proposed by Ferrara and Hodge (2018; see also Hodge et al., 2019). Ferrara and Hodge proposed a theory of language built on Clark's (1996) theory of language use as "actioned" *via* three methods of signaling: describing, indicating, and depicting. This theory is in turn based upon the foundational principles of symbols, indices, and icons first proposed by Peirce (1955).

Ferrara and Hodge (2018) state that: "each method is fundamentally different from the other, and they can be used alone or in combination with others" (p. 1). Subsequently, they define the three types of signs in a very rigid way. For example, they say that symbols - the category in which they include the lexicalized manual signs of signed languages - are signaled through acts of description. Afterward, they refer to the Dingemanse definition of descriptions as "typically arbitrary, without a motivated link between form and meaning . . . these symbols are discrete rather than gradient." Later, the definition of icons presented as partially depicting meaning trough perceptual resemblance in contrast with symbols. . . "they are gradient, varying." This category includes typically "mimetic enactment of people, animals or things" (*ibid.* p. 4; Dingemanse, 2015, pp. 950–951). Icons and depictive signs (or, in other terminology, TU, CAs, and DCS) are considered to be on a par with gestures [a sort of co-sign gestures as in Goldin-Meadow and Brentari (2017)]: "Depicting signs have been compared in varying degrees to the iconic and metaphoric manual gestures (also known as referential gestures) produced as part of spoken language discourse" (Ferrara and Hodge, 2018, p.5).

Even if this approach represents an attempt to overcome the dichotomy between gestural and linguistic elements, it is still possible to see the division between white building blocks (symbol, arbitrary, and categorical) on one side and black building blocks (icon, motivated, and gradient) on the other. In fact, if these building blocks can come together in the signed expression - as the authors correctly points out - why divide them so rigidly? More importantly, is it possible to find a pure symbolic unit in signed language, without any indexicality or iconicity? In other words, is it possible to separate the depicting, describing, and indicating functions in language, or is it rather a matter of dominance of one function over the other?

New Insight From Cognitive Linguistics: A Continuum Between Fixedness and Schematicity

Armstrong et al. (1995) proposed to look closely to the similarity between gestures and signs, introducing what Janzen (2006) nicely defines the continuous account in signed language research, carried on by cognitive linguistics. This continuous account is used to reflect on grammaticalization and gestures-sign interface in Janzen and Shaffer (2002); Wilcox (2004); Wilcox et al. (2010), suggesting that gestural materials are conventionalized as lexical or grammatical items in signed languages, in a transitional, and not abrupt, manner.

More recently, in their commentary to Goldin-Meadow and Brentari (2017); Occhino and Wilcox (2017) pointed out very clearly that the language versus gesture dichotomy based on discreteness versus gradience is too simplistic. The authors explained how a usage-based framework suggests that networks with different levels of complexity, specificity, and schematicity emerge from language use. Considering this approach, gradient elements are not seen as gestural, but simply as linguistic.

Following this approach Wilcox and Occhino (2016); Martínez and Wilcox (2019); and Wilcox and Martínez (2020) introduced the concept of Place as a symbolic structure largely exploited in signed discourse. A Place is a pairing of a specific meaning and a specific location in the signing space in the context of a usage event, it is used in placing and pointing constructions. For example, if a signer wants to make a comparison, she will probably use a placing construction creating a place for each element, signing the signs in a specific location, for instance to the right and to the left. During the signing discourse, the two Places can be recruited again to refers to these elements, using again a placing construction, or a pointing (Wilcox and Martínez, 2020). This perspective, inspired by Cognitive Grammar, shows how it is possible to explain gradient and not listable signed units within a linguistic framework, without having to resort to a "mixed model" with gestural gradient elements seen along with discrete linguistic units.

Recently, Lepic and Occhino (2018) have discussed the language versus gestures issue starting from the rule/list fallacy proposed by Langacker (1987, 2008). The supposed division between grammar rules and lexicon should be rejected since it is imposed by the linguist's need to have abstract categories. In contrast, linguistic rules are schema emerging from use. The point is not to deny the existence of regularities, which are in fact undeniable, but rather to see rules and usage as a whole. Linguistic regularities are not independent operations from the matter on which they are applied, but on the contrary, they are

schemes or organizational lines that emerge from the linguistic matter itself and from the way in which it is associated. In the same way, signs that have been defined as the lexical units at the core of signed language cannot be completely separated from the so-called productive lexicon, they co-exist with highly iconic properties and schemas, and have a gradient rather than discrete internal structure.

The authors, building on Langacker's insights, insist on how the theoretical framework of cognitive linguistics can aid research on signed languages by leaving aside the idea of language as a structure of discrete, enumerable elements. Cognitive linguistics embraces an idea of language analyzable in terms of constructions, of conventionalized pairings of form and meaning, both containing holistic or discrete elements and yet organized in a system, conceived as a network. Conventionality has been seen as a foundational property in the human language since phonology, morphology, grammar, and lexicon are described as a continuum of conventional linguistic units (Croft and Cruse, 2004).

Lepic and Occhino (2018) use Construction Morphology to show that both transfer and lexical units do not have to be divided since: "construction-theoretic analysis instead treats entrenched, highly fixed "lexical" signs and more schematic and productive "classifier" signs alike as learned pairings of form and function (or meaning). Rather than assigning individual sign tokens to distinct domains of linguistic knowledge, all sign constructions can be considered primarily meaningful wholes that also exhibit gradient internal structure" (Lepic and Occhino, 2018).

Furthermore, a linguist may look at signs and analyze them without seeking help from the dichotomy between gesture and language: all signs are equally pairs of form and meaning with different levels of fixedness and schematicity. The usage-based approach has been successively employed to explain "lexicalization" in signed language by Lepic (2019), the author shows how there is not a clear distinction between holistic and structural properties in signed constructions, and it is therefore better to set the analysis on degrees of fixedness rather than on categories.

BEYOND CATEGORIES: THREE FACES OF THE SAME TRIANGLE

The tendency toward categorizing and discontinuity is a product of researchers' needs (e.g., the need to establish which linguistic units are best entered in a dictionary, Johnston and Schembri, 1999; the need to code or annotate signed language data, Cormier et al., 2012) and originate from an alphabet-based culture (of written languages) which has influenced, even if at times subconsciously, our metalinguistic reflection.

Usage-based approaches have laid bare ever-growing doubts about the correctness of the distinction between lexicalized and productive - partly lexicalized - signs; between symbol, icons, and indexes; between the modes of describing, depicting, and indicating. Ferrara and Halvorsen (2017) stress that signs can be used as both descriptions and depictions and should rather be considered as somewhere on a continuum between these two strategies instead of separating them into two distinct categories. In any case, the need to annotate often pushes us, as linguists, to fall into a categorization trap as if a sign can belong to one or the other "category" in an exclusive way.

To overcome the categorization trap, signed language research can find help from the field of semiotics. In fact, semiotics teaches us that: "The same signs can be icons, indices, or symbols depending on the interpretive process" (Deacon, 1997, p. 72). As is well established, Peirce conceives any act of signification as a triadic phenomenon, concerning the sign, the object, and the interpretant. Each sign represents the object to a certain respect, projecting in the sign some features of the object: "the sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen"[2] (Peirce, CP 2.228).

In this sense, the icon is constructing a relation of resemblance with its object, the index of proximity or a cause/effect relation, a symbol of a conventional relation. Nevertheless, Peirce's notion of icon, index, and symbol can be interpreted in terms of features instead of fixed distinct categories. The same sign (even in the same context) has all three features in itself, sometimes in equal measure/gradation, other times with a predominance of one over the others. As Kockelman (2005, p. 246) points out "it is best to talk about iconic, indexical, or symbolic grounds, rather than to talk about icons, indices, and symbols *per se*."

Puupponen (2018) in her Ph.D. thesis (2018) embraces this interpretation and argues that "Because of these inclusive relations in the Peircean theory, Peircian categories are very useful for studying (. . .) Sign languages that present a variety of iconic phenomena imbued with conventional and arbitrary aspects for which the categories elaborated by the linguistics of vocal languages are not sufficient." (p. 43).

Also with respect to iconicity, the field of semiotics has a lot to teach to linguistics. Iconicity is often interpreted as the opposite of arbitrariness and conventionality, making an equation (more or less conscious and explicit) between iconicity and naturalness/necessity. In part, this interpretation of iconicity derives from or is explicitly made to depend on a certain interpretation of Saussure, whose notion of arbitrariness leaves instead ample room for forms of iconicity (diagrammatic).

In an informative essay on iconicity and metaphor "The Map laid down upon the island" the Italian linguist Tommaso Russo (2004) offers us a "reading" of Peirce that establishes the non-equivalence of iconicity and naturalness: "Peircian iconicity presupposes that the iconic relationship manifests itself only on the basis of identifying a perspective through which sign and object enter into a relationship. The signs resemble their objects starting from a complex series of habits and conventions to which they are subjected and which govern the semiotic process, in its

[2]According to Peirce "A sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign" (CP 2.228). The technical term "representamen" has a broader meaning than the term "sign," as it can also refer to the first element of semiotic processes which do not have an interpreter with a mind and therefore cannot have an interpretant of a mental character.

triadic dimension. This process, in fact, always includes a sign, an object, and an interpretant, therefore a series of clothes." (p. 47). Each icon, Peirce points out, shows a resemblance to the object under a certain respect; we need to refer to certain implicit conventions and a way of looking at the object represented. Each icon, just as Plato had argued, is based not only on similarity but also on a habit of representing the object in one way rather than another: "the sensorial and qualitative characteristics of the sign sanction iconic relationships only thanks to the mediation of habits and norms that are part of linguistic competence." (*ibid.* p. 48).

By identifying iconicity and naturalness, one runs the risk of presenting language as if it were merely reflecting characteristics already given in the real world. On the contrary, an iconic sign never mirrors the referents but always mediates a certain meaning through projecting a resemblance. "In languages, the cases in which the iconic dimension and that of arbitrariness and variability coexist and illuminate each other are, indeed, much more relevant and worthy of consideration than those in which these two forces seem to oppose or exclude each other" (*ibid.* p. 52).

How can highly iconic language phenomena coexist with the formal and structural needs of a linguistic system? The coexistence of iconicity and arbitrariness must lie at the heart of the complex interplay between the formal requirements of the linguistic system and the pragmatic constraints which guide the interpretation of a linguistic utterance (Fontana and Volterra, 2020).

The plasticity of linguistic units makes it possible for these to be interpreted in context and change meaning and form (De Mauro, 1982, 2000). In fact, one of the main semiotic features of linguistic signs (signed or spoken) is their indeterminacy, that allows the human language to be inherently plastic. Pietrandrea (in press), has recently shown the relevance to De Mauro's notion of plasticity for signed language research. As shown by De Mauro (1982, 2000) the plasticity allows the signer or the speaker to negotiate the meaning of a linguistic units, as in the case of technical jargon, or to extend the meaning of a unit to a metalinguistic use. Because of this plasticity, linguistic units do not afford a complete and exhaustive interpretation of an utterance and need some pragmatic prompt for the interpretation to take place. Discursive iconicity is thus a major structural resource of signed languages permeating every level of the language and acting as a major pragmatic constraint in utterance interpretation.

In her book "From Speech to Grammar. Construction and form of spontaneous texts," Voghera (2017) starts from the perspective of the modality of face to face communication which places the indeterminacy, vagueness and low definition of the sign in the foreground, alongside the elasticity and instability of the spoken texts (see also Fontana et al., 2017; Volterra et al., 2019; Fanelli and Volterra, 2020; Fontana and Volterra, 2020).

"The form takes shape little by little, because the speaker (. . .) constructs the meaning along the way, also relying on the more or less explicit cooperation on the part of the recipient" (Voghera, 2017, p. 6). "Vagueness, as a systemic property of languages, consists in the possibility of extending and restricting the boundaries of signs and therefore in the possible existence of non-categorical, but vague, fuzzy semantic boundaries" (*ibid.* p. 173). This concept of vagueness was posed by philosophers such as Russell (1923) and Wittgenstein (1953) and taken up by De Mauro (1982).

Although what we have seen above was given as a characteristic of partially linguistic or non-linguistic signs, it is instead precisely the characteristic of the linguistic sign. This is the extraordinary strength of linguistic signs, they are malleable, not discrete, variable, and because they are not inherently defined.

Even in the Peircian vision, icons and symbols fade into each other, or rather they are both features of the same linguistic sign that, depending on the context, and can show one side more than the other. However, they can never be encapsulated in categories strictly defined as self-excluding. Arbitrariness and even more so conventionality, are not the exclusive properties of "symbols" but belong to all linguistic signs, as well as to icons. The three grounds, Peirce emphasizes, are not in nature completely separate from each other: each phenomenon, in short, can be reported with prevalence to one or the other, but will probably exhibit characteristics of the other two as well.

We therefore arrive at a new representation of the three Peircian grounds or features that better represent their non-categorical dimension: not concentric circles (from the center to the periphery), not parallel lines that can activate together but also distinguish themselves, but three faces of the same triangle [as first proposed in Capirci (2018)]. In this perspective each linguistic sign is made up of three sides: indexical side, symbolic side, and iconic side. The key aspect is the proportional length of each side in building the triangle of linguistic signs. We can therefore have an equilateral triangle or other types of triangles depending on the length of each side (Fig 1).

To illustrate the implication of this reasoning we can consider the LIS sign pictured in **Figure 2A** and glossed as "comb." This sign is listed in LIS dictionaries and therefore has a conventional meaning and form, a symbol with a descriptive function. Nevertheless, if we look analytically at its realization, we can see that the hand is depicting a hand holding a comb and moving as if combing the hair, with a strong iconic feature. Finally, the location of the sign is the indexical feature pointing at the head.

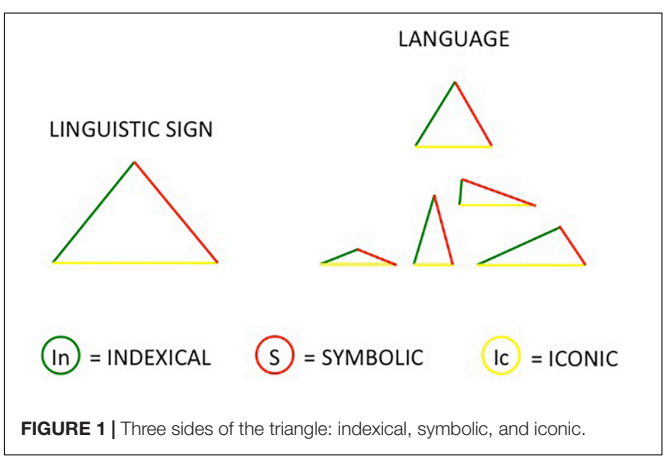


FIGURE 1 | Three sides of the triangle: indexical, symbolic, and iconic.

So, in the case of a sign referring to "comb/combing," we can see that all the triangle's sides are simultaneously present and crucially, that the three sides of the triangle have the same length (see **Figure 2A**). In its citational form there is not a dominance of one side. The sign depicts the handling of the instrument, points to the effective location of the action and is highly conventional in the pair of form and meaning. However, in the signed utterances the sign can be used stretching one side, for example when enacting the event of combing the hair the "iconicity" side gets longer (see **Figure 2B**).

The lexicon of signed languages seem to be characterized by a high degree of iconicity and, at the same time, by the fact that the same signs may or may not appear iconic depending on the discursive and situational context. The same sign can vary these features while remaining the same. Signs can be used as both descriptions (lexemes or LU) and depictions (CAs or DCs, or TU) and should be considered as somewhere on a continuum between these two strategies rather than separating them in two distinct categories: "What is clearly symbolic at one level is part of an icon at another" (Armstrong, 1999, p. 146).

The continuum is well illustrated in figure 3, which reports a part of the famous narrative retelling "Frog where are you?" In the signed utterance, the signer is at first introducing that there is a jar (**Figure 3A**). Then, the signer is enacting a dog being stuck in the jar, as shown in **Figure 3B**. In this case, we can observe that the signer first introduces a lexical unit translatable as "jar," then she uses a transfer of person enacting the dog with her posture and non-manual components and simultaneously a transfer of form depicting the jar turned upside down. The handshape of the conventional sign is built on a transfer of form since it represents the circular shape of the jar (an equilateral triangle as in **Figure 3A**), therefore the iconic features of the conventional sign can be easily implied in a transfer construction, showing the fuzzy border of the distinction between lexical signs and transfer constructions. Also in this case, we can see that the iconic side of the triangle stretched to resemble the scene along

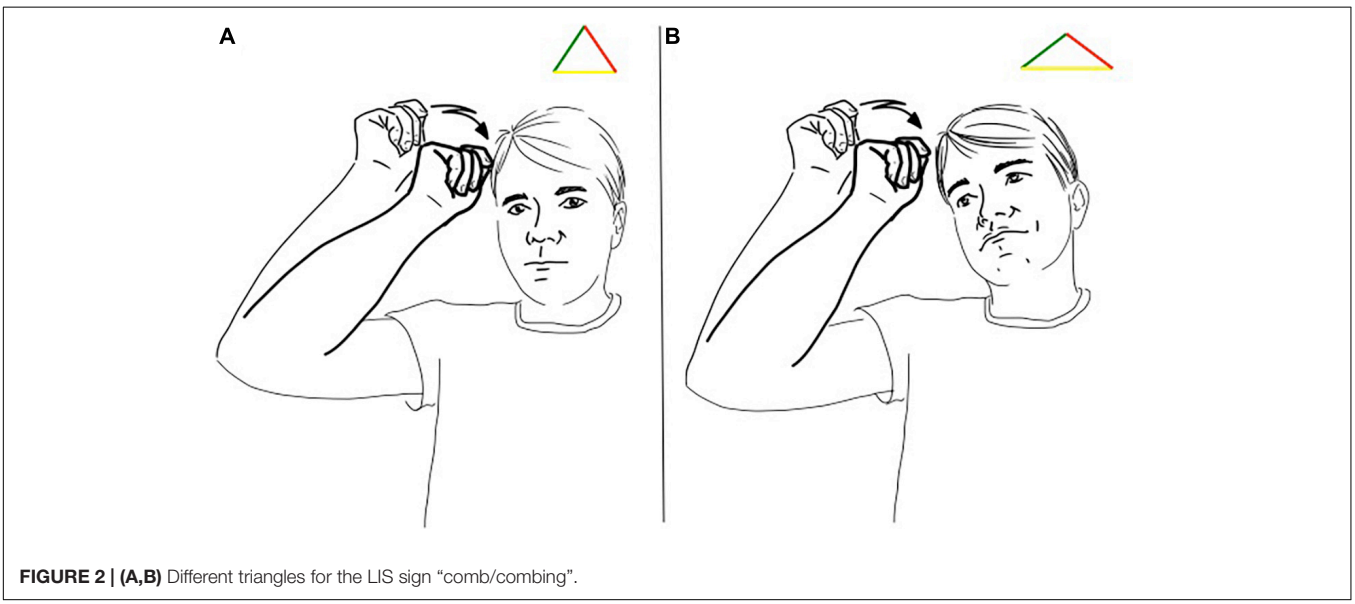


FIGURE 2 | (A,B) Different triangles for the LIS sign "comb/combing".

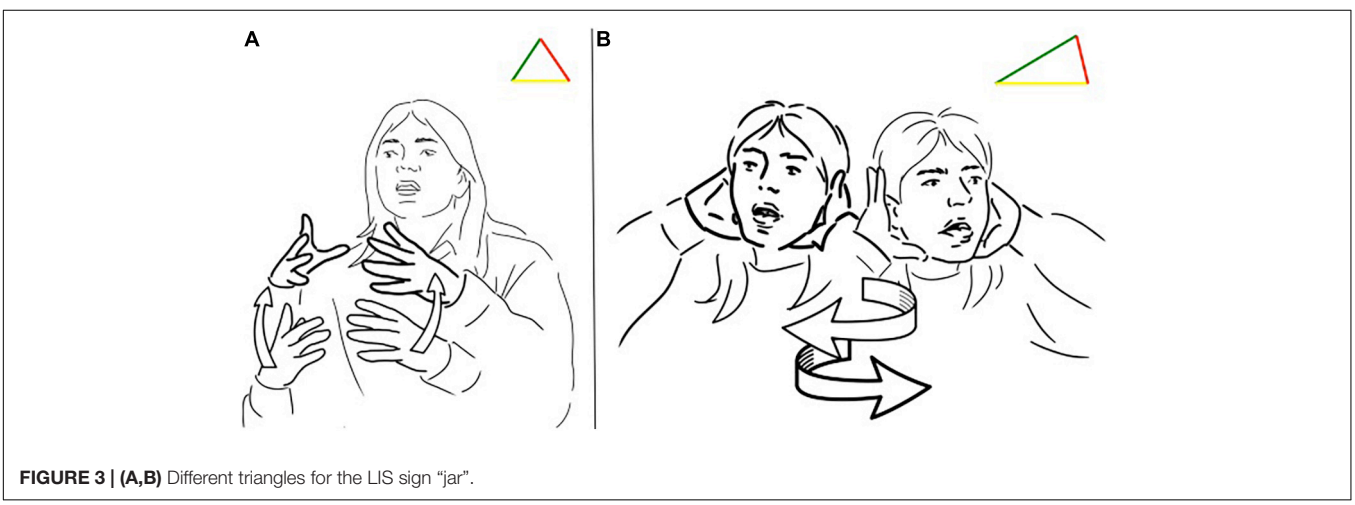


FIGURE 3 | (A,B) Different triangles for the LIS sign "jar".

with indexicality (see **Figure 3B**): the use of space is essential in providing information about the position of the jar being turned upside down and its locative relation with the dog.

In a very different discourse type, a conference, we can observe a similar example: the same sign can present the dominance of a different feature in its use. A conference presenter at the beginning uses the sign translatable as "source" with an equal distribution of the three functions (symbolic, iconic, and indexical), represented in **Figure 4A**. Shortly after, the signer constructs the powerful metaphor of the mind as a source of ideas and thoughts moving the location of the sign in their head, stretching the indexical side of the triangle (**Figure 4B**). The distinction between lexemes and depiction often does not rely upon the sign itself but on its function in the signed utterance: the borders between what is a description or a depiction are fuzzy and determined by the signer use.

The signed utterance reported in **Figure 5** belongs to a narrative about a horse which damages its leg crossing a fence and is nursed by a friendly cow. In the story, the same sign for "band/bandage" is used first as a lexical unit with a neutral value, like an equilateral triangle (**Figure 5A**). Then, the sign is used as a transfer, moving the sign in another location (and therefore stressing the indexicality features) to depict the action of the cow bandaging the horse's leg (**Figure 5B**).

If we look at the level of the signed utterance, we can identify a dominance in one or two features: an iconic dominance, a symbolic or indexical one. Clearly, there is not a clear cut between what is a lexical unit and what is a transfer, each sign has a

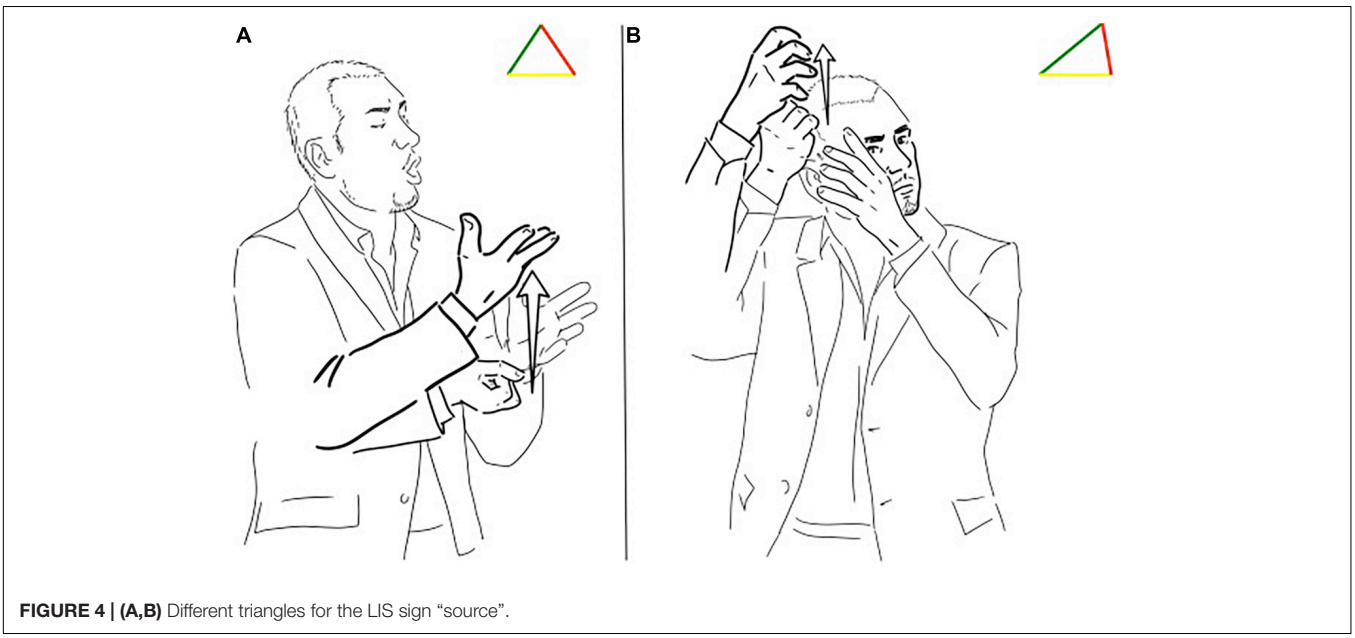


FIGURE 4 | (A,B) Different triangles for the LIS sign "source".



FIGURE 5 | (A,B) Different triangles for the LIS sign "band/bandage".

semiotic potential lying down in the three sides which can be exploited to stress one of its features.

Finally, we want to address the exploitation of the iconicity side in artistic contexts: the case of poems and theater. In signed poems, it is common to see how iconicity re-elaborates the meaning of signs, playing with the potential metaphorical and depictive power of the bodily articulators. The signs illustrated in **Figure 6** are part of a poem about the deaf culture and the use of the old teletypewriter (TTY): a telecommunication device for the deaf largely used in Italy in the past years. The signer is describing the complex relationship between the user and the machine providing cold and frustrating communication. The sign referring to the act of typing on a keyboard (an equilateral triangle in **Figure 6A**) is reformulated to describe the act of writing/writing back (**Figure 6B**) and ending with the frustration of doing so (**Figure 6C**), stretching the iconic and indexical side of the triangles.

In this case, the semiotic resources of the sign presented in **Figure 6A** are poetically exploited to create a triadic unit with a greater iconic and indexical dominance in **Figures 6B,C**. The movement and expression of the signer depict the rate of the action and the emotional content related to it, while the location and orientation of the hands point to the reciprocal construction.

The visual modality allows for the use of space as well as multiple articulators (both hands, torso, head, face expression) for linguistic encoding, providing ample opportunity for exploitation of simultaneity in signed languages. Signers can employ iconicity to represent the information present in events as it is available in the real world and in order to encode actions and interactions. The signer can make use of the affordances of the visual modality by mapping the referent onto the signer's body (e.g., through facial expression, eye gaze, and/or torso) and at the same time encoding the action by one of the hands.

Recently, the use of such iconic simultaneous constructions has been shown to increase with the increase of informative demands indicating that simultaneity can be used to achieve communicative efficiency by Slonimska et al. (2020, 2021). Simultaneity has profound consequences on the whole linguistic

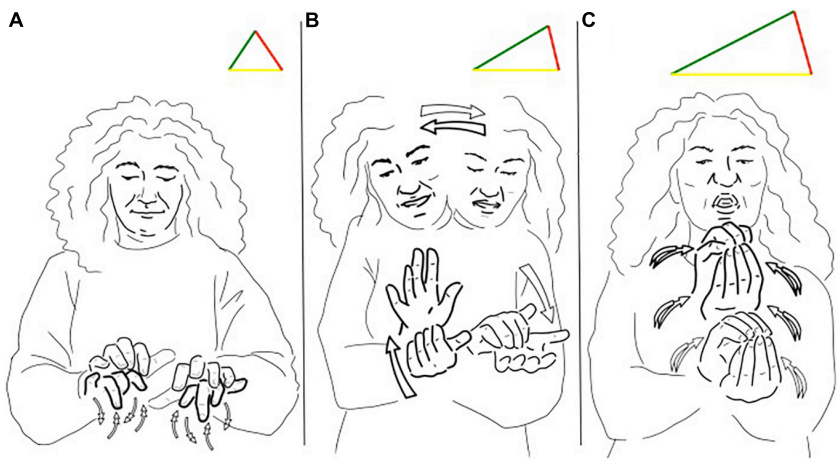


FIGURE 6 | (A–C) Different triangles for the LIS sign "typing".

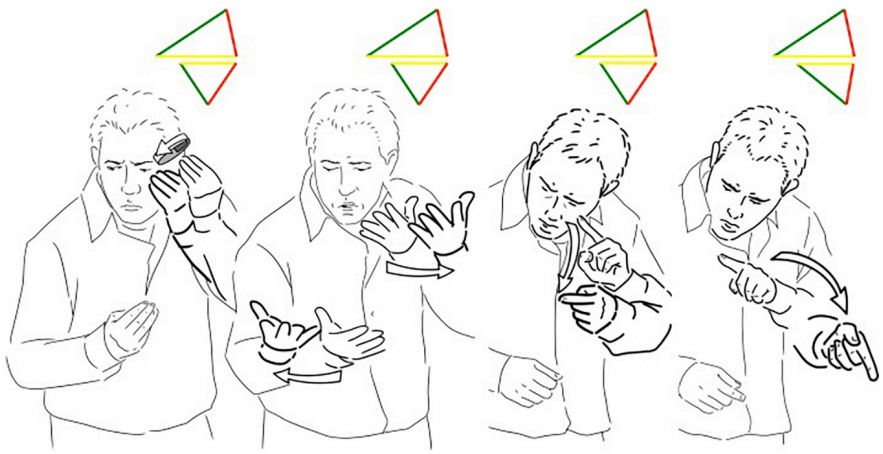


FIGURE 7 | A brief utterance from the theater monolog in LIS.

structure of signed languages. A semiotic structure is thus created in which it is not possible to distinguish, either at the level of a single unit or at utterance level, if this belongs to the category of symbol, icon, or index. We can find products simultaneously, a symbol with an icon, and/or an index. The overall structure of the sentence/utterance will have a greater or lesser degree of one of these elements, the signer will be describing, indicating, and depicting in more or less marked measures.

In the case of a theater monolog, we can observe the complex interplay between different levels. **Figure 7** illustrates a brief sentence from the monolog in which the signer talks about the everyday deaf experience and compares different types of pads to put under the armpit to absorb all the sweat coming from extensive signing. From the head movement, the facial expression and the direction of the eye gaze the signer depicts that he is talking to himself, he is performing a transfer of person. These signs are part of a complex transfer in which the non-manual articulators (eye gaze, oral components, and the head movements) and the manual articulators (right and left hand) can be considered as two different triangles (each one having its three features) presented simultaneously.

Therefore, in **Figure 7** for each sign there are two triangles simultaneously displayed, one referring to the transfer of person mainly expressed by the "non-manual" components (the four upper triangles, with the iconic and indexical sides longer) and the other one referring to the lexical units performed with the hands (the four lower triangles). There is the level of performing the agent (who I am) and the level of telling (what I am signing).

A Triangular Semiotic Model for Signers' Head Movements

The first application of this triangular semiotic model was made by Puupponen (2019).

Puupponen presents a typology of head movements and their iconic, indexical, and symbolic features based on Peircean perspective and uses the visualization of triangles as presented by Capirci at the ISGS Conference in South Africa (2018).

The author argues that head movements present at the same time all three: iconicity, indexicality, and symbolic features, even though: "It may, however, be that these different strategies of signification emerge in different proportions in different head movement types" (Puupponen, 2019, p. 23). For example, the nodding/shaking head for affirmation/negation is a movement type showing a great proportion of indexical and symbolic features, while the iconic one is the smaller side of the triangle. On the contrary, the head movement following the time line metaphor has strong indexical and iconic features and a smaller symbolicity. Puupponen applied Capirci (2018) visualization to head movements and stressed that the symbolic side of the triangles, the red one as presented in **Figure 1**, is definitely not the more prominent one. The triangular model calls upon a perspective that include indexicality, iconicity and symbolicity as equals in language's economy.

In conclusion, Puupponen rejects the distinction within non-manuals between categorial/grammatical non-manual and gradient/uncategorical non-manuals, declaring that in support of this distinction there is not enough empirical evidence and that indeed the results of some recent studies do not confirm this type of theoretical distinction (Puupponen et al., 2015).

CONCLUSION

The social anthropologist Jack Goody (2000) in "The Power of the Written Tradition" (2000), a collection of nine essays, claims: "Words everywhere have meanings. But dictionaries do not only teach how to spell; they spell out meanings in a standardized way, 'dictionary definitions,' which then become the norm and the starting point of a discussion" (p. 144).

In this paper, we discussed how the need to hierarchically divide signs arose precisely from the need to establish which linguistic units are best entered in a dictionary (Johnston and Schembri, 1999) and by the need to code or annotate signed language data (Cormier et al., 2012).

Nevertheless, the discussion of the proposed models brought forth different questions: are there any standard signs (as opposed to others that are less or not standard at all) outside of dictionaries? Does the difference between standard/frozen/conventional/discrete lexicon and "productive"/little or non-conventional/gradient/unstable lexicon exist outside of dictionaries and our coding? Are the signers aware of using something fixed/conventional and something variable/unconventional in the flow of their communication?

Signed languages are "oral" languages, used in real face-to-face communication, without (to date at least) their own written form despite our efforts (by scholars, linguists) to "harness" them in written/discrete forms. Signs seem to fully respond to the description made by scholars of spoken communication, in which it is impossible to trace discretion and stability and where communication is in constant dynamic flow. "Oral tradition languages," i.e., spoken languages lacking a written form, showing little or no codification, used exclusively for face-to-face communication, etc., are the languages that signed languages have most in common with.

We have discussed different models that tried to propose a solution to overcome a structuralist approach to signed language, applied at the very beginning of signed language research. Some models have been proven to be more effective than others, nevertheless, an even greater effort is needed by the field of signed language research to leave the patterns we have inherited, which lead us to categorize and divide into boxes (or circles or lines) elements that instead jump from one box to another.

As we have tried to show, it is not necessary to divide signs into symbols and icons, but rather it is more realistic to find symbolic iconic signs: "icons in which the likeness is aided by conventional rules" (Peirce C.P. 2.279). Iconicity cannot just be regarded as an accidental feature of the surface form of signs, we must instead acknowledge that it is a proper structural device (Pietrandrea, 2002; Russo, 2004), and a permanent feature in signs.

As argued by Boyes-Braem (1981), in signed languages the hands are used with a linguistic purpose. The hands are employed in daily life in many tasks, such as pointing, manipulating objects,

counting, and representing objects. It makes economic sense that signed languages should make efficient use of this pre-codification of the hands in the creation of signs. There is no need to adjust a four-dimensional world to the linearity of the acoustic channel (Hockett, 1978). The peculiar nature of the articulators and the medium employed in signed languages play an important role in preserving iconicity.

Boyes-Braem's argument can be easily extended to explain the linguistic use of the body. The speaker's body is always present in signed language discourse. Again, it makes economic sense to exploit this presence to express meanings that are related to parts of the body (see also Borghi et al., 2014; Tomasuolo et al., 2020).

Since the beginning of modern signed languages studies, researchers have recognized the existence of two kinds of constituent elements. However, in most past and current research only one type of such elements has been granted the status of "truly linguistic items," while the other one has been, and for the most part continues to be classified either as "non-linguistic, gestural, pantomimic items," or as "partially linguistic," but non-lexical.

On the contrary, we proposed to view each signed linguistic unit as a triadic union of iconic, symbolic, and indexical features, all immanent in the unit and potentially exploitable in signed discourse. Seeing each linguistic unit as a triangle helps the linguist to deconstruct the rigid language/gesture hierarchy, since it shows that conventionality coexists with iconicity and indexicality. Moreover, our discussion of signed utterances taken from different discourse types shows how the categories of "lexical unit" and "transfer unit" are actually fuzzy and context-dependent. In this respect, the effort provided by cognitive linguists in explaining the difference between core lexicon and classifiers should be followed by signed language research (Wilcox and Occhino, 2016; Lepic and Occhino, 2018; Lepic, 2019).

We have thus come to the realization that it is most adequate to view the linguistic unit as underspecified, deformable, not systematically discrete, placed in a dynamic flux, negotiable, and context-dependent. The meaning of words or signs is not fixed, given that the structure of language is characterized by a great plasticity that makes it possible to interpret it according to every different context (De Mauro, 1982, 1991, 2000). Signs and words (with gestures, ideophones, prosody) can be used both as descriptions and depictions, and we should look at usage events as objects constructed on and potentially used to express these three semiotic features, instead of separating them into three distinct categories.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The dataset is taken from video collections of theater performances, conferences and thesis studies. Consent forms do not support public access to video or media data. Requests to access the data should be directed to AdR, alessio.direnzo@istc.cnr.it.

AUTHOR CONTRIBUTIONS

OC conceptualized and design the study, conceived the "triangle semiotic model" and visualized it in the figure, and wrote the original draft of the entire manuscript. CB drafted one section and contributed substantially to the final writing of the manuscript. AdR transcribed and organized the video corpora and designed and edited all the figures. All the authors selected the data and wrote the descriptions of the data. All the authors thoroughly discussed and revised critically all the sections of the manuscript and approved the submitted version.

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Language Use in Deaf Children With Early-Signing Versus Late-Signing Deaf Parents

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Previous research has shown that spatial language is sensitive to the effects of delayed language exposure. Locative encodings of late-signing deaf adults varied from those of early-signing deaf adults in the preferred types of linguistic forms. In the current study, we investigated whether such differences would be found in spatial language use of deaf children with deaf parents who are either early or late signers of Turkish Sign Language (TİD). We analyzed locative encodings elicited from these two groups of deaf children for the use of different linguistic forms and the types of classifier handshapes. Our findings revealed differences between these two groups of deaf children in their preferred types of linguistic forms, which showed parallels to differences between late versus early deaf adult signers as reported by earlier studies. Deaf children in the current study, however, were similar to each other in the type of classifier handshapes that they used in their classifier constructions. Our findings have implications for expanding current knowledge on to what extent variation in language input (i.e., from early vs. late deaf signers) is reflected in children's productions as well as the role of linguistic input on language development in general.

Keywords: sign language acquisition, late sign language acquisition, early sign language acquisition, spatial language, language production

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INTRODUCTION

Unlike hearing children who most of the time have early input from their speaking parents, only a small proportion of deaf children (5–10%) receive language input in a sign language mainly from their deaf parents (thus becoming early signers of their language), while the rest does not receive linguistic input accessible to them mainly because they have non-signing hearing parents (Mitchell and Karchmer, 2004). Thus, they may start learning a sign language later in their lives (e.g., at 6 years of age or later, thus becoming late signers), usually after meeting other deaf people at school or in other social environments such as deaf clubs/cafes[1]. A crucial body of research has shown effects of delayed language exposure on language skills of these late signers compared to early signers (e.g.,

[1]Please note that we here refer to the timing of receiving sign language input (early vs. late). As suggested by Henner and Robinson (2021) as well as Koulidobrova and Pichler (2021, this special issue), these signers had initial communication systems before starting to acquire a sign language, thus their sign language can be considered as their second language.

Newport, 1988; Newpot 1990; Karadöller et al., 2017; Mayberry and Kluender, 2018; Karadöller et al., 2021).

In our paper, we are interested in the fact that these late signers may become language models for deaf children. Research conducted with deaf signers usually make a distinction between those with deaf parents versus hearing parents. However, as mentioned above, deaf parents themselves might have received sign language input later in their lives. Thus, their language skills might vary from deaf parents with early sign language exposure. We do not know much about whether and how language use in deaf children with late-signing deaf parents and deaf children with early-signing deaf parents parallels to the patterns observed in deaf adults who are early-versus late-signers.

Previous work with a single deaf child acquiring American Sign Language (ASL) from his deaf parents who are late signers of ASL reported that his signing skills went beyond the language input despite the inconsistent forms (i.e., forms not observed in language productions of deaf signers who acquired ASL since birth) it contained (Ross and Newport, 1996; Singleton and Newport, 2004). However, this is based on a single case study. Furthermore, this finding seems to be in contrast with the research on spoken languages suggesting robust effects of input quality (e.g., syntactic complexity; diversity of vocabulary) on language development (e.g., Rowe, 2012; Hoff and Core, 2013; Jones and Rowland, 2017) as well as the evidence suggesting a facilitating role of language input from native speakers for language development compared to that of non-native speakers (i.e., speakers using their L2 with their children) (Hoff, 2006 for a comprehensive review). To examine these effects for sign language acquisition, we compared language productions of two groups of deaf children with early-signing (acquired sign language since birth) versus late-signing deaf parents (acquired sign language at around adolescence, Newport, 1988). To facilitate the flow of reading, we will refer to deaf children with early-signing deaf parents as DCES (**D**eaf **C**hildren of **E**arly **S**igners) and deaf children with late-signing deaf parents as DCLS (**D**eaf **C**hildren of **L**ate **S**igners). Studying language patterns in such a cohort of deaf signing children expands the previous research since it mainly drew its conclusions based on a single case study in ASL or from spoken language development only.

For spoken language development, the effects of non-native language input have been studied mainly in bilingual language development. Compared to native-speaking adults, non-native-speaking adults' vocabulary and morpho-syntax are likely to be less diverse and less sophisticated, and they are not as phonologically accurate as native speakers (e.g., Core and Hoff, 2014). Thus, the quality of linguistic input that children receive varies greatly depending on the adult language models, which seems to have robust effects on language development. For example, vocabulary use differences and the variation in the phonological accuracy among mothers who are non-native speakers of English are strong predictors of their children's vocabulary development (Core and Hoff, 2014). Furthermore, in a study with Spanish-English bilingual children, Place and Hoff (2011) found that the proportion of children's English input from native speakers was a stronger predictor of their vocabulary and grammar development in English compared to the amount of English input (from both native and non-native speakers) that they receive. In another study with Spanish-English bilingual children, Hoff et al. (2014) reported that English use at home facilitated development of English for these children more when one of the parents was a native speaker of English compared to the cases in which both parents were non-native speakers of English, but still used English at home. In a recent study, Unsworth et al. (2019) found that the degree of non-nativeness in the input is a better predictor of bilingual children's language skills compared to the proportion of native input that they receive or having a native speaker parent or not.

It is important to note however that the caregivers described in many of these previous studies have relatively low proficiency in their later-acquired language compared to their first-acquired language. However, this is not the case with late-signing deaf adults since they are highly proficient in the language that they learnt later in their lives. Furthermore, for these late-signing deaf parents, their sign language can be considered as their second language since they were already using an initial communication system before acquiring a sign language (Henner and Robinson, 2021; Koulidobrova and Pichler, 2021). Thus, it might be more meaningful to consider speakers who are highly proficient in their later-acquired language (i.e., reversed dominance bilinguals) for comparison. Although there is a growing body of research on their language use and processing (e.g., Declerck et al., 2020; Gollan et al., 2020), research examining the effects of their language input on their children's language development is scarce. In one recent study, Stoehr et al. (2019) asked whether language development in Dutch-German bilingual pre-schoolers has been influenced by the language input from their sequential bilingual mothers, who acquired Dutch in their adulthood, and have been using it dominantly in their daily lives. In their study, they focused on the productions of voice onset time (VOT), for which mothers' productions were still non-native in Dutch despite being highly proficient in this language and using it on a daily basis, and also became different than those in German, which is their first language. In this study, they found that their bilingual children differed from their monolingual peers in both languages in the timing of voice onsets. Thus, these findings suggest that bilingual children's language productions were influenced by their mother's highly proficient but still non-native speech patterns.

Non-native input, as defined in these studies, refers to the use of a second language (sometimes together with a native first language with code-switching/mixing) by parents. However, it is also possible that monolingual parents' language productions might include errors while interacting with their children. Earlier work examining how monolingually developing children deal with errors in input has shown that they regularize them when these errors are at low levels of complexity, and according to the dominant pattern in language input in general (Kam and Newport, 2005; Kam and Chang, 2009). Thus, it seems that monolingual children can track structural relations in the language input that they receive despite a certain degree of variation that exists in the input that they receive (Gonzáles et al., 2015). Children's age has also been shown to be significant

in this process. In a recent study, Austin et al. (2021) found that the younger the (speaking) children are, the more regular their language productions are despite the inconsistent forms in their input. When children are at around 7–8 years of age, their ability to regularize language input starts to diminish. Moreover, children in their study could acquire low frequency forms as long as they are used in a consistent fashion, thus showing a stronger role of consistency than that of frequency of linguistic patterns in language input to children.

Considering the findings of the above-mentioned studies, there seems to be conflicting evidence on to what extent and how language patterns used by language models shape language patterns produced by children. Studies conducted with bilingual children who receive non-native input from their parents suggest language proficiency of the parents to be a strong predictor for children's language abilities (e.g., Hoff et al., 2014; Stoehr et al., 2019; Unsworth et al., 2019). On the other hand, studies with monolingual children, who can be exposed to errors and variations in their parents' speech, indicate that these children's language productions do not reflect such forms, thus suggesting that these children can regularize them in their own language use (Kam and Newport, 2005; Kam and Chang, 2009; Gonzáles et al., 2015; Austin et al., 2021). However, it is not clear how frequent and persistent these forms are in parents' input to their children. Thus, it is possible that they might happen at such a low frequency that children may be ignoring them. Furthermore, De Bree et al. (2015) showed that bilingual children, but not monolingual children, could learn novel language patterns when presented with input with variations, and concluded that bilingual children are better at detecting regularities in language input compared to monolingual children. Therefore, children's ability to deal with variation in their language input might be related to bilingualism (De Bree et al., 2015) or complexity of linguistic forms (Kam and Newport, 2005; Kam and Chang, 2009) or frequency of such variations in the input (Gonzales et al., 2015; Austin et al., 2021).

Research on sign language acquisition presents us a possible avenue to approach these issues in a novel way because of the heterogenous profile of language acquirers, which is mainly the result of different ages of sign language acquisition by deaf signers. A crucial body of research has shown the effects of delayed language exposure on language skills of late signers compared to early signers (see Mayberry and Kluender, 2018 for a review). In a series of studies, Newport (1988, 1990) compared early-signing deaf adults to late-signing deaf adults on several syntactic and morphological language production tasks. She found performance differences between these groups in different aspects of morphologically complex constructions. To be specific, she concluded that early exposure to sign language is of utmost importance to master morphologically complex verbs of motion and location, and that late input has long-lasting effects on their mastery even in adulthood. In two recent studies, Karadöller et al. (2017; 2021) compared descriptions of spatial configurations of objects by late-signing deaf children (aged between 7; 3–10; 9) and late-signing deaf adults to the age-matched early-signing deaf users of Turkish Sign Language (TİD). Their results revealed that in describing locative relations between objects (e.g., pen left to paper), early signers mainly used morphologically complex classifier predicates, in which the location of the hands encodes the location of the referents, while the handshape encodes referent type by classifying it in terms of certain semantic features such as size and shape (Supalla, 1982; Emmorey, 2002; Zwitserlood et al., 2012; Sümer et al., 2014; Perniss et al., 2015; Sümer, 2015). In **Figure 1A** below, a TİD signer first introduces the lexical signs for Ground (paper) and Figure (pen) and uses a classifier construction in which the flat surface of her right hand is the classifier handshape for the paper and the index finger of her left hand is the classifier handshape for the pen. The position of her hands in signing space encodes the spatial relation as shown in the stimulus picture. Late signers used these forms less frequently than early signers. They rather preferred morphologically less complex linguistic forms such as pointing to space to indicate relative locations between objects as shown in **Figure 1C**, in which another TİD signer points to the location of the Figure (cat) with respect to the Ground (boat) encoded by a classifier handshape (her left hand). Please note that the signer first introduced the lexical signs for Ground and Figure objects in her spatial description.

In TİD, it is also possible to use lexical signs (i.e., relational lexemes) that mean LEFT or RIGHT to encode these spatial relations (Sümer et al., 2014; Sümer, 2015; Karadöller et al., 2017; Karadöller et al., 2021). Relational lexemes encode spatial relationships between entities but not the information about the shape of the specific entities themselves. Thus, they are semantically less specific and iconic to the size and shape of the referents than classifier predicates are since they only exhibit the relationship between any two objects regardless of their size and shape. Therefore, as relational lexemes do not require classifier handshapes and locations in space, they can be considered to be morphologically less complex. In these forms, TİD signers tap onto the upper part of their left or right arms or at the back of their left or right hands. In **Figure 1B** below, after introducing the lexical signs for Ground (paper) and Figure (pen), a TİD signer uses the relational lexeme in which she taps her left arm to encode left in her locative description. Please note that these forms can be used as the mere locative strategy in spatial descriptions or combined with classifier constructions or other locative strategies such as pointing (Sümer et al., 2014; Sümer, 2015). In their study, Karadöller et al. (2017; 2021) found similarities in how early and late signers of TİD use these forms.

As shown by above-mentioned studies, early (with deaf parents) and late signers (with hearing parents) differ in their locative encodings in terms of the language forms that they employ. We do not know much if and to what extent these differences will be observed in the locative encodings of deaf children with such early-versus late-signing deaf parents. In a previous study, Lu et al. (2016) compared early lexical sign productions of deaf children with deaf parents to deaf children with hearing parents with level one proficiency in British Sign Language (BSL). So, these hearing parents, for whom sign language was a second language, provided sign language input to their deaf children–albeit with forms that differed from deaf

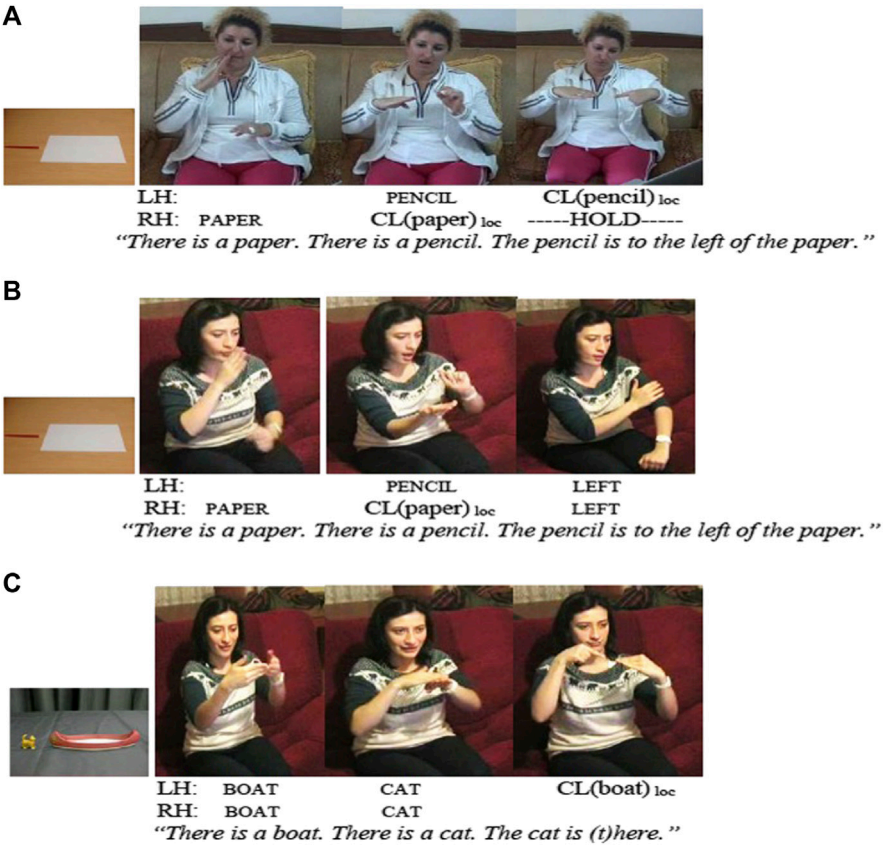


FIGURE 1 | Different locative forms used to describe object locations by TİD signers.

early signers of BSL. It is also important to note that these hearing parents reported using English with their deaf children, thus providing bimodal bilingual language input. The study found that deaf children with hearing parents knew fewer lexical signs and made more errors in using correct handshapes in these lexical signs that they produced than deaf children with deaf parents. However, it is not clear how their output compared to adult patterns in terms of accuracy and complexity. There is also one case study with an ASL-acquiring deaf boy (Simon) whose deaf parents were late ASL signers (Ross and Newport, 1996; Singleton and Newport, 2004). In this study, covering between 2; 6–9; 1 year of age, researchers looked into his motion event encodings, and compared them to those elicited from his late-signing deaf parents as well as his deaf peers with early-signing deaf parents. As a result, they found his classifier constructions in encoding motion events to be more regular than those of his parents since they were similar to those produced by early signers of ASL in terms of indicating movement of the referents and use of signing space in these forms.

However, certain aspects of Simon's productions differed from those of early signers of ASL. For example, his choice of classifier handshapes in classifier predicates was not similar to that of early signers. Indeed, differences in classifier handshape choice were also observed between his parents and early-signing deaf adults. It seems that Simon's output in using classifier handshapes parallels to these differences between his parents and early signers of ASL. It is also important to note that the difference in the use of classifier handshapes was observed for encoding the central objects (i.e., moving object), but not the secondary ones (i.e., relative to which central objects move) in his data. However, these findings come from only one case study, thus it is not clear if these findings can be generalized to other signing children who receive language input that is characterised by variations.

In the current study, we investigated how language productions of deaf children with late-signing deaf parents compared to those from deaf children with early-signing deaf parents by collecting data from a large cohort of sign language acquiring deaf children. Here, we focused on the domain of spatial language, more specifically locative encodings, for which recent studies have shown differences in the choice of linguistic forms between early and late signers of TİD (Karadöller et al., 2017; Karadöller et al., 2021). Considering the previous research, we entertained the following predictions: if DCLS are similar to DCES, it would suggest that differences reported in encoding locative relations between early and late

adult signers are not reflected in the language productions of these children. Therefore, despite the possible variation that these children might receive in their language input, their developmental track in learning to encode spatial relations will be similar to each other (Ross and Newport, 1996; Singleton and Newport, 2004; Kam and Newport, 2005; Kam and Chang, 2009; Gonzales et al., 2015; Austin et al., 2021). It is also possible that DCLS will be using classifier predicates less often than DCES, thus being parallel to the differences observed in early versus late adult signers. Thus, the differences observed in the language productions of these children can be explained by and reflect the linguistic input that they receive from the language models (e.g., Hoff, 2006; Place and Hoff, 2011; Rowe, 2012; Hoff and Core, 2013; Core and Hoff, 2014; Jones and Rowland, 2017). Finally, it is also possible to see differences in deaf children's outputs for different aspects of locative encodings such as differences for the use of classifier handshapes (Ross and Newport, 1996; Singleton and Newport, 2004), but not for the frequency of using different locative forms.

The findings of our study will contribute to current understanding on children's ability to deal with variation in adults' use of language by providing evidence from a unique population of deaf children with deaf parents with varying ages of sign language exposure, that has never been studied systematically before. In addition, the present study is about monolingual language development, thus controlling for a possible effect of bilingualism–unlike previous studies with speaking children[2]. Our study is also unique in examining the language input by parents who are highly proficient in a language that they have acquired later in their lives, which has been largely unexplored for spoken language development (but Stoehr et al., 2019). Furthermore, it presents a broader perspective by focusing on different aspects of locative encodings such as types of linguistic forms and classifier handshapes rather than by focusing on only classifier constructions or phonological handshapes. It also presents data from a larger group of deaf children with deaf parents, thus expanding the previous research by Ross and Newport (1996) and Singleton and Newport (2004) and providing more data on this topic. Finally, sign language studies so far grouped deaf signers with deaf parents as native signers without considering the differences in language performance of their deaf parents, which might be modulating sign language development in various ways. This study aims to shed light on whether and how such a differentiation among so-called native signers, considering differences in their input, can be meaningful in sign language acquisition research as well as contributing data on the role of language input on language development in children in general.

[2]In our study, we consider deaf children to be monolingual signers of Turkish Sign Language (TİD) since their teachers and parents reported that they have low reading, writing and oral language proficiency in Turkish or any other spoken language.

TABLE 1 | The number (N) of participants as well as the mean (M) and the standard deviation (SD) of their ages.

	Number	M_{AGE}	SD_{AGE}
Early-signing deaf adults	8	27	8.7
Late-signing deaf adults	8	41.25	6.5
Deaf children with early signing parents	8	8.27	1.15
Deaf children with late signing parents	8	8.09	0.92

MATERIALS AND METHODS

Participants

As mentioned earlier, early signers consist of a very small proportion of a deaf population (Mitchell and Karchmer, 2004), which makes it a challenging task to find enough participants for this study. It was even a further challenge since the current study divided deaf children with deaf parents into two groups. For this reason, we analyzed data previously collected for two different projects, which entertained related research questions. Thus, the data used for this paper have been published before in papers with a different research focus, namely the comparison of spatial language development between early signing deaf children and speaking children (e.g., Sümer, 2015) and effects of delayed sign language exposure on learning to encode various spatial relations (Karadöller et al., 2017; 2021).

Deaf children in the current study were split into two groups: DCES (mean age = 8.27) and DCLS (mean age = 8.09) with eight children in each group. We also analyzed locative encodings elicited from a group of early-signing deaf adults (also with early-signing deaf parents) as well as a group of late adult signers of TİD, who acquired TİD after 7 years of age (n = 8 in each group) for the classifier handshape analysis (**Table 1** for their demographic information) since we lack previous studies on the differences between early and late signers for the use of classifier handshapes in locative encodings in TİD.

All participants reside in Istanbul, Turkey. All deaf children in this study attend a school for the deaf. It is important to note that TİD was not systematically taught at the schools for the deaf, and thus was not part of the curriculum at the time of data collection. Furthermore, deaf children and adults learned very little Turkish at school. Adult participants reported themselves to be profoundly deaf and unable to understand spoken Turkish as well as not being proficient in reading and writing in Turkish.

Stimuli

To collect language production data, we used a picture description task, which showed slight variations in format between the two projects (**Figure 2** above). Please note that the differences in stimuli did not meaningfully contribute to our findings as revealed by the statistical models used for the data analysis.

In this task, participants were asked to describe a target picture (indicated with a red frame or a black arrow) displayed together with three other pictures (non-targets) in a picture set. In all of these pictures, one object (Figure) was situated in relation to another object (Ground). All the target pictures analyzed for the current study showed objects located on the lateral axis (e.g., pen

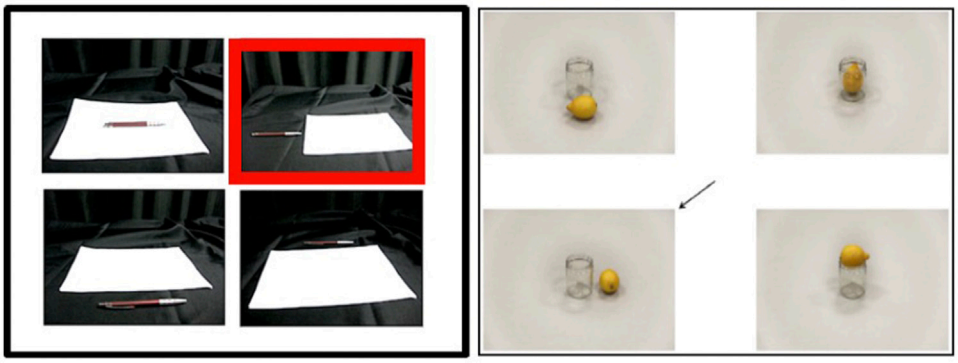


FIGURE 2 | Example of the displays used in the current study. Differences in their format (e.g., background, indication of the target pictures to be described) are because they were used in two different, but related, projects. The stimuli on the left were originally developed by Dr Jennie Pyers (Wellesley College, The United States).

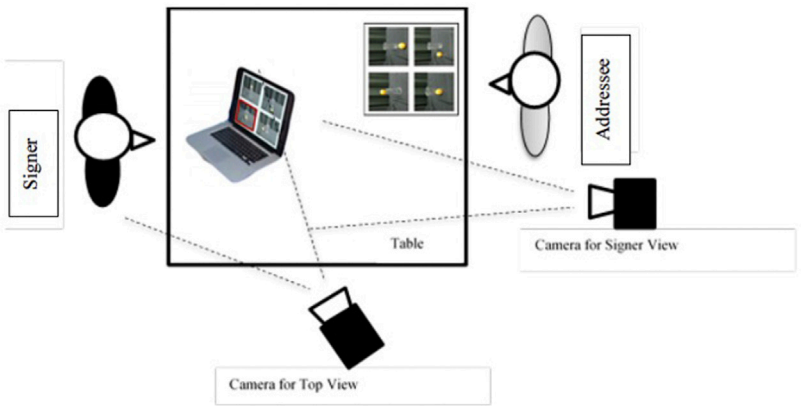


FIGURE 3 | Data collection set-up.

left to a paper). In the non-target pictures, the location of the objects varies such as sagittal axis (pen in front of paper), containment (lemon in jar), or support (pen on paper). In total, there were 118 picture sets, out of which 34 picture sets were analyzed, and the rest functioned as fillers. We chose left and right as the focus of the current study because we previously found systematic differences between early- and late signing deaf adults in encoding them, but not for in and on type of spatial encodings (Karadöller et al., 2017; 2021). Furthermore, it is not yet known whether and how early and late signing deaf adults differ in encoding front/behind in TİD, and therefore there is no baseline for comparing our findings with.

Procedure

In data collection sessions, signers were asked to sit opposite the addressee, who was a deaf confederate. There was a laptop located on a table between them, and the table was below the waist of the participants so that their hands could easily be seen (**Figure 3**). To collect data, the participants were shown sets of four pictures and asked to describe the target picture with the red frame/arrow to the addressee who had the same picture set (but without any red frames/arrows and pictures in a scrambled order) in a booklet in front of them. The task of the addressee was to choose the picture described by the signer. The participants were asked to describe the target picture. They were never asked questions such as "Where is X?" before they began their descriptions since such questions might have invoked a description of the location of that object without a full locative description. Addressee did not give any feedback on whether the descriptions were correct or not. In cases where the participants did not express the spatial relations, addressee only asked for the location of the Figure item using the lexical sign of WHERE in TİD and the lexical sign of the Figure item in the target picture. Thus, addressee feedback did not provide any linguistic strategies to locate the Figure item in relation to the Ground item. All participants' descriptions were recorded by two cameras from different angles so that both a front and a top view were available, providing as much information as possible on locations, movement directions and sign forms, which facilitated the coding of the data considerably. However, since data collection sessions took place in different

home and classroom environments, recording set-ups and camera angles showed some variation in different data collection sessions.

Data Coding and Analysis

The picture descriptions were annotated, coded, and checked by a deaf signer of TİD and two hearing researchers with knowledge of TİD. The annotations were done in ELAN, a free annotation tool (http://tla.mpi.nl/tools/tla-tools/elan/) for multimedia resources, developed by the Language Archive Group at the Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands (Wittenburg et al., 2006).

Picture descriptions in which children encoded a correct spatial relation (i.e., left, right) between Figure and Ground were coded for 1) the type of linguistic forms used to indicate the spatial relation and 2) classifier handshapes used to encode the location of the Figure object with respect to the Ground object. For the first point, we compared two groups of deaf children with each other only since we already knew preferred patterns from both early and late adult signers of TİD from previous work (Karadöller et al., 2017; Karadöller et al., 2021). Thus, we wanted to see if similar patterns reported in this previous work were also observed in DCES versus DCLS in the current study. Please note that we could not compare these deaf children with their deaf parents in interaction because we lack data. However, we also think that, in such a comparison, it would be difficult to understand the possible effects of child-directed signing, in which parents tend to simplify linguistic forms for their deaf children even when these children would be around 8 years of age (Perniss et al., 2017; Ortega et al., 2017). It would then be difficult to understand the differences between two groups of deaf parents if they modify and/or simplify input in describing locative relations. For the second point, we coded data from a group of early-signing adults (with early-signing deaf parents) as well as a group of adult late signers (with non-signing hearing parents, thus exposed to sign language, for example, at around 6 years of age or later) for their preferences in the use of classifier handshapes in their locative constructions since we did not have previous knowledge on these patterns from these groups in TİD. In this analysis, we also focused on the classifier handshapes for Figure only following Ross and Newport (1996) and Singleton and Newport (2004), who reported errors in classifier handshapes for the location of Figure (primary) objects, but not for the Ground (secondary) objects.

The coding and analysis of our data for the linguistic strategies used in the correct spatial encodings in which the location of the Figure item was mentioned in relation to the Ground item revealed three main categories: 1) classifier constructions, 2) relational lexemes, and 3) other forms such as pointing. In **Figure 4**, a deaf child (with early-signing deaf parents) is describing the location of the soap with respect to the jar. After introducing the lexical signs for the jar and the soap, he uses a classifier construction in which his left handshape represents the round shape of the jar, and the shape of his right hand refers to the flat surface of the soap. The location of his hands in signing space reflects how the soap is located in relation with the jar in the picture. In **Figure 5**, another deaf child (with early-signing deaf parents) is describing a picture that displays an apple to the right of a box. After mentioning the lexical signs for the entities in the picture, he uses a lexical sign that means RIGHT in TİD. In **Figure 6**, a deaf child (with late-signing deaf parents) is encoding the location of the wristwatch with respect to the cup. In her description, lexical signs for the entities are followed by the use of an index finger pointing directed towards the left side of the signing space.

Next, we focused on the descriptions in which signers used a classifier predicate to encode the spatial relation between the Figure and the Ground. Here we focused on only the use of the classifier handshape to encode the location of the Figure since earlier studies (Ross and Newport, 1996; Singleton and Newport, 2004) reported a difference between Simon and his deaf peers of early-signing deaf parents in the use of classifier handshapes for the primary objects (i.e., Figure), but not for the secondary ones (i.e., Ground). Please note that in this analysis, we compared not only two groups of deaf children with each other, but also compared them to a group of adult early and late signers of TİD, as opposed to two previous analyses, since we lack data on the adult-like patterns of using classifier handshapes in locative constructions in TİD. Here we used the classifier handshape inventory for TİD (Kubus, 2012). For each spatial display, we listed the classifier handshapes for Figure objects as preferred by adult early signers. As shown in **Figure 7** below, in our data, for example, it emerged that early signers of TİD used 8-handshape (or V-hooked) to localize the Figure (horse) in signing space (third still, left hand). Thus, other handshapes used for the same Figure by deaf adult late signers as well as deaf children were considered to differ than the patterns observed for the early signers (**Figure 8**).

RESULTS

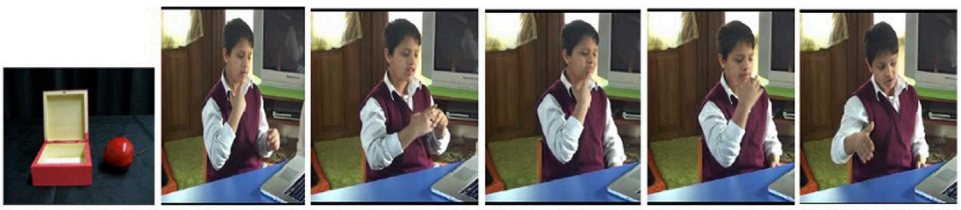
Data presented in this section were analyzed using generalized binominal linear-mixed effects modelling (glmer) with random intercepts for Participants. All models were fit with the lme4 package (version 1.1.21; Bates et al., 2015) in R (R Core Team, 2019).

As the first step, we checked if two groups of deaf children differed in how frequently they encoded a correct spatial relation (i.e., left, right) out of all picture descriptions in which they expressed Figure, Ground, and a locative form (n = 205). Please note that we included all the descriptions with a left or right encoding, thus did not consider possible viewpoint differences (i.e., encoding right for a picture that displays objects in a left configuration). It is also important to note that we took out non-responses or responses that were missing Figure, Ground, and/or spatial encoding (n = 13) since they could have happened as a result of the factors not related to the lack of ability to encode spatial relations (e.g., not seeing the objects or spatial relation clearly). For example, In **Figure 9** below, a deaf child (with early signing deaf parents) is producing the lexical signs for the cup and the banana without further encoding the spatial relation between them. Also, in **Figure 10**,



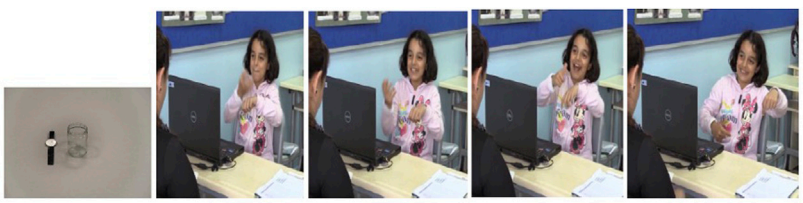
LH: GLASS JAR SOAP CL(jar) loc
RH: GLASS JAR SOAP CL(soap) loc
"There is a glass jar. There is a soap. The soap is to the right of the jar."

FIGURE 4 | Encoding the spatial relation between Figure and Ground in classifier predicates in TİD.



LH: WOOD
RH: RED WOOD RED APPLE RIGHT
"There is a red wood. There is an apple. The apple is to the right."

FIGURE 5 | Encoding the spatial relation between Figure and Ground by using a relational lexeme in TİD.



LH: GLASS WATCH IX
RH: GLASS CUP WATCH
"There is a glass cup. There is a watch. The watch is here."

FIGURE 6 | Encoding the spatial relation between Figure and Ground by using an index finger pointing in TİD.

another deaf child (with early signing deaf parents), encodes the lexical sign for the apple, and then shows its location without mentioning the box, which makes the description too vague to understand the location of the apple. Thus, descriptions like these were not considered to encode a (correct) spatial relation between the objects. We also checked this decision with our deaf research assistants and informants, who advised similarly, and indicated that the descriptions were not correct/informative enough in TİD.

The comparison of the picture descriptions with a correct spatial encoding ($M = 0.98$, $SE = 0.01$ for DCES, and $M = 0.94$, $SE = 0.02$ for DCLS) to those with incorrect ones (e.g., front, on) showed no differences between two groups of deaf children ($\beta = 1.28$, $SE = 0.83$, $z = 1.55$, $p > 0.5$).

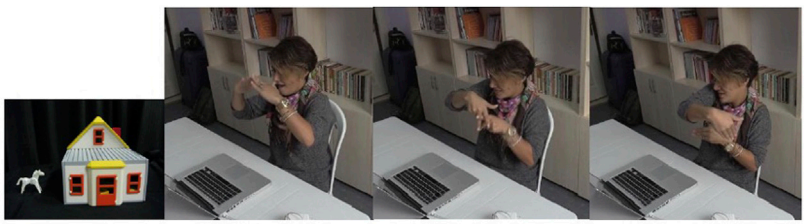
Types of Linguistic Forms in Spatial Encodings

In order to understand whether DCES and DCLS differ in their preferred linguistic forms to encode spatial relations, we focused on the picture descriptions with correct spatial encoding (left, right). To this end, we used separate glmer



LH: HOUSE HORSE $CL(horse)_{loc}$
RH: HOUSE HORSE $CL(house)_{loc}$
"There is a house. There is a horse. The horse is to the left of the house."

FIGURE 7 | Use of a classifier predicate with a classifier handshape as preferred by an early signer of TİD.



LH: HOUSE HORSE $CL(house)_{loc}$
RH: HOUSE HORSE $CL(horse)_{loc}$
"There is a house. There is a horse. The horse is to the left of the house."

FIGURE 8 | Use of a classifier predicate with a classifier handshape which is not observed in the patterns found for early signers of TİD.



LH: BANANA
RH: CUP BANANA
"There is a cup. There is a banana."

FIGURE 9 | Picture description that does not include any encoding of a spatial relation between objects.

models to test the fixed effect of Group (DCES, DCLS), coded with numeric contrasts, on the use of each linguistic form (Classifier Constructions, Relational Lexemes, Other), which was coded as the binary dependent variable (0 = No, 1 = Yes). It is also important to note that in some of the descriptions, participants used more than one linguistic strategy to describe the spatial relation in the target picture. For example, one description could include both a classifier construction followed or preceded by a relational lexeme. These cases were counted for the presence of both categories. Consequently, the results presented in this part include all the strategies for a single description and thus allow us to investigate each linguistic strategy with separate models, which is also similar to the statistical models used in the study by Karadöller et al. (2021).

As a result of these analyses, we found main effects of Group (DCLS, DCES) on the use of Classifier Constructions ($p < 0.05$) and Other forms ($p < 0.001$): DCES preferred classifier constructions more frequently than DCLS (**Figure 11**; **Table 2**). For the use of linguistic forms from the Other category, we saw a reverse pattern, in which DCLS used them more often than DCES (**Figure 12**; **Table 3**). We did not observe any effects of Group for the use of relational lexemes ($\beta = -0.27$, $SE = 1.21$, $z = -0.23$, $p > 0.5$).



LH:
RH: APPLE CL(apple)$_{loc}$
"There is an apple. The apple is here."

FIGURE 10 | Picture description that does not include the mention of the Ground object (box).

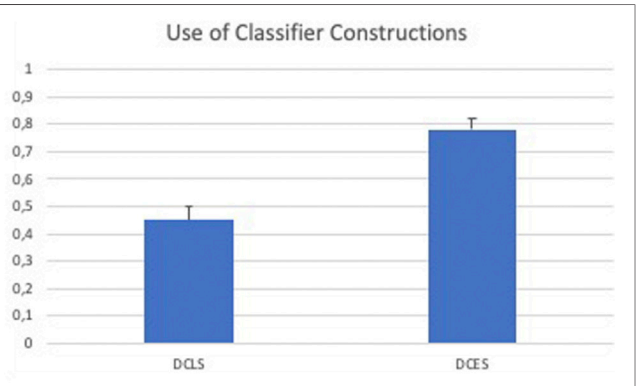


FIGURE 11 | Mean proportions and SEs of the use of classifier constructions by deaf children with early-signing deaf parents (DCES) and deaf children with late-signing deaf parents (DCLS).

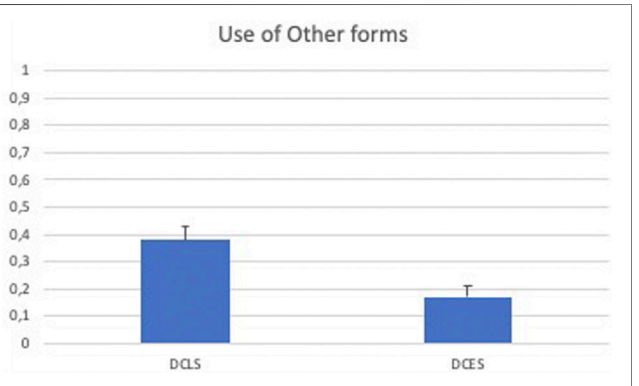


FIGURE 12 | Mean proportions and SEs of the use of language forms Other than classifier constructions and relational lexemes (e.g., pointing signs) by deaf children with early-signing deaf parents (DCES) and deaf children with late-signing deaf parents (DCLS).

TABLE 2 | Fixed effect estimates from the glmer model for frequency of classifier constructions use.

Fixed effect	—	—	—	—
—	*β*	*SE*	*z*	*p value*
(Intercept)	0.48	0.26	1.84	0.06
Group$_{DCES\ vs\ DCLS}$	1.27	0.53	2.42	<0.02*

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using Classifier Constructions ~ Group + (1 | Participants).*

TABLE 3 | Fixed effect estimates from the glmer model for frequency of use of other forms.

Fixed effect	—	—	—	—
—	*β*	*SE*	*z*	*p value*
(Intercept)	−0.99	0.21	−4.76	<0.001***
Group$_{DCES\ vs\ DCLS}$	−1.14	0.41	−2.78	<0.001***

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using Other forms ~ Group + (1 | Participants).*

Types of Classifier Handshapes in Classifier Constructions

We further investigated the use of different classifier handshapes in picture descriptions where signers used a classifier construction. Please note that in the following analyses, we only focused on the classifier handshapes used to represent the location of the Figure object, as in line with earlier studies by Ross and Newport (1996), and Singleton and Newport (2004). Here we were interested in understanding whether the preferences for different classifier handshapes differed between: 1) two groups of children (DCES vs. DCLS); 2) two groups of adults (early vs. late), 3) DCES and early-signing adults, and 4) DCLS and late-signing adults.

To understand if the two groups of deaf children differed in their use of classifier handshapes in their locative expressions, we tested the fixed effect of Group (DCLS, DCES), coded with numeric contrasts, on the binary dependent variable of classifier handshape choices (0 = Classifier handshapes different than those of early-signing adults, 1 = Classifier handshapes as also used by early-signing adults). This analysis did not reveal a difference between the two groups (**Figure 13**; **Table 4**).

We further examined if late-signing adults were similar to early-signing adults in their choice of classifier handshapes. Thus, we tested the fixed effect of Language Status (Early-signing, Late-signing), coded with numeric contrasts, on the binary dependent variable of

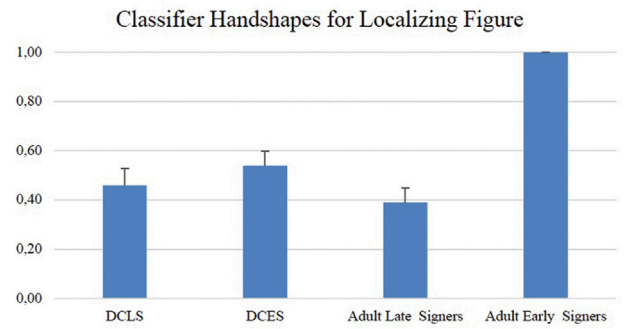


FIGURE 13 | Mean proportions and SEs of the choice of classifier handshapes for Figure object by two groups of deaf children (those with late-signing deaf parents, DCLS, and those with early-signing deaf parents, DCES) as well as two groups of deaf adults (early versus late signers).

TABLE 4 | Fixed effect estimates from the glmer model for frequency of using classifier handshapes by deaf children in each group.

Fixed effect	–	–	–	–
–	*β*	*SE*	*z*	*p value*
(Intercept)	0.03	0.17	0.17	0.87
$Group_{DCES\ vs\ DCLS}$	–0.33	0.34	–0.97	0.33

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using classifier handshapes ~ Group + (1 | Participants).*

TABLE 5 | Fixed effect estimates from the glmer model for frequency of using classifier handshapes by deaf adults.

Fixed effect	–	–	–	–
–	*β*	*SE*	*z*	*p value*
(Intercept)	18.45	181.2	0.102	0.92
$Language\ Status_{Early\ vs\ Late}$	–37.81	362.04	–0.104	0.92

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using classifier handshapes ~ Language Status + (1 | Participants).*

classifier handshape choices (0 = Classifier handshapes different than those of early-signing adults, 1 = Classifier handshapes as used by early-signing adults). We did not find any statistical differences in their choice of classifier handshapes (**Figure 13**; **Table 5**).

In order to check to what extent deaf children were similar to deaf adults in their classifier handshape preferences, we compared DCES to early-signing adults (**Table 6**) and DCLS to late-signing adults (**Table 7**). We did not observe any differences between these groups (**Figure 13**).

TABLE 6 | Fixed effect estimates from the glmer model for frequency of using classifier handshapes by DCES and early-signing deaf adults.

Fixed effect	–	–	–	–
–	*β*	*SE*	*z*	*p value*
(Intercept)	17.77	159.92	0.111	0.91
$Age_{DCES\ vs\ Early\text{-}signing\ deaf\ adults}$	35.15	319.84	0.110	0.91

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using classifier handshapes ~ Age + (1 | Participants).*

TABLE 7 | Fixed effect estimates from the glmer model for frequency of using classifier handshapes by DCLS and late-signing deaf adults.

Fixed effect	–	–	–	–
–	*β*	*SE*	*z*	*p value*
(Intercept)	–0.30	0.19	–1.63	0.10
$Age_{DCLS\ vs\ Late\text{-}signing\ deaf\ adults}$	–0.31	0.36	–0.87	0.38

*Significance codes: *0.05, **0.01, ***0.001. Formula in* R*: Using classifier handshapes ~ Age + (1 | Participants).*

DISCUSSION

In this study, we examined locative encodings of deaf children with early-signing versus late-signing deaf parents. Considering the previous research showing substantial differences in linguistic encoding of space (more specifically for left-right encodings) between early and late signers of TİD (Karadöller et al., 2017; 2021), it is possible that these two groups of deaf children could also differ in their spatial descriptions. We explored this possibility, previously tackled by Ross and Newport (1996) and Singleton and Newport (2004) for sign language acquisition, by focusing on a larger cohort of deaf children, who were divided into two groups depending on whether their deaf parents were early signers of TİD or not. We compared these two groups of deaf children in how frequently they used linguistic forms (classifier constructions, relational lexemes, other forms such as pointing) in locative constructions as well as how frequently they used a classifier handshape as preferred by early-signing adults. We found differences between two groups of children in their preferences of using different linguistic forms in their locative encodings in ways parallel to the differences in early and late signing adults as reported in previous research. Such a difference, on the other hand, was not observed for the use of classifier handshapes.

Types of Linguistic Forms Used in Locative Encodings

Previous studies showed different language production patterns between early and late adult signers both for the expression of motion events (Newport, 1988; Newport, 1990) and the locative expressions (Karadöller et al., 2017; Karadöller et al., 2021). In our study, DCLS differed from DCES in choosing classifier constructions less often. They, instead, preferred forms such as pointing to the location of the Figure object with respect to the Ground object. This pattern is quite similar to that of reported for late adult signers of TİD (Karadöller et al., 2017; Karadöller et al., 2021). Our study, thus, provides further evidence for such a variation in even deaf children with deaf parents. Thus, the effects of delayed sign language exposure may not be immediate to deaf signers with hearing parents, but to their deaf children, as well.

Although we did not compare these deaf children with their deaf parents due to the possible confounding effect of child-directed signing, the variation in using locative forms in these two groups of deaf children might still suggest corroborating support for the role of language input (e.g., Rowe, 2012; Hoff and Core, 2013; Jones and Rowland, 2017) on language development by showing that

differences observed between early and late deaf adult signers were also found in deaf children with deaf parents who are either early or late signers. This finding seems to stand in contrast with the evidence suggested by the earlier studies for speaking children's ability to regularize input when exposed to inconsistent patterns (Kam and Newport, 2005; Kam and Chang, 2009; De Bree et al., 2017; Austin et al., 2021). In our study, we also attested their finding with data from deaf children who kept the variation that they were exposed to in their language productions.

However, the characterization of input differs in our study compared to the studies with speaking children and parents. In our case, some of the language forms produced by late-signing adults and DCLS in encoding left and right type of spatial relations (e.g., pointing) can be considered to be well-formed and accepted despite being less preferred by early-signing adults and DCES. Therefore, one can think that DCLS might have been simply aligning with the patterns in their linguistic input rather than failing to regularize it since these forms are not inconsistent as defined by the research with speaking populations. The difference observed between two groups of deaf children makes it difficult to distinguish these two views. If DCLS would have been found to be similar to DCES in their preferences of locative forms, then linguistic alignment between these children and their language models would be a less likely interpretation. This would then suggest a weaker role of language input on shaping language development. However, the differences between early- and late-signing adults were also found between two groups of children, which suggests language learning processes in children could be influenced by language models and input in their environment, and one mechanism that allows this could be linguistic alignment in language productions of children and adults.

Finally, language productions of DCLS in our study diverged from those of ASL-acquiring deaf child (Simon) studied by Ross and Newport (1996) and Singleton and Newport (2004). However, in that study, Simon could surpass his language models for movement/location morpheme, but not for classifier handshape morpheme. In our study, we did not focus on individual morphemes, but first took a general perspective to see if there are differences in the types of locative forms preferred by them. We do not know if and what type of other language forms were used by Simon and his deaf parents in their motion event descriptions. One significant difference between Simon and DCLS in our study was that Simon did not attend a school for the deaf, thus his linguistic input was limited to his deaf parents. DCLS, on the other hand, were exposed to sign language input from various sources such as their deaf peers at school. In this case, one might assume less alignment between children's output and their deaf parents' input due to more variation that these children were exposed to. However, it is likely that these children were exposed to sign language input mostly form late-signing deaf peers (with hearing parents), which might have reinforced their patterns even further.

Regarding the use of relational lexemes to encode object locations, our results did not reveal a difference between these two groups of deaf children. This is also similar to the previous research showing no differences in using these forms by early and late adult signers of TİD (Karadöller et al., 2017; Karadöller et al., 2021). It seems that these deaf children have an understanding of left and right since they could use these terms correctly. However, when it comes to using morphologically complex constructions such as classifier constructions, DCLS used them less frequently than DCES. Relational lexemes can be considered to be morphologically less complex compared to classifier constructions since handshapes in these forms do not denote any size and/or shape information about the referents: they are frozen lexical items used for these spatial relations regardless of the type of the objects. Previous studies on the differences in language productions of early versus late signers consistently report more frequent use of frozen lexical verbs (rather than verbs of motion) in describing motion events (Newport, 1988; Newport, 1990). Thus, in our study, we also observed a similar pattern for the locative expressions in deaf children whose deaf parents differ in their age of TİD acquisition. It is also important to note that these relational lexemes in TİD can also be body-anchored in which signers tap their left arms or back of their left hands to encode left and their right arms or back of their right hands for right. Previously, Sümer (2015) and Sümer et al. (2014) found an early acquisition of these forms (around 4 years of age) by deaf children acquiring TİD from their deaf parents and suggested a facilitating role of body in their production. In the current study, simple morphological structure of the relational lexemes as well as involvement of body in their production might have helped DCLS become similar to DCES in the use of these locative forms.

Types of Classifier Handshapes in Classifier Constructions

Our final analysis, which was on the use of classifier handshapes, did not reveal any differences between two groups of deaf children. Moreover, they were also similar to early-signing adults in their choice of classifier handshapes in their locative descriptions. Considering the fact that there was no difference between early- and late-signing adults as revealed by the current study, it is not surprising to see that two groups of deaf children were similar to each other in this respect. It seems that although DCLS differed from DCES in their choice of locative forms in describing spatial relations (classifier predicates versus other forms such as pointing), when they used classifier constructions, their classifier handshapes used to refer to entities (Figure object more specifically) were similar.

Lack of difference between two groups of deaf children in their use of classifier handshapes in locative expressions seems to be in contrast with what was found for Simon by Ross and Newport (1996) and Singleton and Newport (2004). In their study, classifier handshape was the only parameter for which Simon could not surpass his language models, i.e., his deaf parents. Furthermore, previous studies report that late signers do not catch up with early signers in their choice of classifier handshapes, and handshape being the most susceptible to the effects of delayed language exposure (Newport, 1988; Newport, 1990; Singleton and Newport, 2004). In our study, handshape in classifier constructions seems to be resilient to the possible differences in

language acquisition of these two groups of deaf children. This might be due to the nature of locative spatial relations as opposed to motion events, which include more components (Figure, Ground, Motion, Path, Manner) (Talmy, 1985; Engberg-Pedersen, 1993; Taub and Galvan, 2001; Cuxac and Sallandre, 2007). Thus, effects of late language exposure or exposure to variation in input might become evident when signers are engaged in producing syntactically and semantically more complex utterances. Syntactic complexity was also observed to be a factor contributing to the differences in language productions of early versus late signers. For example, Newport (1990) reports no differences among three groups of ASL signers (native, early, and late) in their acquisition of basic word order. Similarly, for adolescents acquiring a sign language as a first language, Ramirez et al. (2013) found the use of relatively short and non-complex utterances, and the acquisition of declaratives earlier than more syntactically complex utterances such as Wh-questions, although they might still differ in the strategies (e.g., event knowledge rather than basic word order) that they use to comprehend sentences (Cheng and Mayberry, 2021). Similarly, Cheng and Mayberry (2019) provide further evidence for the resilience of simple syntactic structures to the effects of delayed language exposure.

CONCLUSION

In our study, we have presented evidence for both similarities and differences in the language use of two groups of deaf children with deaf parents, who were first exposed to a sign language at different ages (since birth or at later ages). Differences previously reported for early-versus late-signing adults in their locative form preferences were observed between these two groups of deaf children as well. However, these children did not differ in the handshapes they used in classifier constructions to encode object locations. We would like to highlight that all the locative forms produced by the deaf children in our study were acceptable forms in TİD although some might be preferred less often than the others. Thus, our findings do not suggest any detrimental effects of language input by deaf parents who are late signers themselves. We rather show that language productions of children are influenced by the language patterns that they are exposed to in their immediate environment.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: archive.mpi.nl.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Radboud University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the individual (s), and minor (s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

All authors have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Nominal Word Order Typology in Signed Languages

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Although spoken language nominal typology has been subject to much scrutiny, research on signed language nominal word order typology is still a burgeoning field. Yet, the structure of signed languages has important implications for the understanding of language as a human faculty, in addition to the types of universals that may exist across the world's languages and the influence of language modality on linguistic structure. This study examines the order of nouns and attributive modifiers (adjectives, numerals, demonstratives, quantifiers, genitives, and relative clauses) in 41 signed languages, which span national and village signed languages from various lineages and geographic regions. Despite previous typological research on clausal phenomena indicating that the clausal structure of signed languages differs systematically from spoken languages (Napoli and Sutton-Spence, 2014, among others), the results of this survey indicate that signed language nominal word order typology is strikingly similar to spoken languages in several ways: 1) the most common word orders in spoken languages are also common in signed languages, 2) the uncommon word orders in spoken languages are also uncommon in signed languages, but are attested, unlike uncommon major constituent orders, and 3) the relative ranking of word order strategies, particularly relative clauses, is similar across signed and spoken languages.

Keywords: noun phrase (NP), typology, signed languages, adjectives, numerals, demonstratives, genitives, relative clause (RC)

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INTRODUCTION

Spoken language typology is a robust discipline, with a copious amount of research dedicated to examining linguistic phenomena and how genetic and areal relationships between languages influence the patterns observed across spoken languages. However, much typological research often excludes a fairly large subset of human languages in their investigation of linguistic phenomena–signed languages. Yet, the structure of signed languages has important implications for the understanding of language as a human faculty, in addition to the types of universals that may exist across the world's languages and the influence of modality on linguistic structure. While research aiming to understand linguistic typology must therefore include languages from *across* modalities, this effort is hampered by the fact that the typology of signed languages, as well as the study of signed languages more broadly, is still a burgeoning field and, thus, it is not well-understood how signed languages may inform the existing literature on (spoken) language typology.

Typological research on signed languages has focused almost exclusively on lexical and clausal phenomena, including negation and question formation (Zeshan, 2013a,b; Zeshan and Sagara, 2016; Zeshan and Palfreyman, 2017) and other syntactic and semantic phenomena outlined in **Section 2**. Studies on word order, although thoroughly studied in spoken languages, have focused predominantly on the question of constituent order and agreement, where language modality is argued to influence agreement phenomena (Lillo-Martin and Meier, 2011), which in turn affect the

observed orders of subject, verb, and object (Napoli and Sutton-Spence, 2014). Other studies of phenomena related to nominal structure, such as relative clauses (Branchini, 2014; Wilbur, 2017), have been small-scale and have mostly examined signed languages which are relatively well-researched, such as European signed languages and American Sign Language. While the linguistic phenomena in these studies and others are diverse and hundreds of signed languages now have some form of linguistic documentation, there are relatively few large-scale typological studies of signed languages and some signed languages, particularly non-European ones, still remain understudied and underrepresented in linguistic research. Further, despite ample discussion of clausal word order, there is no typological research on noun phrase (NP) word order in signed languages and it is unknown if language modality may impact NP structure in signed languages, as has been argued for clausal word order.

This study examines the word order of nouns and nominal modifiers (adjectives, numerals, demonstratives, quantifiers, genitives, and relative clauses) in 41 signed languages, using existing linguistic documentation and description those signed languages, as well as primary fieldwork in Mexican Sign Language (LSM). In doing so, this study explores how the nominal structure of signed languages can be categorized typologically, forming a clear description of nominal word order typology in signed languages.

The typology of signed language NP word order is then considered in the context of spoken language NP typology, in an effort to examine what effects, if any, modality may have on nominal structure and how signed languages may inform the study of (spoken) language typology. If there are systematic differences in the attested word orders of modifiers and nouns in signed and spoken languages, or differences in their overall prevalence across this sample compared to results from spoken language surveys, then this would indicate that modality effects on word order may extend to the NP, as well as being present within the clause. However, if the NP word order preferences across signed and spoken languages are similar, then the NP is not a site for modality effects on word order, unlike the clause.

The 41 signed languages, which span both national and village sign languages from various lineages and geographic regions, have the same general word order patterns of nouns and nominal modifiers that have been attested in spoken languages. Although the overall prevalence of some nominal word orders are different, the most common orders found in spoken languages were also exceptionally common in signed languages, namely Noun-Num and Noun-Dem (Dryer, 2013b; Dryer, 2013d), and uncommon NP typological features in spoken languages, such as predicative-only adjectives, post-nominal genitives, and non-externally-headed relative clauses (Dryer, 2013a; Dryer, 2013c; Dryer, 2013e), are also uncommon in the signed languages sampled here, but are attested, unlike uncommon major constituent orders in signed languages (Napoli and Sutton-Spence, 2014). Further, six signed languages are identified as having mixed relativizing strategies, five of which are considered part of the French Sign Language lineage, constituting a previously unreported genetic pattern among some signed languages related to Old French Sign Language.

The similarity in nominal word order across signed and spoken languages is somewhat unexpected given that the prevalence of major constituent word orders in signed languages differs from spoken languages, a difference that has been ascribed to language modality effects on agreement and the use of space in signed languages to mark referents, which in turn impacts major constituent order (Napoli and Sutton-Spence, 2014). This would suggest that, although language modality seems to impact major constituent order in signed languages, modality does not affect noun phrase word order in signed languages, supporting previous hypotheses that modality effects may be generally sparser in syntax, particularly in less accessible levels of syntactic structure, like noun phrases (Lillo-Martin, 2002; Meier, 2002).

In **Section 2**, previous research on signed and spoken language typology is presented. The data and methodology used in this study is outlined in **Section 3** and the results are discussed in **Section 4**, followed by the implications of the analysis and directions for future research in **Section 5**.

SIGNED AND SPOKEN LANGUAGE TYPOLOGY

Previous Research on Typology of Signed Languages

Signed languages, although not themselves homogeneous, typologically differ in a number of ways from spoken languages; these differences, which may involve the presence or absence of certain linguistic structures or variation in their overall prevalence across language modalities, seem to suggest that modality effects are at least partially responsible for the variation observed across signed and spoken language modalities (Zeshan and Palfreyman, 2020).

Most typological research on signed languages seeks to situate the phenomena studied in signed languages within the typological literature on spoken languages, especially since many of the details are quite distinct across modalities. Agreement, for example, is strikingly similar across signed languages (Pfau et al., 2012, 2018), but is also quite distinct from agreement patterns found within most spoken languages (Corbett, 2006). All established signed languages studied to date exhibit a three-way classification system of verbs: plain verbs that do not agree with their arguments, agreeing (directional) verbs that do agree with their arguments, and spatial verbs that agree with the location of their arguments in the signing space (de Quadros and Quer, 2008). This is quite different from the patterns described in spoken languages, where agreement is generally either absent entirely in a language or obligatorily marked on all verbs (Corbett, 2006). Additionally, no known spoken languages make this three-way distinction in verb types that is found in signed languages.

As a result of the unusual nature of agreement in signed languages (from the perspective of spoken languages), investigations of word order typology in signed languages have almost exclusively focused on the clause, or constituent word order (Johnston et al., 2007; Vermeerbergen et al., 2007b,a; Quadros and Lillo-Martin, 2010; Napoli and Sutton-Spence, 2014). Agreement/directionality appears to affect major constituent order in signed languages, with plain and

reversible verbs[1] favoring SVO, but verbs with agreement or non-reversible arguments often showing SOV or other word orders (Napoli and Sutton-Spence, 2014). SOV is also argued to be grammatical in all signed languages and objects are immediately adjacent to verbs[2] (Yau, 2008; Napoli and Sutton-Spence, 2014). While the prevalence of SOV and SVO in signed languages, as well as the adjacency of verbs and objects, is predicted via universal pressures on the structure of language and the internal structure of the verb phrase, the preference for SVO in reversible sentences is not; instead modality effects are responsible for some of the patterns observed in major constituent order across signed languages (Napoli and Sutton-Spence, 2014). Further, other basic word orders[3] are uncommon in spoken languages but are attested (e.g. VSO, VOS), unlike in signed languages. Although this may be an artifact of the number of signed languages compared to spoken languages, the preference for SVO and SOV is likely partially an effect of the language modality (Napoli and Sutton-Spence, 2014), as the visual-gestural modality allows for the proliferation of certain features across signed languages (e.g. agreement, SVO/SOV, visual iconicity, and classifiers) which are otherwise uncommon or unattested in spoken languages, particularly in areas where syntax meets space Lillo-Martin (2002); Meier (2002).

Exceptions to this focus on constituent word order include collections of work from several signed languages that examine other aspects of linguistic structure, either in smaller-scale studies of signed languages from a typological perspective, or in typological studies including many signed languages. These include studies of question particles (Zeshan, 2013b); interrogatives (Zeshan, 2004; Aboh et al., 2005); formation of kinship terms, numerals, and color terms (Wilkinson, 2009; Zeshan and Sagara, 2016); word classes and classification criteria (Schwager and Zeshan, 2008); possessives and existential constructions (Chen Pichler et al., 2008; Perniss and Zeshan, 2008); numeral incorporation (Fuentes et al., 2010); relative clauses (Branchini, 2014; Wilbur, 2017); expression of semantic roles and locatives (Boyes Braem et al., 1990); object marking (Börstell, 2017); the distribution of negative markers (Zeshan, 2013a; Zeshan and Sagara, 2016); irregular negatives (Zeshan, 2013a); coordination and subordination (Tang and Lau, 2012); prosodic cues (Tang et al., 2010); and classifier constructions (Aronoff et al., 2003). There are typological handbooks detailing several linguistic phenomena or short grammatical descriptions of several signed languages (Fischer and Gong, 2010; Pfau et al., 2012; Velupillai, 2012; Zeshan and Palfreyman, 2017; Guen et al., 2020) and some signed languages have also been individually examined from a typological perspective, including Turkish Sign Language (Zeshan, 2006), Indo-Pakistani Sign Language (Zeshan, 2003), Sign Language of the Netherlands (Coerts, 1992; Oomen and Pfau, 2017), German Sign Language (Glück and Pfau, 1998), Italian Sign Language (Branchini and Donati, 2009), Japanese Sign Language (Sagara, 2014, 2016), and Inuit Sign Language (Schuit et al., 2011; Schuit, 2014, 2015), among others.

However, there are no typological studies on word classes and nominal word order more generally in signed languages, only small-scale studies of relative clause types and a few studies on morphosyntactic processes effecting nouns. Generally, signed languages have open and closed word classes and the categories of noun (entity) and verb (event) are present in all signed languages studied to date, with the caveat that some signs may have properties of both nouns and verbs (e.g. may function as either) (Schwager and Zeshan, 2008; Velupillai, 2012).

However, the distinction between these categories is upheld by differences in morphological and syntactic processes applied to them. For example, the syntactic distribution of event signs, which in American Sign Language cannot combine with quantifiers or pre-modify other signs (Schwager and Zeshan, 2008), and mouthings, which occur mostly with entity signs in LSM (Quinto-Pozos, 2008), but with event signs in Quebec Sign Language (Voghel, 2005), may distinguish these categories. Nouns may also be inflected for number, frequently via reduplication; however in some signed languages nouns cannot be inflected for number at all, although verbs and pronominal signs might be (Velupillai, 2012). However, other ϕ-features typically associated with nouns in spoken languages, such as gender and case, are not typically present in signed languages. No documented signed language is argued to have grammatical gender, although it may have gendered nominal signs, such as + FEM in LSM, an affix which can optionally indicate the gender of female animate entities. Some signed languages are argued to mark case as part of verb agreement (?) or in possessive pronouns or suffixes (Abner, 2012 for a discussion of the genitive sign POSS in ASL and Johnston and Schembri, 2007 on genitive suffixes in Auslan). Combining these morpho-syntactic properties of nominal signs with the semantic properties of nouns outlined by Croft (1991), which defines nouns in terms of reference, modification, and predication, then researchers working on signed languages can arrive at a criteria for nominal/entity signs which is fairly flexible and allows for the realization of this category and its properties to vary somewhat across signed languages.

Signed languages vary however, as to whether they have other lexical categories and the functions those categories have. Many signed languages have modifiers (property) signs that can modify nouns or verbs (Schwager and Zeshan, 2008; Velupillai, 2012), correlating with the classes adjective and adverb, but others do not. Argentine Sign Language, for example, has been argued to lack most adjectives, instead using stative verbs (e.g. BE-TALL) as attributive nominal modifiers (Massone and Curiel, 2004), while

[1]Reversible verbs can take arguments that can act as either a subject (agent) or an object (patient). For example, the sentence "Violet eats the kibble" is not reversible; only "Violet" can be understood as the agent, barring the existence of a kibble monster. However, in the sentence "Violet hugs Marzipan", either animate argument, Violet or Marzipan, could be the agent and this is disambiguated in some languages through word order.

[2]Napoli and Sutton-Spence (2014) note that OSV occurs in signed languages, but is typically analyzed as object topicalization, yielding a non-adjacent surface order.

[3]However, attempts to define default constituency order in signed languages are complicated by interference from spoken languages and the effect of agreement, topicalization, and other clausal phenomena on surface word order (Johnston et al., 2007).

modifiers in modifiers in Kata Kolok only serve predicative functions (Schwager and Zeshan, 2008). Conversely, while German Sign Language modifiers can act as attributive modifiers or predicatively modify nouns and verbs (Schwager and Zeshan, 2008).

One area of signed language nominal structure subject to much scrutiny is relative clauses; however typological studies of relative clauses in signed languages are small-scale and focused on distinguishing relativization strategies in a few, relatively well-documented signed languages from Europe and the US (Galloway, 2011; Branchini, 2014; Geraci, 2015; Wilbur, 2017). Thus, many non-European signed languages are underrepresented in the literature on relative clauses. Compounding the problem of scarce documentation of many non-European signed languages, efforts to identify and differentiate types of relative clauses in signed languages can be challenging due to the complexity of these structures, the similarities between relative clauses and other embedded structures, and how little is known about relativizing strategies in signed languages more broadly (Branchini, 2014; Kubus and Nuhbalaoglu, 2018; Kubus, 2021). Further, many of the signed languages considered in these small-scale studies have typologically unusual relativizing strategies (e.g. internally-headed, correlative, mixed strategies), when compared to the patterns found in spoken languages, which complicates attempts to generalize signed language relative clause typology and to determine whether there are differences in how languages in different modalities form relative clauses.

Yet, the position of some nominal modifiers (like genitives) in spoken languages is known to correlate with the order of the object and the verb (Dryer, 2013c), and there are some clear areal patterns in the order of the noun and its modifiers, a set of phenomena that would certainly inform much typological literature if it were present (or not) in signed languages. Thus, as it is not known how signed languages may inform the existing literature on (spoken) language typology, nor whether language modality, argued to play a critical role in agreement patterns, acquisition, processing, and constituent word order in signed languages (Morgan et al., 2007; Lillo-Martin and Meier, 2011; Napoli and Sutton-Spence, 2014; Villameriel et al., 2019), has effects on nominal word order in signed languages and their processing, studying nominal word order in signed languages would greatly inform the understanding of language as a human faculty and linguistic typology more broadly, as well as increasing the representation of signed languages in linguistic typology.

NP Typology in Spoken Languages

Due to large-scale investigations of spoken language typology, the word order of nouns and nominal modifiers across spoken languages is well described, as is how these word order patterns vary based on areal, genetic, and other factors. The signed language data presented in this study is compared with data from the World Atlas of Language Structures (WALS). Spoken languages predominantly favor post-nominal modifiers (Dryer, 2013a,b,d,e), excluding genitives, which are cross-linguistically pre-nominal (Dryer, 2013c). While initially there appeared to be a correlation between the order of adjectives and nouns and the order of verbs and objects, subsequent research has shown that there is no correlation between Noun/Adj[4] and Obj/Verb word orders (Velupillai, 2012). However, there is a cross-linguistic correlation between the order of Noun/Genitive and the order of Obj/Verb (Dryer, 2013c).

The most common order of the adjective and noun is Noun-Adj, which accounts for about two-thirds of the languages surveyed in WALS (Dryer, 2013a). Adj-Noun order is second most common order, but is much less frequent. Less than a 10th of languages have either Noun-Adj or Adj-Noun as an option, with neither dominant. It is very rare for languages to lack attributive adjectives entirely; the languages that only have predicative adjectives are all found in the Americas (Dryer, 2013a).

The order of the numeral and the noun exhibits clear geographical patterns (Dryer, 2013d). Num-Noun order, which just under half of the spoken languages have, is found mostly in Europe, the Middle East, North Africa, Asia, Indonesia to western Micronesia, and across the Americas. The order Noun-Num, which accounts for just over half of the languages, is predominant in sub-Saharan Africa, Southeast Asia, New Guinea and eastern Indonesia, and pockets of Canada and the Eastern United States. Relatively few languages in Dryer's sample have neither order as dominant and only two languages have numerals that only modify verbs.

By comparison, the occurrence of pre-nominal and post-nominal demonstratives is much more equivalent across spoken languages; slightly more languages place the demonstrative after the noun (45.8%) than before the noun (44.2%) (Dryer, 2013b). Far less common in Dryer's sample are demonstrative affixes (together accounting for 3%), demonstratives both before and after the noun (1.4%), and languages that have two or more of these types available (5.5%). The Dem-Noun order is dominant in Europe, Asia, and the Americas. Noun-Dem order is found in Africa, Southeast Asia into the Pacific, Australia, and New Guinea. Languages with demonstrative affixes are uncommon, but slightly more common in Africa. Doubled demonstratives are clustered among Tibeto-Burman languages, but are otherwise scattered across the globe. Languages without a dominant strategy are also scattered, but slightly more common in Africa (Dryer, 2013b).

As pre-nominal genitives correlate with pre-verbal objects, Gen-Noun is most common cross-linguistically (Dryer, 2013c). Gen-Noun order is dominant in pockets of Africa, Asia (other than Southeast Asia), New Guinea into eastern Indonesia, and the Americas. Noun-Gen order accounts for a third of Dryer's sample and is common in Europe, Africa, Southeast Asia, Austroneasian languages, the Pacific Northwest, and Mesoamerica. Languages lacking a dominant order are uncommon, but are more common in Australia.

[4]Slashes between modifiers and nouns do not indicate a relative ordering between them, while dashes do indicate a relative ordering; e.g. Noun/Adj does not refer to a specific order, but Noun-Adj refers to post-nominal adjectives.

The order of the relative clause and the noun is the final typological study of nominal word order included in WALS. There are several methods of encoding relative clauses, with two major strategies: pre-nominal externally-headed and post-nominal externally-headed relative clauses (Dryer, 2013e). Noun-Relative is the dominant type across the world's languages, except across most of Asia and in pockets of New Guinea, Ethiopia and Eritrea, and southern Colombia, where the Relative-Noun order is dominant. Internally-headed relative clauses, which are embedded clauses with the head noun in the base position of the clause, are scattered, but more common in North America and northeast India and adjacent areas. Correlatives are another type of internally-headed relative, but the relative clause is located outside of the main clause and anaphorically connected to an NP in the main clause that corresponds to the head. Correlatives as a dominant relativizing strategy are uncommon cross-linguistically, mostly found in Southeast Asia and a small area of West Africa. Adjoined relative clauses are outside the main clause and have an external head which is within the matrix clause; the relative clause does not form a constituent with the head noun. Adjoined relative clauses as a primary strategy are represented in only eight languages in Dryer's sample, mostly in Australia. The final type of relative clause are doubly-headed relative clauses, which have both an internal and an external head. These are found as a primary relativizing strategy in only one language, which is spoken in Indonesia.

These samples from WALS provide a fairly clear indication of the cross-linguistic tendencies found in spoken languages, although there are issues with the notion of *dominant* word order and certain limitations of large-scale samples like these. For example, these samples rely on descriptions of language data collected by researchers using differing methodologies and identifying dominant word order and relative clause types, for example, is notoriously difficult. In particular, it is quite possible that non-externally-headed relative clauses are much more frequent in spoken languages than this sample might indicate, due to these issues (Dryer, 2013e).

DATA AND METHODOLOGY

The process of coding data from 41 signed languages is described in **Section 3.1**. I explore how signed languages fit into the typical model of language family classification, as well as the ways in which signed languages do not easily conform to the model of language classification that has been developed based on spoken languages, in **Section 3.2**.

Typological Data

Using published sources for 41 signed languages, in addition to my own collected data from LSM, I coded the word order of nouns and nominal modifiers (adjectives, numerals, demonstratives, quantifiers, genitives, and relative clauses), which are listed along with sources in **Table 1**. These signed languages comprise a selection from the typological study on constituent word order in 42 signed languages conducted by Napoli and Sutton-Spence (2014).[5] I modeled my sample on theirs to facilitate comparison between their results on constituent order and those on nominal word order presented here (although I do not compare those results here). Additionally, their sample of signed languages represents both village signed languages and national signed languages, as well as signed languages that are both geographically and genetically distant. See the following subsection for discussion of the distribution of this sample and sign language classification issues.

While the LSM data comes from my own fieldwork, supplemented by Cruz Aldrete's (2008) descriptive grammar, the majority of the data used in this typological study comes from published manuscripts, including grammars of particular signed languages, small scale typological studies of other phenomena in signed languages (e.g. Branchini, 2014; Wilbur, 2017; Hauser et al., 2021), and larger scale typological studies and handbooks of signed languages (e.g. Zeshan, 2006; Pfau et al., 2012; Zeshan and Sagara, 2016; Zeshan and Palfreyman, 2017). When a generalization about the Noun/Modifier order was explicitly stated, I coded that statement in the data set (see the supplementary materials for values coded for each signed language). When a source did not explicitly state which order was preferred, reported data (typically glossed in the meta-language with all caps) was used to determine the order of the noun and its modifier. Crucially, the modifier had to be used attributively, which was determined based on a variety of cues, including the syntactic glossing, meta-language glossing, the presence of a verb, etc. While this methodology is typical of large-scale typological studies, this is not an ideal method for collecting information about word order; however, it was necessary in order to report observed word order in these signed languages, many of which are under-represented in linguistic research. As a result, it is possible that the word order listed for a language only accounts for the possible orders in a given language, not the preferred word order in that language. Additionally, language contact with spoken languages may influence what individual signers produce, so the order found in the data may not be the canonical order in that signed language. Further, methodologies for collecting data may differ between studies; if the data is from naturalistic speech, it may more accurately represent the word order of a signed language than direct elicitation or other tasks. However, full nouns are often replaced with pronominal forms, null pronouns (with or without verbal marking) or referential body shift in discourse. As a result, full noun phrases are uncommon in discourse and when present they may be focused or topicalized, sometimes leading to changes in word order. Conversely, if data was collected in an elicitation or interview setting, there may be more "unnatural" utterances. This is an issue not unique to the study of signed languages, and instead is a persistent problem typological studies must contend with because they rely on data collected with varying methodologies.

[5]One language from their study was not included, French Swiss Sign Language, which did not have sufficient published data to provide generalizations about nominal modifiers.

TABLE 1 | Signed languages in the study and sources.

Signed Languages	Sources
Adamorobe	Nyst (2007)
Al-Sayyid Bedouin	Sandler et al. (2005), Padden et al. (2010)
American	Valli and Lucas (2000), Chen Pichler et al. (2008), Quadros and Lillo-Martin (2010), Galloway (2011), Branchini (2014)
Argentine	Massone and Curiel (2004), Fuentes et al. (2010), Massone and Martínez (2015)
Australian	Johnston and Schembri (2007), Johnston et al. (2007)
Austrian	Hunger (2006), Chen Pichler et al. (2008), Schalber (2015)
Brazilian	de Quadros (2003), de Quadros and Quer (2008), Nunes and de Quadros (2008), Quadros and Lillo-Martin (2010), Nunes and de Quadros (2004)
British	Deuchar (1983)
Catalan	Morales-Lopez et al. (2005), Fuentes et al. (2010), Mosella Sanz (2011, 2012)
Chinese	Yang and Fischer (2002), Huihua and Liqun (2011), Yang (2015, 2016)
Colombian	Oviedo (2001)
Croatian	Milković et al. (2006, 2007), Chen Pichler et al. (2008)
Danish	Kristoffersen (2003), Engberg-Pedersen (1990, 2003), Hansen (1975), McGregor et al. (2015)
Estonian	Miljan (2003), Hollman (2016)
Finnish	Jantunen (2008), Savolainen (2006), Takkinen et al. (2015)
Flemish	Vermeerbergen et al. (2007b, 2007a)
French	Kuhn (2015), Kuhn and Aristodemo (2017), Millet et al. (2015), Hauser (2020)
German	Glück and Pfau (1998, 1999), Plaza Pust (2008), Pfau and Steinbach, (2005), Wilbur (2017)
Greek	Antzakas (2006b, 2006a), Sapountzaki (2015)
Hong Kong	Sze (2003), Siu (2016), Tang and Lau (2012)
Indian (Indo-Pakistani)	Zeshan (2003)
Inuit	Schuit et al. (2011), Schuit (2014, 2015)
Irish	Johnston et al. (2007), Matthews (1996), Leeson et al. (2015)
Israeli	Vermeerbergen et al. (2007a), Sandler et al. (2005), Tang et al. (2010), Branchini et al. (2007)
Italian	Volterra et al. (1984), Bertone (2010), Geraci (2015), Branchini and Donati (2009), Brunelli (2011)
Japanese	Fischer and Gong (2010), Sagara (2014, 2016), Ichida (2010), Penner et al. (2019)
Kenyan	Jefwa (2009), Morgan et al. (2015)
Malagasy	Minoura (2012)
Mexican	Cruz Aldrete (2008); own video data
New Zealand	McKee and Kennedy (2005), McKee (2016)
Polish	Rutkowski et al. (2015)
Portuguese	Martins et al. (2019), Almeida et al. (2015)
Providence Island	Washabaugh et al. (1978), Woodward (1987)
Quebec	Berthiaume and Rinfret (2000), Parisot et al. (2015)
Russian	Kimmelman (2012, Kimmelman, (2017), Khristoforova and Kimmelman (2020)
Netherlands	Coerts (1992), Oomen and Pfau (2017), van Gijn (2004), Brunelli (2011), Klomp (2019)
South African	Vermeerbergen et al. (2007b)
Spanish	Bobillo-García et al. (2006), Morales-López et al. (2012), Cabeza-Pereiro and Iglesias-Lago (2015), Zeshan (2004)
Swedish	Bergman and Wallin (2003), Nilsson (2007), Börstell (2017)
Taiwanese	Zeshan (2004), Smith (2005), Zhang (2007), Tai and Tsay (2015)
Turkish	Zeshan (2006), Kubus (2016)

If it was unclear whether something was an instance of an attributive nominal modifier in a noun phrase (i.e. a noun followed by a demonstrative point that could be interpreted as a predicate, such as "the NOUN is there", or a noun with an ambiguous string that could be a relative clause or an adjective) I did not include that example in my coding. Frequently, there were other examples in the same source that were analyzed as noun phrases with a nominal modifier, so excluding examples did not impact the coding or results. If sources on a particular language conflicted (for example, Providence Island Sign Language had conflicting claims about Noun/Adj word order), I erred with the source that was more recent, which generally had more examples of the word order they claimed was dominant. If there was no claim about the dominance of one word order over another and both occurred, I coded the order as allowing for either. Finally, when there was a clear dominant word order in a signed language, as stated by the source, but there were other possible orders that occurred rarely in the corpus, I coded that language as having the dominant word order.

Figure 1 contains a map of the signed languages in this sample categorized by family affiliation,[6] with sources for the data presented here listed in **Table 1**. All of the 41 languages were coded for Noun/Adjective order. Criteria for determining adjectives in reported data, if not addressed directly by authors, included: 1) a class of word *attributively* modifying a noun (identified by the presence of a verb or verb phrase that appeared to be a constituent to the exclusion of the noun and attributive modifier) and 2) that word belonged to a semantic field often associated with adjectives following Dixon and

[6]All maps were made using the open-source statistical software R and the R package lingtypology (Moroz, 2017), which links to the Glottolog database and pulls language names and geographic coordinates from there (Hammarström et al., 2020).

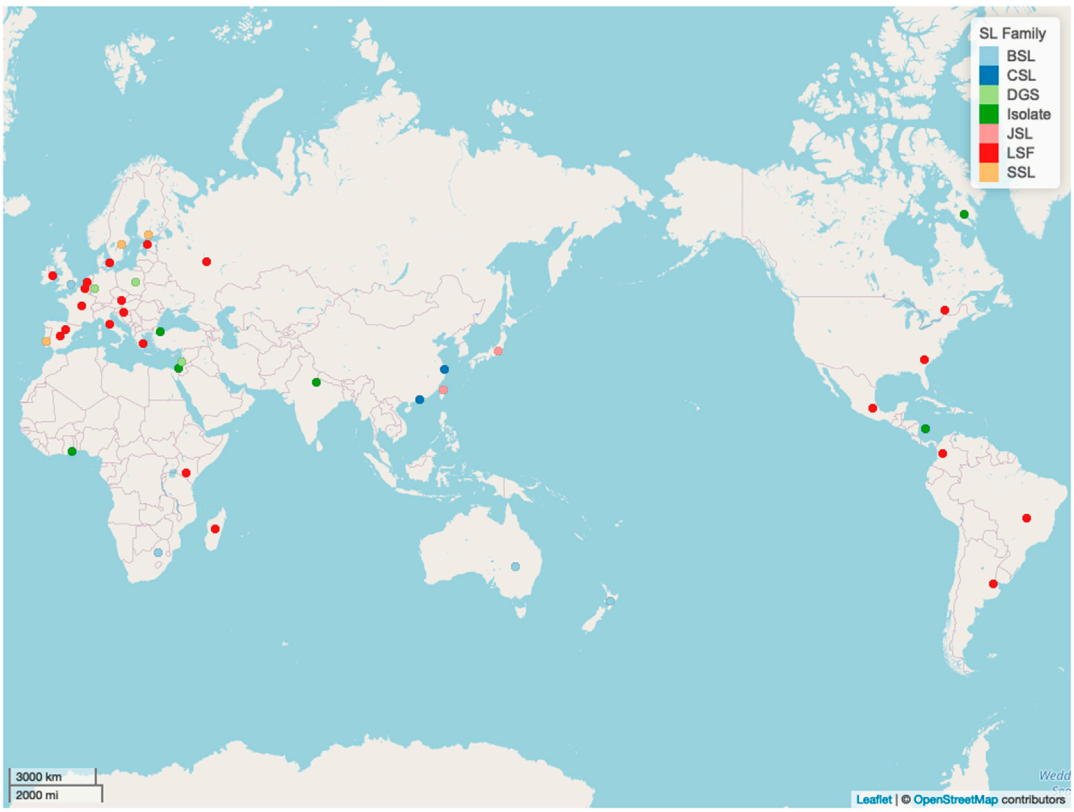


FIGURE 1 | Map of signed languages by family affiliation in the sample.

Aikhenvald (2004). These criteria could inadvertently include modifiers such as reduced relative clauses or relativized verbs, which in many languages may be functionally and structurally identical to adjectives (Gil, 2013). Unfortunately, this is unavoidable due to how data is reported and/or analyzed; questionable examples were noted and excluded from the analysis.

Of the 41 languages in this study, 36 had data that included information on the order of the Noun/Numeral. Only cardinal numerals used attributively to modify a noun were included, identified by the presence of a verb which appeared to form a constituent to the exclusion of the noun and numeral based on data glossing, translation, and analysis. A different but overlapping subset of 36 signed languages had data on the order of the Noun/Demonstrative. If Noun/Demonstrative word order was not stated explicitly by researchers, lexical demonstrative signs and indexical points analyzed as demonstratives were used as evidence. Locative points and indexical/pronominal points that could possibly be interpreted as locatives following the glossing, translation, and analysis of the data were excluded from the coding of demonstratives for the purposes of this study.

Quantifiers were coded separately from demonstratives, for descriptive purposes. Only 28 of the languages included in this study had information on Noun/Quantifier order. Quantifiers used attributively to modify nouns included ALL, SOME, FEW, MANY, etc. If it was not clear if a quantifier was modifying a noun attributively, or if it seemed that the position of a quantifier in relation to the noun may be due to quantifier floating, then that example was excluded. In principle, even supposedly adnominal quantifiers could be floated, so the Noun/Quantifier results presented here should be considered with this in mind.

34 languages had Noun/Genitive order reported in published sources. These languages were coded for the order of the possessor (head noun) and possessum (genitive) that occurred most frequently in the reported data, unless a generalization about genitive word order was stated. Possessors included full nouns, as well as possessive pronouns (sometimes glossed with spoken language pronouns or with POSS) and indexical pronouns/pointing signs. In several signed languages, a dominant order was not apparent based on the scarcity of data, so those languages were coded as having either or multiple strategies.

Finally, 30 languages in the set had relative clauses reported in the published sources or were included in research on relative clauses in a particular language or set of languages. The study of relative clauses in signed languages is still ongoing and several signed languages with substantial research on relative clauses, such as ASL and Italian Sign Language (LIS), have conflicting

analyses of relative clause structure.[7] For example, analyses of the structure of ASL relative clauses run the gambit: externally-headed, internally-headed, correlative, conjoined, and all of the above (Liddell, 1978, 1980; Galloway, 2011; Branchini, 2014). As recent research argues that ASL utilizes multiple relative clause types based on a number of diagnostics, ASL was coded as a mixed strategy language.

However, in LIS the structure of relative clauses is less clear due to a number of mitigating factors. Initial proposals argued that LIS has correlatives, but other analyses propose that these are in fact internally-headed relative clauses (Cecchetto et al., 2006; Branchini and Donati, 2009; Brunelli, 2011; Cecchetto and Donati, 2016); the number of conflicting analyses and the structural similarity of the proposed relativization strategies, complicates current attempts at classification. For this study, I followed the generalizations of the more recent research, which gave contextualized counter arguments for why an internally-headed relative clause is a better analysis for LIS than the correlative one (Branchini and Donati, 2009; Cecchetto and Donati, 2016), as well as evidence for the existence of externally-headed relative clauses in LIS (Brunelli, 2011), which would mean that LIS may be a language which uses mixed relativizing strategies.

Coding languages like LIS as using a mix of strategies, given the conflicting analyses, is less than ideal, but is a limitation imposed by the availability of linguistic data and analyses due to the study of signed languages being a burgeoning field. Thus, great care must be taken in forming generalizations about relative clauses in signed languages due to the lack of data in many signed languages allowing a clear determination of relative clause type and the difficulty with confirming that relative clauses are not adjuncts or conjuncts of the main clause (Wilbur, 2017).

Sample Bias and Puzzles for Classification

Unfortunately, it is impossible to know exactly how many signed languages there currently are, but it is likely that there are several hundred signed languages (Zeshan and Palfreyman, 2017), of which only a small portion have been documented or researched extensively. The signed languages that have a lot of documentation over-represent the signed languages of Europe, particularly western Europe (Zeshan and Palfreyman, 2017). Many of the signed languages found in Africa, Eastern Europe, Meso- and South America, and Asia are underrepresented in the literature, and so have very few linguistic sources regarding their grammatical structure.

This survey includes eight languages in North and South America, 18 in Europe, four in Africa, seven in Asia, two in the Middle East, and two in Australasia. As a result, the languages in this survey, while encompassing both village (rural) sign languages and national (urban) sign languages, skew toward over-representing European sign languages, particularly those of western Europe. African sign languages, for example, are most certainly under-represented in this study, as there are only four included in the sample, but there are at least 17 signed languages in use just in West Africa (Nyst, 2010). This geographical bias is in part due to the availability of documentation and research on those languages, compared to non-European sign languages; however, in North America and Australasia, there are few signed languages used in large geographic regions, so no representative sample is possible in these cases. See the next subsection for further discussion about issues involving genetic classification of signed languages. This has been cited as evidence challenging the applicability of language families to signed languages at all, and is certainly a concern for any typological work.

While areal bias may be difficult to avoid in typological studies of signed languages, it is not the only issue signed language typologists have to contend with. Genetic bias, as noted by Zeshan and Palfreyman (2017), is also a problem since signed languages do not have the same genetic relationships that spoken languages do. Many signed languages around the word have developed due to the establishment of schools for the Deaf, where Deaf educators brought their own signed language into a community that may have had some signs or signing systems of their own. Other signed languages, particularly in Africa, have been in extensive contact with ASL brought in by US missionaries. In many cases, we do not know which languages are related at all.

These issues are compounded by the fact that "the very notions of "language family" and "genetic relationship" are not well-defined" (Zeshan and Palfreyman, 2017, p.3) and many of the lexical items that linguists look to in order to determine genetic relationship between spoken languages are iconically motivated in signed languages or shared due to other factors, such as language contact, obscuring genetic relationships. Thus, it is not clear how well traditional historical linguistics methodologies, like the comparative method, may be applied to signed languages, although some recent work in this vein has substantiated traditional signed language families (Power et al., 2020; Reagan, 2021). As a result, the genetic classification of signed languages mostly relies on non-linguistic historical evidence, such as documents, letters, and oral history, and there are a number of difficulties related to defining language families within signed languages, although there appear to be at least some clear instances of contact and shared lineage between some signed languages, including LSM. Yet, some signed languages do not have any clear relationship with other signed languages. Following this, most typological descriptions of signed languages consider signed languages as their own group distinct from spoken languages, although extensive contact with local

[7]Although some spoken languages distinguish restrictive and non-restrictive relative clauses, either syntactically or through other means, this distinction is not part of the analysis presented in Dryer (2013e) and has not been systematically examined in the literature on relative clauses signed languages. A reviewer suggested that contrasts between restrictive and non-restrictive relative clauses may be where modality effects within the NP are visible. Initial description of relative clauses in LSM by Cruz Aldrete (2008) indicated that restrictive and non-restrictive relatives were distinguished by the presence of a relative pronoun. I have not been able to replicate that finding in my own data, but if this is the case in LSM, then it would not constitute a modality effect inasmuch as a point of variation in relative clauses present in some language regardless of modality. Due to the lack of available data and existing evidence of contrasts between restrictive and non-restrictive relative clauses not indicating the presence of modality effects, relative clauses were not coded based on whether they were restrictive or non-restrictive, although this may be possible as more data becomes available.

TABLE 2 | Overall Word Order Typology of SLs (percentages based on SLs with data).

Position	—	Adj	Num	Dem	Quant	Gen	Rel
Pre-nom	—	10 (24.4%)	15 (41.7%)	12 (33.3%)	13 (46.4%)	22 (64.7%)	2 (6.6%)
Post-nom	—	16 (39%)	11 (30.6%)	10 (27.8%)	10 (35.7%)	2 (5.9%)	16 (53.3%)
Either	—	14 (34.1%)	10 (27.8%)	11 (30.6%)	5 (17.9%)	10 (29.4%)	0 (0.0%)
Other	Pred. only	1 (2.4%)	—	—	—	—	—
—	Internal-head	—	—	—	—	—	4 (13.3%)
—	Correlative	—	—	—	—	—	1 (3.3%)
—	Adjoined	—	—	—	—	—	0 (0.0%)
—	Double	—	—	—	—	—	0 (0.0%)
—	Mixed	—	—	3 (8.3%)	—	—	7 (23.3%)
No data	—	—	5	5	13	7	11

spoken languages, a situation unique to signed languages (Quinto-Pozos and Adam, 2012), may further obscure genetic relationships between signed languages and also challenges the notion of language families in signed languages at all[8].

This sample overwhelmingly represents signed languages that have historical ties to French Sign Language (LSF). What type of relationships these signed languages have with LSF likely varies dramatically by language and the extent of the language contact between the LSF-associated language and indigenous sign systems and languages. Additionally, there are a number of isolates and languages from other lineages, including the British, Chinese, German, Japanese, and Swedish Sign Language families.

NP TYPOLOGY OF SIGNED LANGUAGES

Overall, the word order preferences identified in spoken languages also exist in the signed languages surveyed here. Although there is not such a clear preference for post-nominal modifiers across signed languages, post-nominal modifiers are quite common for all modifiers except genitives, as in spoken languages. Additionally, uncommon word orders and modification strategies in spoken languages (such as only having predicative adjectives, or non-externally-headed relative clauses) are also uncommon in the signed languages in this sample. It is possible that these findings are an artifact of the sample and the data available, but these preferences in the sign language sample appear to parallel the general trends of nominal word order in spoken languages. The word order of nouns and nominal modifiers in the signed languages in this sample is summarized in **Table 2**.

Due to limitations on available data for many signed languages, this study examines the order of nouns relative to individual modifiers and leaves word order with multiple nominal modifiers for future research. I discuss the word order data for each noun and modifier set in the following subsections: adjectives in **Section 4.1**, numerals in **Section 4.2**, demonstratives in **Section 4.3**, quantifiers in **Section 4.4**, genitives in **Section 4.5**, and relative clauses in **Section 4.6**.

TABLE 3 | Noun/Adjective order in signed and spoken languages.

Order	Signed	Spoken
Adj-Noun	10 (24.4%)	373 (27%)
Noun-Adj	16 (39%)	878 (64%)
Either	14 (34.1%)	110 (8%)
Verbal Adj only	1 (2.4%)	5 (0.3%)
Total	41	1,366

Noun/Adjective

All 41 signed languages had data available on Noun/Adjective word in the noun phrase, summarized in **Table 3**, with the spoken language data from WALS for comparison. Post-nominal adjectives are the most common, shown in example (1), mirroring what is found in spoken languages. However, signed languages with either order of adjective and noun are quite common,[9] as in example (2), as are signed languages with pre-nominal adjectives, as in (3). Only one language, Argentine Sign Language, did not have a class of signs which are clearly adjectives that can attributively modify nouns; instead, stative verbs may act as attributive or predicative modifiers as in (4), and when they are attributive they have a clearer adjectival function (Massone and Martínez, 2015).

[8]As a result of these challenges associated with categorizing signed languages into families, the familial relations represented in this study may be contested or otherwise artifacts of using Glottolog to create typological maps. For example, as one reviewer pointed out, South Africa Sign Language is classified in Glottolog as part of the extended British Sign Language family, even though this is not the best classification for this language.

[9]While some spoken languages have a dominant modifier word order, changing the order can result in semantic contrasts; for example, the placement of the adjective *viejo* "old" relative to the noun in Spanish and other Romance languages results in a change in meaning (*mi vieja amiga* "my long-time friend" and *mi amiga vieja* "my elderly friend"). These languages are still classified following their dominant word order (post-nominal adjectives, in the case of Spanish), so although there are no examples of this type of semantic shift in the signed language data presented here, it would not impact the classification of these languages.

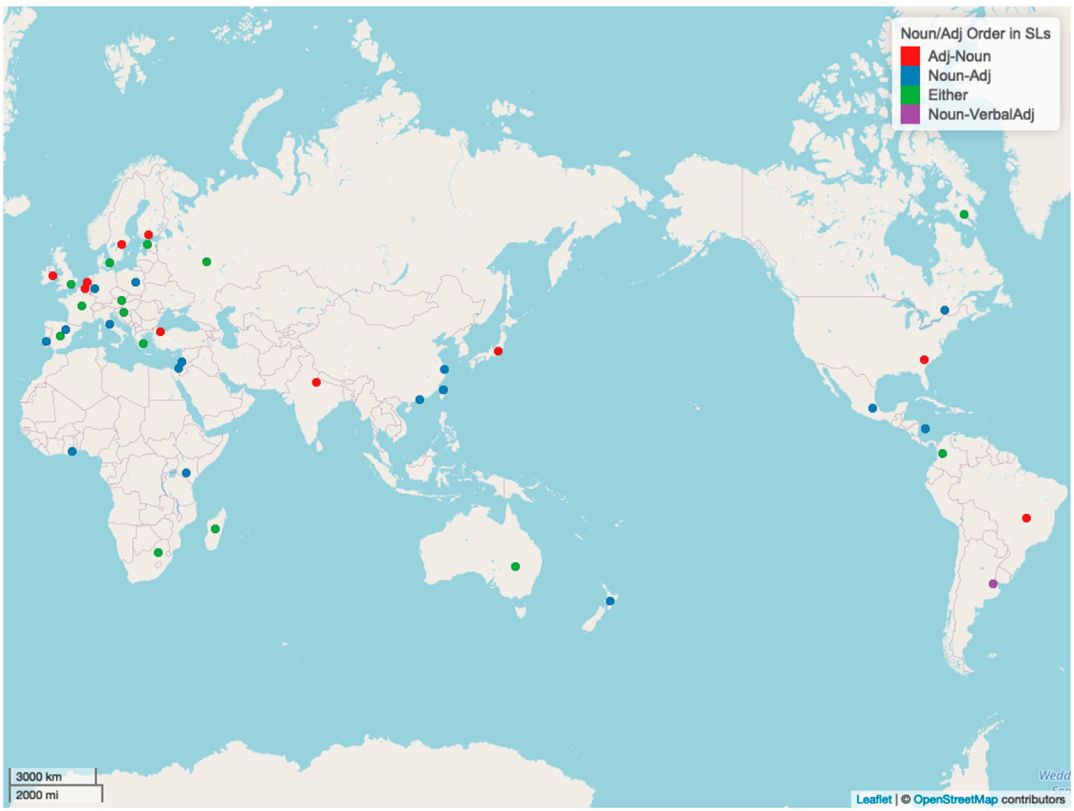


FIGURE 2 | Map of noun/adjective order in sign languages.

(1) OTHER ONE CAT GREY AWAKE SIT+ IN FS(SOFA) CL:V.SITTING-OPPOSITE
[Det Num Noun Adj]
'The other grey cat is awake and sitting on the sofa' (LSM; own field work, 200924_LSM_ELV 08:25)

(2) a. POSS-1 UNCLE WORSE OLD
[Det Noun Adv Adj]
'My uncle is older (my older uncle).' (Auslan; Johnston and Schembri (2007):193)

b. MANY BLACK CAR DISAPPEAR
[Det Adj Noun]
'Many black cars have disappeared.' (Auslan; Johnston and Schembri (2007):191)

(3) DEAF FAMILY HAVE / HAVE SOME/1
[Adj Noun]
'There are some deaf families.' (Japanese Sign Language; Sagara, 2016:314)

(4) MAN BE-TALL ENGINEER
[N Stative] Predicate
'The tall man is an engineer.' (Argentine Sign Language; Massone and Curiel, 2004:82)

The distribution of these orders is in **Figure 2**. There do not appear to be any areal trends in the distribution of Noun/Adjective word orders, nor any clear relationship between signed language family and Noun/Adjective word order. Further, although not analyzed systematically here due to the fact that many (typologically different) spoken languages may be in contact with a given signed language, there is not an obvious association between the default Noun/Adjective order in a signed language and the local spoken language(s).

Noun/Numeral

Of the 36 signed languages which had information available about Noun/Numeral word order, the most common order was Num-Noun, shown in example (5), although the order Noun-Num in (6) was also very common, as was having either pre- or post-nominal attributive numeral modifiers, as in (7). The distribution is summarized in **Table 4**, along with the spoken language data from WALS.

TABLE 4 | Noun/numeral order in signed and spoken languages.

Order	Signed	Spoken
Num-Noun	15 (41.7%)	479 (42%)
Noun-Num	11 (30.6%)	607 (53%)
Either	10 (27.8%)	65 (5%)
Numerals modify verbs	—	2 (0.17%)
No Data	5	—
Total	41	1,153

(5) PRO-3 HAVE THREE KIDS
[Num Noun]
'He has three kids.' (American Sign Language; Chen Pichler et al. (2008):447)

(6) BOOK NEW TWO IX, MINE
[Noun Adj Num Det]
'These two new books are mine.' (Italian Sign Language; Bertone (2010):22)

(7) a. THREE BOY+ C-WALK-D
[Num Noun]
'The three boys are walking' (Colombian Sign Language; Oviedo (2001):196)

b. CHILD-MALE (...) FRIEND THREE CL:Q(obj)OF-c-MOVE-TO-c.dist
[Noun Num]
'The boy gives each of his three friends a fruit.' (Colombian Sign Language; Oviedo (2001):204)

There does not appear to be any areal or genetic trends in Noun/Numeral order, the distribution of which are shown in **Figure 3**.

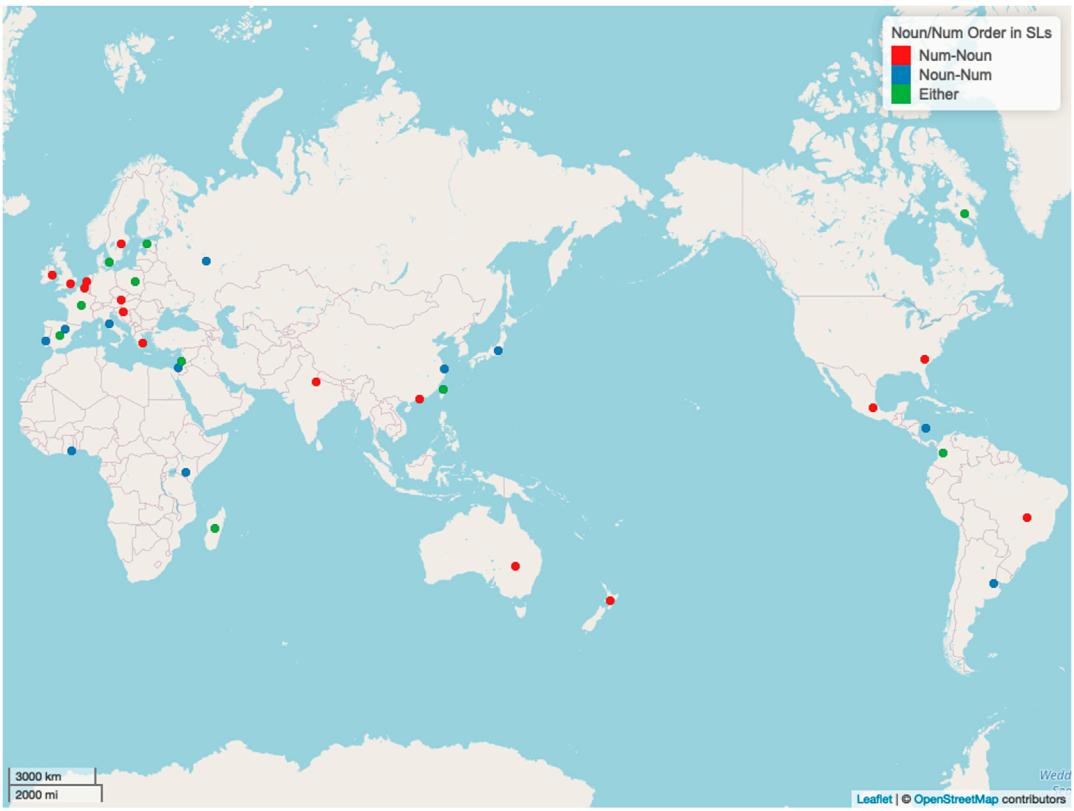


FIGURE 3 | Map of noun/numeral order in sign languages.

TABLE 5 | Noun/demonstrative order in signed and spoken languages.

Order	Signed	Spoken
Dem-Noun	12 (33.3%)	542 (44.2%)
Noun-Dem	10 (27.8%)	561 (45.8%)
Dem prefix	0 (0.0%)	9 (0.7%)
Dem suffix	0 (0.0%)	28 (2.3%)
Either	11 (30.6%)	0 (0.0%)
Dem-Noun-Dem	0 (0.0%)	17 (1.4%)
Multiple types	3 (8.3%)	67 (5.5%)
No Data	5	—
Total	41	1,224

Noun/Demonstrative

Of the 36 signed languages with demonstrative data available, summarized in **Table 5** with the spoken language data for comparison, pre-nominal demonstratives, as in (8), are slightly more common than post-nominal demonstratives, such as (9). Flexible order of Noun/Demonstrative and post-nominal demonstratives are also quite common; in some languages, such as Malagasy Sign Language shown in (10), the order was dependent on noun type (ordinary vs. areal), which is likely an effect of contact with spoken Malagasy. Languages with flexible ordering and demonstrative-doubling, as in (11), were uncommon (categorized as *multiple types* in the signed language data to distinguish from languages with pre-and post-nominal demonstratives), although it is possible that the languages in this category only use doubling in semantically-marked contexts, like topicalization, and would be better classified as one of the preceding categories.

(8) THAT B-E-E-R PINT CHEAP
[Dem Noun]
'That pint of beer is cheap' (British Sign Language; Deuchar (1983):70)

(9) BOOK INDEX INTERESTING INDEX
[Noun Dem]
'Is that book interesting?' (Indo-Pakistani Sign Language; Zeshan (2004):20)

(10) a. BOOK IX WANT BUY IX_2
[Noun Dem]
'Do you want to buy that book?' (Malagasy Sign Language; Minoura (2012):166)

b. HIDE IX HOLE RAT
[Dem Noun]
'The rat hides in the hole' (Malagasy Sign Language; Minoura (2012):166)

(11) a. CAT 3SG MY
[Noun Dem] Predicate
'That cat is mine.' (Danish Sign Language; McGregor et al. (2015):219)

b. WHO BUILD THAT HOUSE WHO
[Dem Noun]
'Who built that house?' (Danish Sign Language; McGregor et al. (2015):223)

c. DET+FR LEADER DET+FR / AFTER PRON+FR TRAVEL^GONE JUTLAND PROFORM+SR
[Det Noun Det].TOPIC
'The leader, later she went to Jutland.' (Danish Sign Language; Engberg-Pedersen (2003):275)

Although there are no signed languages with demonstrative affixes noted in this sample, this strategy is rare in spoken languages and it is possible that the smaller sample of signed languages presented here excludes a signed language with affixal demonstratives. However, identifying manual affixes in signed

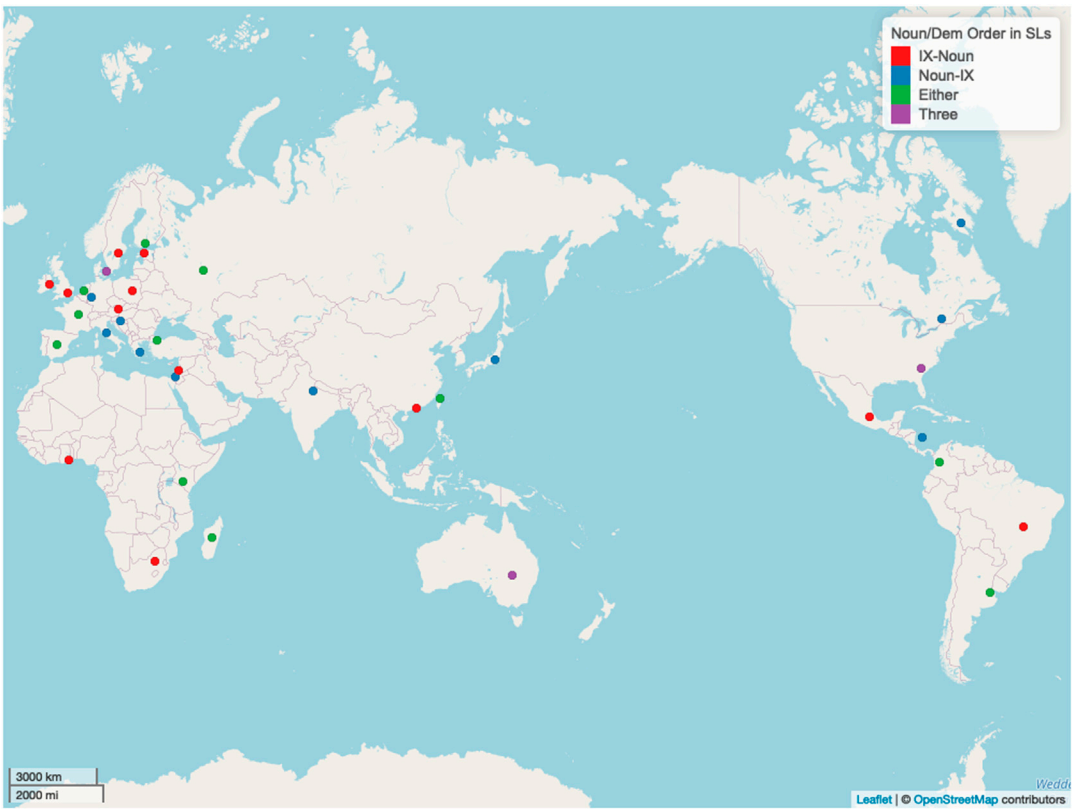


FIGURE 4 | Map of noun/demonstrative order in sign languages.

languages can be difficult. Thus, it is possible that a language identified as Dem-Noun, Noun-Dem, etc. actually has an affixal demonstrative (point or manual sign) attached to the noun, although signed languages generally do not utilize sequential affixation.[10] More research is needed to discern whether this distribution is due to sample size/bias or inadvertent misidentification.

There does not appear to be any areal or genetic trends in the order of Noun/Demonstrative, the distribution of which is shown in **Figure 4**.

Noun/Quantifier

Noun/Quantifier data was available for 28 signed languages, summarized in **Table 6**; Dryer's nominal modifier data in WALS did not categorize quantifiers separately from other modifiers, so the discussion presented here is limited to signed languages. Overall, quantifiers pattern like demonstratives in signed languages, which is not entirely unexpected. Pre-nominal quantifiers, as in (12), are the most common, although closely followed by post-nominal quantifiers, as in example (13). Relatively few languages showed no dominant order, such as the examples in (14), although the signed languages in this sample do demonstrate some flexibility in the order of quantifiers and nouns. Flexible ordering could be due to quantifier floating or other syntactic/pragmatic processes.

TABLE 6 | Noun/quantifier order in signed and spoken languages.

Order	Number
Quant-Noun	13 (46.4%)
Noun-Quant	10 (35.7%)
Either	5 (17.9%)
No Data	13
Total	41

(12) FINISH? ALL MONEY PAY FINISH?
[Quant Noun]
'Have (you) paid all money?' (Hong Kong Sign Language; Tang (2009):25, in Lee (2002))

(13) MAN MANY ENTER-right
[Noun Quant]
'A lot of men entered.' (Adamorobe Sign Language; Nyst (2007):178)

(14) a. SEVERAL MAN DIE-rep-arc
[Quant Noun]
'Several men died.' (French Sign Language; Kuhn and Aristodemo (2017):14)

b. IX-3 MEET-PL GIRLS ALL PI PLAY-PL HOPSCOTCH
[Noun Quant]
'She (Mary) met all the girls who were playing hopscotch.' (French Sign Language; Hauser (2020):58)

There does not appear to be any areal or genetic trends in the order of Noun/Quantifier, the distribution of which is shown in **Figure 5**.

[10]It is worth noting that definiteness and specificity could be marked through the association of a referent with a location in the signing space as part of concord, as argued by Neidle et al. (2000); if so, this could constitute part of an affixal determiner or demonstrative, although this issue is outside the scope of this paper.

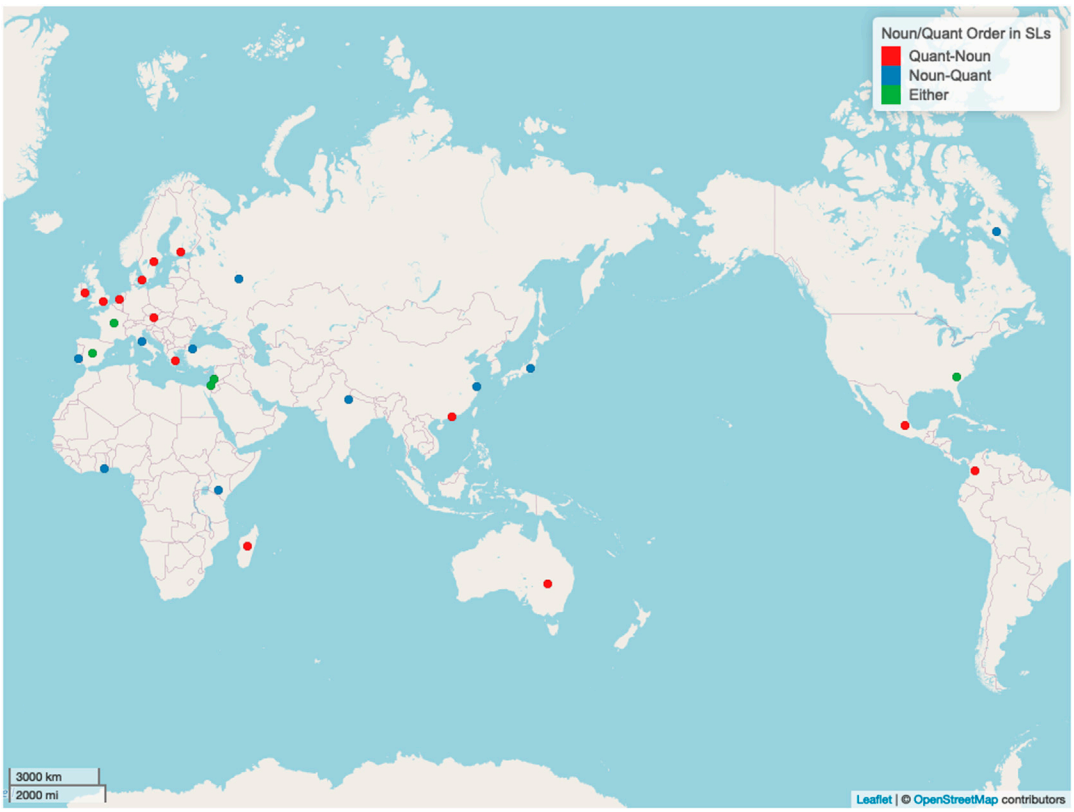


FIGURE 5 | Map of noun/quantifier order in sign languages.

Noun/Genitive

Noun/Genitive order with both pronominal and nominal genitive possessors in signed languages overwhelmingly favors pre-nominal genitives, as in (15) over post-nominal ones, such as example (16), more so than in spoken languages, as shown in **Table 7**. Of those classified as allowing either order, shown in (17), this was generally found when there were pronominal or POSS-type possessive signs that agreed with the location of the possessor in the signing space. It is possible that with full noun possessors in these languages, there is a clear word order preference that was not apparent in the available data. The distribution of Noun/Genitive is shown in **Figure 6**.

(15) (FATHER) POSS-3S BROTHER
possessor POSS Possessum
'My father's brother/his brother' (Austrian Sign Language; Chen Pichler et al. (2008):442)

(16) SCHOOL POSS.SELF, SPECIAL STUDENT GROUP PROFESSOR
[Possessum Possessor]
CL:PROF-GROUP-APPROACH-ONE-PERSON, ALL SAME LITTLE COOL SAME PROUD BECAUSE
BEST STUDENT
'At the school where I was, of all the students in the group the professor led, I was a little cool, proud, because I was the best student.' (Spanish Sign Language; Bobillo-García et al. (2006))

(17) a. FURNITURE ANTIQUE (IX), PE UNCLE MY GIVEN BROKE
Possessum Possessor
'The antique furniture, which my uncle gave me, is broken' (Italian Sign Language; Bertone (2010):9)

b. BOOK HISTORY$_j$ POSS$_j$
Possessor Possessum POSS
'the history of the book/the book's history' (Italian Sign Language; Bertone (2010):15)

There appears to be a weak areal trend for Genitive-Noun order in the Americas and Asia. The possibility of either Gen-Noun or Noun-Gen appears to be geographically spread out and the Noun-Gen order occurs in two unrelated and geographically distant European signed languages.

TABLE 7 | Noun/genitive order in signed and spoken languages.

Order	Signed	Spoken
Gen-Noun	22 (64.7%)	685 (54.8%)
Noun-Gen	2 (5.9%)	468 (37.5%)
Either	10 (29.4%)	96 (7.7%)
No Data	7	0
Total	41	1,249

Noun/Relative Clause

Relative clause typology in signed languages has been described for a small subset of the languages represented in this study. Based on available data, 30 languages had some kind of information about relative clause structure and word order, summarized in **Table 8**. Relativizing strategies in signed languages generally do not correlate with those reported in the ambient spoken languages in WALs (Dryer, 2013e), with a few exceptions where the dominant strategy in both the signed language and the ambient spoken language was pre-nominal externally-headed relative clauses.

Externally-headed relative clauses are by far the most common relativizing strategy in this sample, with post-nominal Noun-Rel externally-headed clauses with (18a) or without (18b) an overt relative pronoun found in over half of the sample and very few languages with predominantly Rel-Noun order (19)[11].

(18) a. GIRL [BICYCLE FALL]$_r$ IS HOSPITAL
N Rel
'The girl that fell off the bicycle is in the hospital' (Brazilian Sign Language; Nunes and de Quadros, 2004:180, in Branchini, 2014:163)

b. [MAN IX$_3$ $\overline{\text{[RPRO-H}_3\text{ CAT STROKE]}_{CP}}^{\text{re}}$]$_{DP}$
N Rel
'The man who is stroking the cat' (German Sign Language; Pfau et al., 2005, in Branchini, 2014:163)

(19) a. WHITE-MAN [INUK] INDEX$_1$ MOVE-CL$_{two-vehicles}$ SNOW-MOBILE GO$_{3a}$
Rel N
'A white man and me, an Inuk, go by snow mobile (to Landing Lake)' (Inuit Sign Language; Schuit et al., 2011:22)

b. [SODA] BOX [SODA] BOX MANY
Rel N Rel N
MOVE$_{up}$:CL$_{box}$ SHELFS MOVE$_{up}$:CL$_{box}$ MOVE$_{up}$:CL$_{box}$
'I put boxes with soda onto the shelves' (Inuit Sign Language; Schuit et al., 2011:23)

Internally-headed relatives are reported as a primary relativizing strategy in two signed languages in the Chinese Sign Language family, Chinese Sign Language and Hong Kong Sign Language, and three unrelated sign languages, Catalan Sign Language (French Sign Language family), Israeli Sign Language[12] (German Sign Language family) and Turkish Sign Language (isolate). The example in (20) shows the relative clause non-manual marker squint scoping over the head noun and relative clause, which is evidence for the head noun being internal (Kubus, 2016).

(20) $\overline{\text{[GIRL FAR VILLAGE IN]}}^{\text{sq}}$ BOY$_i$ IX$_i$ LOVE
'The girl, who was from a village far away, loved the boy' (Turkish Sign Language; Kubus, 2016:208)

Only Swedish Sign Language was identified as using correlatives (based on available data), and no signed languages were identified as only using adjoined relative clauses. However, adjoined relatives are very rare in spoken languages, so this could be an artifact of the sample. The relative clauses in (21a) and (21b) are internally headed and adjoined at the periphery of the matrix clause, the right edge and left edge, respectively. The non-manual marker (rel) in (21b) consists of raised brows, raised cheeks, and chin drawn back, which scopes over the head BOY, an indication that the head is inside the relative clause.

(21) a. PLUS NON-1ST-SING-1 GLADLY MUCH DISCUSS WITH PERSON PATIENT OBJ.PL DIE PATIENT WILL ON WAY DIE INDEX-F-FL
'And she enjoys discussing a lot with patients who are going to die' (Swedish Sign Language; Nilsson, 2007:23)

b. $\overline{\text{TWO BOYS HERE,}}^{\text{rel}}$ DEAF-MUTE BOTH
'The two boys who were here are both deaf' (Swedish Sign Language; Bergman, 1994:315)

Several signed languages showed mixed relativizing strategies; it is unknown if this category is in fact larger than represented here, since relative clauses are understudied in signed languages and identifying the type of relativizing strategies a given language uses to encode relative clauses can be extremely difficult (Dryer, 2013e; Branchini, 2014; Kubus and Nuhbalaoglu, 2018). As a result, it is likely that many languages (spoken and signed) use strategies other than externally-headed and have not been identified as such.

The distribution of Noun/Relative Clause orders and strategies is in **Figure 7**, which indicates several patterns in the distribution of relativization strategies. Namely, the use of internally-headed relative clauses in Chinese Sign Language and Hong Kong Sign Language appears to constitute a genetic pattern among the Chinese Sign Language family that is not the result of contact with ambient spoken languages, which have pre-nominal externally-headed relatives (see Dryer, 2013e). Data from Taiwan Sign Language may substantiate this, since it is a member of the Japanese Sign Language family and has had substantial contact with Chinese Sign Language. If Taiwan Sign Language has internally-headed relative clauses, this may indicate that this strategy is an areal phenomenon, rather than a purely genetic one; however, if Taiwan Sign Language patterns like Japanese Sign Language, then this would provide evidence for internally-headed relative clauses being a genetic feature of the Chinese Sign Language family.

Of the seven signed languages with mixed strategies, six are part of the French Sign Language family and are geographically disparate, forming a genetic pattern: American Sign Language, French Sign Language, Italian Sign Language, Malagasy Sign Language, LSM, and Russian Sign Language. The other signed language which uses mixed strategies is Japanese Sign Language (part of the Japanese Sign Language family).

DISCUSSION

Although this is a small sample compared to large-scale typological studies of spoken languages, the smaller number of signed languages and lack of documentary material for most of them limited the number of signed languages which could be included. Despite this limitation, the signed language data in this sample is generally comparable to the typological studies of

[11]As a reviewer suggested, (19a) and (19b) may be analyzed as a parenthetical and as a compound or adjective, respectively, rather than as examples of relative clauses. Parentheticals may take the form of nominal appositions and non-restrictive relative clauses and the syntactic structure of parentheticals varies (Dehé and Kavalova, 2007). In the case of (19a), INUIT represents a possible parenthetical relative clause or apposition following the typology laid out by Dehé and Kavalova (2007) and based on the translation provided in Schuit et al. (2011). As for (19b), the classification of SODA as a reduced relative clause is more tenuous. Many languages, attributive adjectives and relative clauses may be (nearly) functionally indistinguishable (Gil, 2013), making an analysis of relative clauses difficult; Inuit Sign Language may be one of those languages. For both of these examples, more evidence would be needed to confirm the presence of multiple relativizing strategies in Inuit Sign Language, including prosodic and other diagnostic evidence.

[12]Branchini et al. (2007) tentatively proposed that Israeli Sign Language has internally-headed relative clauses, based on the distribution of non-manual markers on the relative clause reported in Sandler (1999). However, the non-manual marker squint on relative clauses in Israeli Sign Language appears to be prosodic, rather than grammatical (Nespor and Sandler, 1999; Dachkovsky, 2018), and also serves to mark other structures, in addition to relative clauses, which are low on the Accessibility Hierarchy (Dachkovsky and Sandler, 2009). Other research on relative clauses in Israeli Sign Language focuses on prosody and non-manuals, rather than relativizing strategy; while further research is needed to determine whether Branchini et al. (2007) proposal is accurate, relative clauses in ISL are generally considered by linguists to be internally-headed, although this is not explicitly stated.

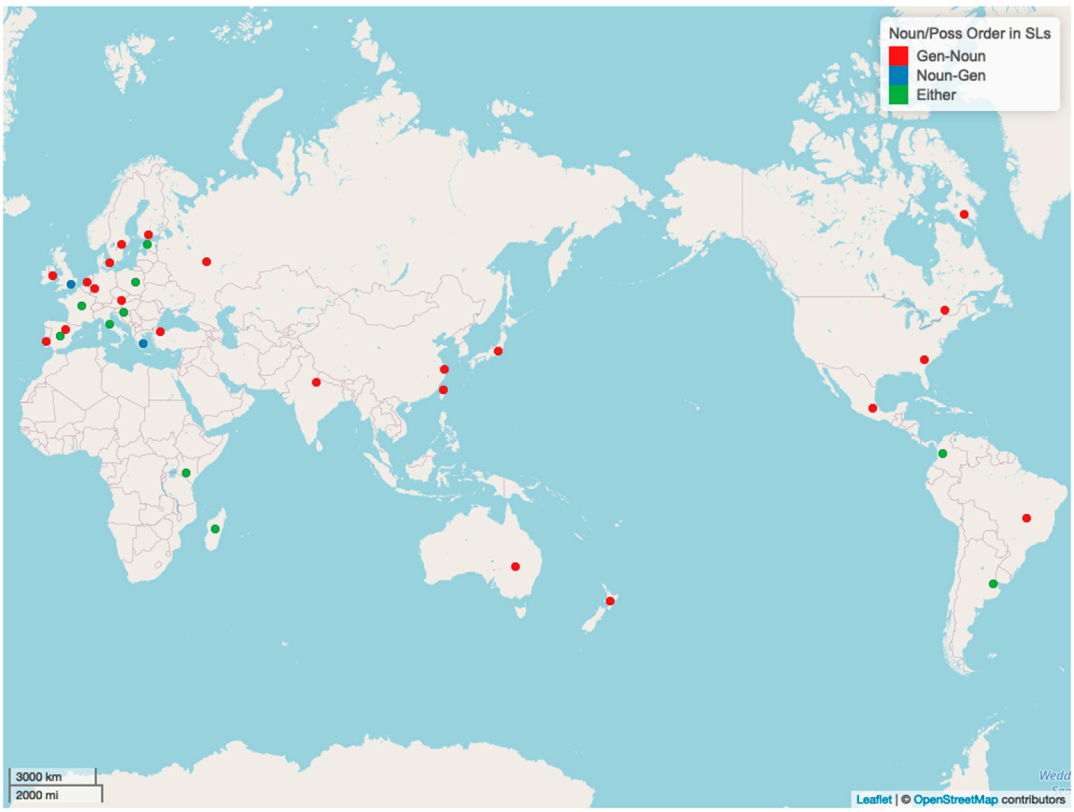


FIGURE 6 | Map of noun/genitive order in sign languages.

TABLE 8 | Noun/relative clause order in signed and spoken languages.

Order	Signed	Spoken
Externally-headed Noun-Rel	15 (50.0%)	579 (70.3%)
Externally-headed Rel-Noun	2 (6.6%)	141 (17.1%)
Internally-headed	5 (16.7%)	24 (2.9%)
Correlative	1 (3.3%)	7 (0.8%)
Adjoined	0 (0.0%)	8 (1.0%)
Double-headed	0 (0.0%)	1 (0.1%)
Mixed strategy none dominant	7 (23.3%)	64 (7.8%)
No data	11	0
Total	41	824

spoken language nominal word order in WALS (Dryer, 2013a,b,c,d,e). Overall, the signed languages have similar nominal word order patterns to the spoken languages in the samples in WALS, although a higher proportion of signed languages than spoken languages allow for multiple word order options in the noun phrase. This flexibility is likely an artifact of the available signed language data, which often did not address nominal word order directly or refrained from generalizing it, or is due to other factors, such as language modality. Further, relativizing strategies are strikingly similar across signed and spoken languages, with a clear preference for externally-headed post-nominal relative clauses while other strategies for encoding relatives have a similar relative prevalence across both samples.

Noun-Adj order is more common than Adj-Noun in the signed language data, as in spoken languages (Dryer, 2013a). However, it is far more common for signed languages to allow for either order than it was for the spoken languages in Dryer's study, likely for the reasons stated above. Of note is that only one signed language (2.4%) in this set, Argentine Sign Language, has only predicative adjectives, which is also extremely uncommon in spoken languages (5 languages, 0.3%). It would seem that, regardless of language modality, it is typologically unusual for languages to lack attributive adjectives.

The same proportion of spoken languages (479 language, 42%) (Dryer, 2013d) and signed languages (15 languages, 41.7%) have Num-Noun as the preferred word order. However, it is far more common among the signed languages to have no dominant order of Noun/Num, compared to the spoken languages, and the most common order in spoken languages, Noun-Num (607 languages, 53%), is the second most common strategy in the signed languages sampled (11, 30.6%). No signed languages were identified as having numerals that only modify verbs; however, this strategy is only attested in two languages (0.17%) in Dryer's sample, so this may be an exceedingly rare structural limitation on nominal modification that is not represented in the signed language sample for that reason.

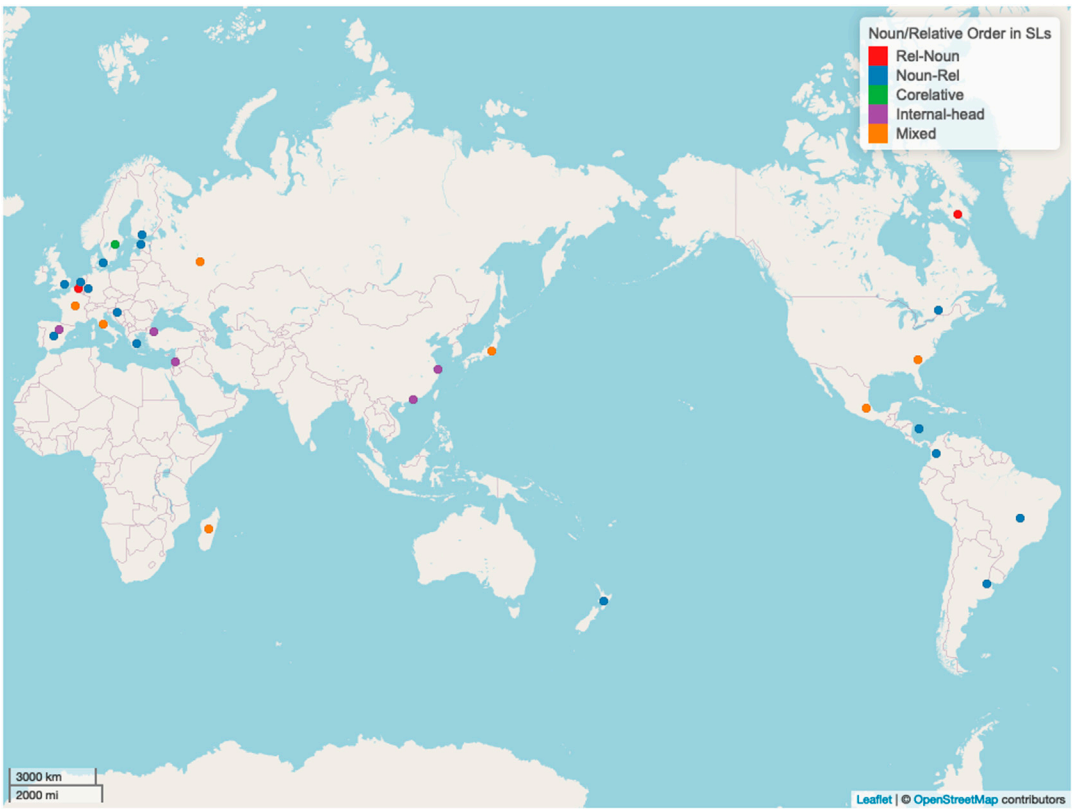


FIGURE 7 | Map of noun/relative order in sign languages.

A third of signed languages (12 languages, 33.3%) predominately use Dem-Noun word order, but Noun-Dem, which is most common in spoken languages, is present in just under a third of the signed language sample (10, 27.8%). The remaining third of signed languages are split across flexible word order (11 languages, 30.6%) and multiple types (3 languages, 8.3%). Although this is a different distribution than was noted in Dryer, 2013b sample, there are several possible reasons for this difference. First, there is a difference in how demonstrative word orders were grouped in this study, compared to Dryer's, for descriptive purposes. This study distinguishes signed languages which have either order (Noun-Dem or Dem Noun) from signed languages which have either word order and demonstrative doubling (Dem-Noun-Dem), classified as multiple types. Dryer's sample collapses these categories into languages which have any combination of two or more strategies (multiple types), which mostly includes languages with flexible word order. If these two categories are collapsed following Dryer, then a substantially larger percent of signed languages have multiple types than in spoken languages. However, this difference may be an artifact of the sample and the data reported in the signed languages, which did not generally indicate a dominant word order when there were examples of multiple types. Further, changes to demonstrative and noun word order due to topicalization and other syntactic and discursive processes have been documented in many signed languages, so it is likely that some signed languages coded here as having multiple word orders may, in fact, have a dominant word order that was not identified or was otherwise obscured by those processes. Finally, the overall prevalence of demonstrative affixes and demonstrative doubling in spoken languages is very low, so their absence from the signed language sample may be either a sampling artifact, or due to difficulties with distinguishing affixes from free morphemes.

Quantifiers overall patterned like demonstratives in signed languages; Quantifier/Noun word order was not included in WALS, so it is not possible to make a direct comparison with spoken language data. In a few signed languages, quantifiers and demonstratives were identified as having different patterns; for example, Austrian Sign Language and Danish Sign Language were both identified as having multiple word orders for demonstratives, but only one word order for quantifiers. However, the amount of data available for these languages is likely influencing the results reported here, so more investigation is needed to determine if this pattern is due to the availability of data, or if quantifiers and demonstratives really do pattern differently in these languages.

Gen-Noun order is common in both signed languages (22 languages, 64%) and spoken languages (685 languages, 54.8%); yet, the prevalence of the other possible orders is quite different between signed and spoken languages. Noun-Gen order was

found in only two signed languages (5.9%), but is far more common in the spoken languages in Dryer, 2013c sample (468 languages, 37.5%). However, both orders were attested in almost a third of signed languages (10 languages, 29.4%), but were only present in 7.7% of Dryer's sample (96 languages). It is possible that the occurrence of flexible genitive word order in signed languages is over estimated, as languages may have a preferred order that was not reported in the literature and the use of POSS-type genitive signs could influence the order of possessors and possessums due to spatial marking of referents. Additionally, flexible word order is possible with many nominal modifiers in signed languages, including genitives, and is often influenced by syntactic, semantic, or discursive practices, which may in turn complicate efforts to discern dominant word orders.

Lastly, there are two notable observations about relative clauses across signed and spoken languages. The first is that the least common relativizing strategies in spoken languages are also uncommon in signed languages, but are attested (adjoined and doubly-headed relative clauses occur as part of mixed strategies), unlike uncommon constituency orders in signed languages (Napoli and Sutton-Spence, 2014). Conversely, the most common relativizing strategy in spoken languages, externally-headed post-nominal relative clauses (Dryer, 2013e), is also the most common among signed languages. The second observation is that despite limitations due to the small number of signed languages with documented relative clause strategies, the similarities in the ranking of those strategies in signed and spoken languages–especially the most common and uncommon strategies–are striking. Externally-headed post-nominal relative clauses are the most common relativizing strategy in both spoken and signed languages, with pre-nominal relative clauses only used by less than a 10th of signed languages as a dominant strategy and by a fifth of spoken languages. Other uncommon relativizing strategies (internally-headed, correlative, and mixed) also have the same relative ranking according to prevalence in signed and spoken languages, although the small sample of signed languages makes direct comparisons of the proportions difficult.

The similarity across signed and spoken language relative clauses is somewhat unexpected, given that clausal constituent word order in signed languages differs from spoken languages, a difference that has been ascribed to language modality effects (Napoli and Sutton-Spence, 2014). This suggests that, although language modality may impact other linguistic phenomena in signed languages and may aid processing of some linguistic structures, modality does not affect the structure of relative clauses in signed languages and their overall prevalence in the same way; nor does the visual-manual modality aid in the processing of the uncommon and syntactically more complex relativization strategies or prosodically-heavy constituents like relative clauses. Instead, these preferences in spoken and signed languages must be due to the structure of language as a human faculty, providing support for cognitive processing and economic (structural complexity) hypotheses regarding the competing pressures to reduce structural complexity, as well as patterns of language contact and descent resulting in areal and genetic patterns, like the genetic pattern of mixed strategies observed in the French Sign Language family, that have led to pockets of typologically uncommon relativization strategies among historically associated languages.

The parallels in nominal word order between signed languages and spoken languages suggests that noun phrases occupy a level of syntactic structure which is less susceptible to modality effects on word order than clausal syntax and major constituent word order is. Given that many of the modality effects observed in the syntax of signed languages are related to the use of space in linguistic structure (Lillo-Martin, 2002; Meier, 2002; Napoli and Sutton-Spence, 2014), it is not immediately clear why noun phrases are not subject to the same modality effects. Both nouns and nominal modifiers can be associated with locations in the signing space, including relative clauses, and noun phrases themselves may be subjects and objects whose order in the clause is impacted by the modality effects on verb agreement. Thus, while modality effects are common in the interface of syntactic structure and the use of space, not *all* syntactic structure is affected equally. Under some theories of syntax, this could possibly be accounted for either by phase boundaries (wherein structure is "locked", preventing it from being accessed or changed by other syntactic processes) as in Distributed Morphology, or by movement due to agreement processes under the Minimalist Program, leading to differences between noun phrases and verb phrases/clauses. A more atheoretical approach may consider that the properties of nouns and verbs could give rise to a distinction between these categories, such that modality effects are different between them. If so, we might expect that a signed language which does not functionally distinguish between nouns and verbs (a language with a type 1 or type 7 part of speech system under Rijkhoff, 2007) would exhibit modality effects equally across syntactic structure.

Although not explicitly examined, it is worth noting that the signed languages studied here, known to prefer either SOV or SVO word orders with relatively equal frequency (Napoli and Sutton-Spence, 2014), show a marked preference for Gen-Noun word order. Previous typological studies of spoken languages have noted a correlation between verb/object and noun/genitive word order, but it would seem that correlation is not present in the signed language sample here. If this is not an artifact of the sample and available data, it would seem that language modality may have influenced constituency word order patterns in signed languages, as discussed in Napoli and Sutton-Spence (2014), and disrupted the correlation between genitive word order and verb/object word order in some way. However, further research is needed to confirm that signed languages do not have this correlation between constituent word order and genitive word order, as this was outside the scope of this paper.

Future research should focus on expanding this survey to include more signed languages, especially those that are not associated with the French lineage, which are over-represented here. Attempts to include more signed languages should also try to make the set as geographically unbiased as possible given current available research, as European signed languages and American Sign Language continue to be at the forefront of linguistic research on the structure and typology of signed languages. Additionally, more data on many of these signed

languages is needed to fill in the gaps in the data presented here. Due to the sample size of 41 languages in this study, not all of which had data for all nominal modifiers, it is possible that the weaker trends presented here and at least a few of the unusual features of signed languages, such as the prevalence of flexible nominal word order, are due to sampling and availability bias, and are not representative of signed languages as a whole. Further, it is possible that languages which were coded as having either order did, in fact, have a dominant order that was not presented in the sources or was obscured due to contact with local spoken languages. Conversely, it is possible that there are more signed languages which have variable word order than this study seems to suggest, due to the availability of data, contact with other languages, and how data was collected, and other factors not addressed here, such as non-manual markers, topical prominence, etc., which may facilitate alternations in word order.

Finally, this survey did not examine relative modifier-noun word order with multiple nominal modifiers due to the scope of this paper and the lack of data available for many signed languages. However, a few signed languages did have data with multiple nominal modifiers; typically, these examples had two modifiers, such as an adjective and a numeral or an adjective and a determiner, but a couple of signed languages had data with three modifiers (determiner, numeral, and adjective). In these cases, Greenberg's 1963) universal 20 and Cinque's (2005) subsequent identification of 14 attested orders of nouns, demonstratives, numerals, and adjectives out of 24 possible orders (see discussion in Bertone 2010), was adhered to in the observed signed language data. Of course, more evidence and thorough analysis is needed to confirm this initial observation, especially as many of the signed languages included in this study did not have a plethora of nominal modifier data or generalizations available due to available research.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Texas at Austin Internal Review Board. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

CC is the sole author of the article and conducted the literature review, data coding, analysis, and original article and figure/table drafting. Any inaccuracies or mistakes in the generalizations and data represented here are my own.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2021.802596/full#supplementary-material

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Preliminary Considerations on the Development of a Bicultural Trilingual Education Model for Deaf Children in the Tunisian Context

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Deaf educational methods have been the subject of controversy among advocates of the oralist and the bilingual approaches for centuries. Over the past decades, the bilingual-bicultural method has proved its effectiveness in facilitating formal school learning and downscaling a higher rate of illiteracy compared to the hearing population. The bilingual-bicultural model in Western countries is designed and implemented in predominantly monolingual contexts or multilingual contexts with a dominant majority language. It aims at providing deaf learners with a simultaneous dual access to the deaf and hearing cultures through sign language and the written form of the majority spoken language. The objective of this dual access is to create a balanced form of bilingualism which will reinforce literacy development. In the Western context, the relative proximity of the written and spoken forms of the majority language allows the written form to function as a means of access to the socio-cultural heritage of the hearing community and to develop a sufficient degree of autonomy in a world where literacy became crucial. The application of the Western bilingual-bicultural model may at first glance seem tempting to mitigate a significant rate of illiteracy affecting 98% of the deaf Tunisian population. However, the diglossic situation in Tunisia, and in the Maghreb countries in general, rests upon the existence of two linguistic forms exhibiting considerable linguistic differences. On one hand, the Tunisian Dialectal Arabic (TDA) is the spoken form, and is the vehicle for the Tunisian socio-cultural heritage transmission. On the other hand, the written form, Modern Standard Arabic (AMS), assumes the role of institutional and literacy language. This particular situation requires a specific educational framework different from the classical bilingual-bicultural approach. We hypothesize that without taking into account Tunisian Dialectal Arabic, learners will not access the Tunisian hearing culture. This situation will potentially hinder literacy development in Modern Standard Arabic. Our article puts forward a trilingual-bicultural educational model adapted to the Tunisian diglossic situation. It includes TSL, and written ADT, as representatives of the deaf and hearing cultures which will both contribute to a more fluid development in a third language, written MSA, as the literacy language.

Keywords: trilingual-bicultural model, bilingual-bicultural education, Tunisian diglossic context, Tunisian Sign Language, Tunisian dialectal Arabic, modern standard Arabic (MSA)

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1 INTRODUCTION

D/deaf literacy[1] development research stresses the significance of developing adequate language skills in the written form to foster deaf integration into the educational and professional spheres (Musselman, 2000). Even if most deaf children succeed in developing functional communicative skills in sign language (SL), their social integration remains challenging due to the absence or lack of skills in the spoken modality. In these cases, literacy endorses a crucial role as the main portal of access to culture, education, and employment. Despite the crucial role of literacy as a main gateway for integration, the alarming illiteracy rates within deaf communities all over the world bears witness to the inadequacies of educational solutions and models aiming at deaf literacy development.

This very same social integration is even more complicated for deaf children in the Arab speaking context. The diglossic situation imposes a different path of linguistic development as well as different linguistic requirements for social integration. The existence of two languages in two different modalities, each fulfilling distinctive functions, makes it difficult for deaf children to access culture, education, and employment through the intermediacy of the literacy language only. This situation further contributes to higher illiteracy rates.

This article will first provide an overview of the deaf illiteracy situation in different contexts. Second, approaches to deaf literacy development will be discussed in terms of their theoretical backgrounds, pedagogic implications, and limitations. Third, an assessment of the applicability of the bilingual-bicultural approach implemented in terms of sociolinguistic pertinence to the Tunisian context will be presented. Finally, a more sociolinguistically sensitive trilingual-bicultural model will be proposed, drawing from the bilingual-bicultural model's theoretical premises, and extending its binary linguistic conceptualization to a trilingual-bicultural model. The model will then be discussed in terms of theoretical backgrounds, pedagogic implications, and limitations.

2 DEAF ILLITERACY

The history of Deaf education in several countries bears witness to the alarming illiteracy situation of deaf children as well as the various obstacles to education that the Deaf community experiences on a daily basis in the French-speaking countries (Gillot, 1998; Dalle, 2003; Niederberger, 2004; Balosetti, 2011; Hamm, 2012; Millet and Estève, 2012), English speaking countries (Traxler, 2000; Wilbur, 2000; Moores, 2001; Knoors and Marschark, 2014) and Arabic speaking countries (Hendriks, 2009; Al-Fityani and Padden, 2010; El Zraigat and Smadi, 2012; Trine, 2013). This deaf illiteracy is described as heterogeneous because it "takes on a variety of forms, ranging from a complete lack of ability to read, to a simple difficulty in grasping the nuances of a literary text" (Balosetti 2011, 47).

2.1 The Global Context

It is difficult to accurately define the number of deaf people in the world. According to the World Health Organization (WHO) there are 466 million people with disabling hearing loss (over 40 dB in the better ear for adults and 30 for children). However, this number does not outline any distinction between born-deaf, pre-lingual deafened, and deaf or hard of hearing in adulthood. Another figure presented by the World Federation of the Deaf (WFD) is around 70 million deaf people worldwide. About 80%

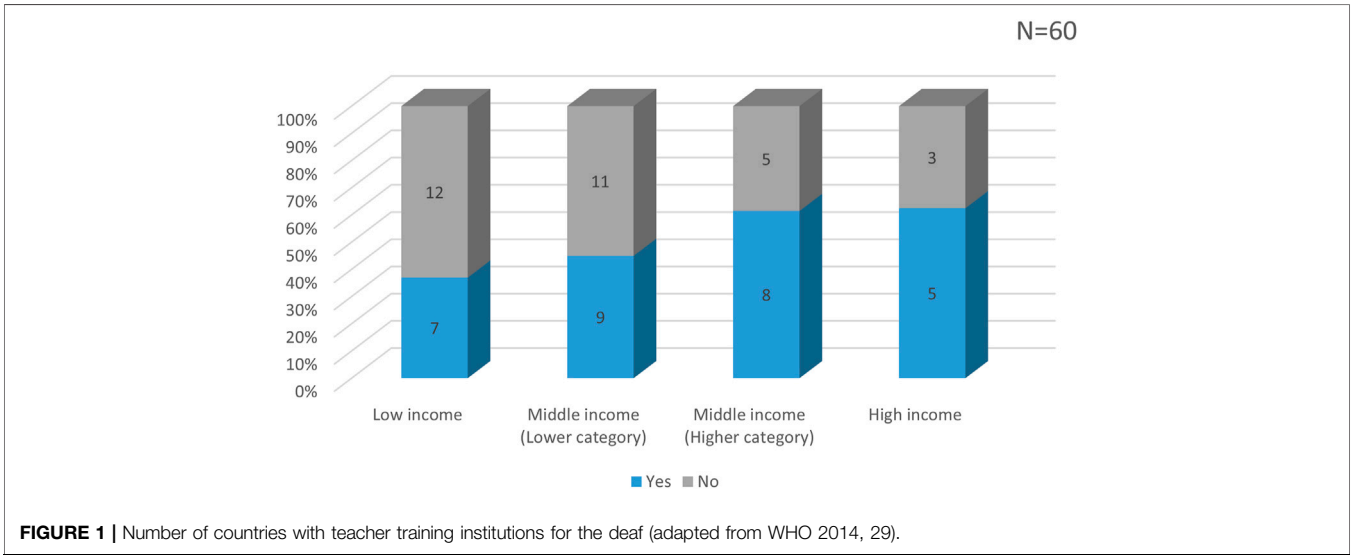


FIGURE 1 | Number of countries with teacher training institutions for the deaf (adapted from WHO 2014, 29).

of them, or 56 million, do not receive any education. Even when the lucky ones (20%) have the opportunity to access to schooling, their level of education is low and illiteracy rates are high.

The WHO report (2014, 29) shows that: "The availability of training institutions for teachers of deaf students varies according to the income level of countries. 61.5 and 62.5% of participants among upper middle-income countries and among high-income

[1]The upper case "D" in expressions such as Deaf community and Deaf culture is used to refer to the socio-cultural component of the community. The lower case "d" is used to refer to the audiological aspect of deafness. The upper/lower case "D" in D/deaf education and literacy is used to underscore the cultural as well as the audiological components involved in D/deaf education.

countries, respectively, indicated that such facilities were available. These institutions existed in 37% of low-income countries and 45% of lower-middle-income countries that responded" (see **Figure 1**).

Despite the fact that the numbers provided by the WHO report are indicative of the average resources and efforts made by many countries to sustain an education by professionals capable of creating a bilingual school environment as stipulated in The Convention of the United Nations (UN) on the Rights of Persons with Disabilities and Optional Protocol (CRPD) in articles (2, 21.b, 21.e, 23.3, and 24.3b), these numbers (62.5% in the best cases) are based on the results of research in only 60 countries out of 194 WHO member states. This small number (30.92%) is not likely to stand as a representative of the world's deaf population, the majority of which, does not have access to adequate education.

In Africa, for example, Adepojou (1984) argues that in terms of service for D/deaf education, Nigeria is 200 years behind compared to Europe and the United States. In Morocco, Soudi and Vinopol (2019) state that: "no research has been carried out to validate the pedagogical approaches or strategies, therefore the education [of deaf and hard of hearing children] takes place without investigation, evaluation or thoughtful revision." In Tunisia, demonstrations by the deaf are increasing since 2011 to claim their right for employment and education. Indeed, the lack of data about the deaf population in the world makes attempts to assess the reality of D/deaf education around the world incomplete and sometimes even misleading.

2.2 Arab Speaking Context

Providing indicative figures for the proportion of the illiterate deaf in the Arab world as well as valid statistics on the education of the deaf in general is difficult given the lack of such extensive studies in the Arab world. However, the few studies on deaf children education in Arab countries are indicative of the general state of education of deaf children in this area.

In fact, the development of SL status differs widely between the Arabic-speaking and western context. This difference has an impact on the valuation of SL as well as its use in the education of deaf children. Even though SL has been recognized as a full-fledged language in the Arabic-speaking context, the extension of its legal recognition, unlike the western context, still has a long way to go (Broughton, 2017).

Broughton (2017) explains that the creation of deaf schools in several Arabic-speaking countries was not the result of an initiative by the Deaf community or of a structured governmental effort to spread SL through its formal structures but was mainly the outcome of Christian organizations' efforts targeting the education of deaf children in those countries. Such efforts led to the creation of deaf schools in Lebanon: the Lebanese School for the Blind and the Deaf in 1957; in Jordan: Institute of the Holy Land of Jordan for the Deaf in 1964; in the United Arab Emirates: the AI-Amal school for the deaf in 1979; in Egypt: the unit of the deaf in 1982. In the Arab Maghreb countries, the creation of educational establishments for the deaf was initiated by the French protectorate in the case of Algeria at the end of the 18th century (Colonial School of the deaf-mutes of Algeria, in 1887) or a century later by associations under the supervision of the government in the case of Tunisia (Tunisian Association for the Assistance of the Deaf, 1970) and Morocco (The Moroccan Association of Deaf Children, 1975).

More recently, the symbolic recognition of SL in Arabic-speaking countries did not provide it with the necessary support as a language of instruction in the educational context. On the other hand, the analogy between diglossic situation in the Arab speaking context (MSA/DA) and the existence of several Arabic sign languages raised further questions about the suitability of SL in the school environment. Compared to the western context where SL research has reached its maturation stage enabling the gradual incorporation of SL in the development of deaf teaching approaches and methods, SL research in the Arab speaking context is still at its incubation stage. Up to this stage, there are still no clear formulations as to the role of SL in D/deaf education in the Arabic-speaking context (Khayech, 2011).

Abdel-Fattah (2005) explained that the efforts to document and standardize Arab SL began to bear fruit in some Arab countries such as Jordan, Egypt, Libya, and Middle Eastern countries. However, the idea of creating a Unified Arabic SL (UASL) paralleling the diglossic situation in the majority language highlighted by Ferguson (1959) where a variety (L) would correspond to dialectal Arabic (AD) and national SL, has further impeded the development of SL as a language of instruction.

Several researchers also explained that the imposition of a UASL on Arab communities is counterproductive (Abdel-Fattah, 2005; Al-Fityani and Padden, 2010; Adam, 2015). On the one hand, because deaf Arab communities have difficulties understanding a standardized language that has poor lexical correspondence with the SLs they acquired and are using (Al-Fityani and Padden, 2010). On the other hand, the prescription of uniformity where there are already many naturally formed SLs reveals both a diminutive view of Arabic SLs and a potential threat to their continuity (Adam, 2015).

2.3 Tunisian Context

The scarcity of data on the deaf population in Tunisia makes a global assessment of the D/deaf educational situation, education methods, or the role of SL in such methods, a highly challenging task. Assuming that the official recognition of Tunisian Sign Language (LST) in 2006 endowed it with a certain legitimacy, it did not mitigate the perplexity as to its nature and its potential role in D/deaf education.

One of the very first attempts to define LST came in the form of rhetorical question by Khayech, (2011) explaining that the dearth of descriptive studies or linguistic research on LST as a stable and independent linguistic system with its own standards does not necessarily entail that it is not a fully-fledged language. In fact, most research aiming at the formal description of LST tend to concur on two main characteristics. The first is the authenticity of TSL as a carrier of the Deaf Tunisian cultural heritage "despite numerous borrowings, LST includes "Tunisian" signs on which there is no way to be mistaken as to their origin because they are quite cultural signs referring to the traditions, to the history of Tunisia and the customs of deaf Tunisians." The second

characteristic is the heavy borrowing from French Sign language (LSF) as well as from other sign languages such as the Italian Sign Language (LIS) and the Arab Unified Sign Language (LSAU) (Khayech, 2011; Mhimdi, 2018) due to the historical and cultural influence of these languages over the Tunisian deaf population.

The last large-scale study including data on deaf people and their schooling in Tunisia was provided by the Tunisian government in 2010 in the form of an initial report on Tunisia's compliance with article 35 of the International Convention on the Rights of Persons with Disabilities (CRDPH).

Article 7 of this compliance report entitled "Children with disabilities" reveals the schooling procedure for deaf children in Tunisia. According to the report, there is only one public establishment intended for the deaf in Tunisia in 2009 which includes 43 deaf children (see **Table 1** below).

TABLE 1 | Distribution of public special education and rehabilitation establishments by type of disability 2009 (Initial report on Tunisia's compliance with article 35 of the International Convention on the Rights of Persons with Disabilities 2010, 34).

Type of handicap	Number of institutions	Number of enrolled
Mental handicap	2	203
Auditory handicap	1	43
Motor handicap	2	119
Visual handicap	6	631
Total	11	996

On the other hand, there are two associations, under the supervision of the Ministry of Social Affairs, which have 51 centers including 2,664 deaf children. This equates to a total of 2,707 deaf children enrolled in 52 specialized centers for the deaf in 2009 (see **Table 2** below).

This report did not provide any informaton on the type, level of deafness, the criteria or process by which these children are admitted to these centers, the number of deaf children attending mainstream schools, the education methods used in these centers, or the reason why such associations are exclusively responsible for D/deaf education instead of governmental institutions. However, a comprehensive answer to such questions should first begin with a detailed depiction of the D/deaf educational landscape in the Tunisian context.

The education of deaf children in these centers is an exclusively oralist education even though LST has been recognized since 2006. The use of LST in the classroom is minimal or absent and teachers do not have any training in LST. Gagne and Coppola (2021) report these similar problems with emerging SLs where SL is not institutionalized either because an inferior sociolinguistic status, or simply because a lack teaching professionals fluent in SL. Such infrastructural problems are still underscored even in countries where SL instruction was institutionalized several decades ago (Dalle, 2003). Gagne and Coppola (2021) explain that in the case of emerging SLs, various environmental factors have a direct impact on the patterns of development. SL sustainment, institutionalization and dissemination are dependent on the size of the deaf population, the availability of SL in school, and the sociopolitical support for the provision of qualified teachers, interpreters, and the necessary resources.

In this sense Kayech (2011:5) explained that although: "The LST has been officially recognized since 2006. (. . .) the mechanisms for its dissemination and teaching are slow to be defined and put in place by the institutions because of its non-standardization, a *sine qua non* for its institutionalization many questions remain unanswered such as the training of teachers, the training of interpreters, the place of LST in the classroom and in teaching, etc." These same observations were attested 7 years later by Mhimdi (2018) in her investigation of the teaching methods in three education establishments for the deaf children in the capital city of Tunisia.

Although at the surface level this report acknowledges certain efforts and measures taken by the government for the right of Tunisian deaf children to education, a closer investigation may reveal that the D/deaf education situation in the Tunisian context is the least we can say chaotic. The Tunisian education system is not designed to accommodate or take into consideration the special needs of deaf students. In the first 6 years of primary education (6–12 years) deaf children are put into specialized schools before integrating mainstream secondary schools.

TABLE 2 | Distribution of special education and rehabilitation associations for the deaf 2009 (Initial report on Tunisia's compliance with article 35 of the International Convention on the Rights of Persons with Disabilities 2010, 35).

Auditory handicap			
Associations	**Centers**	**Sections**	**Number of students**
Association tunisienne d'aide aux sourds (ATAS)	38	37	2 049
Association pour la protection des sourds	13	13	615
Total	51	50	2,664

Contrarily to what the term "specialized schools" may suggest, there is nothing special about these schools. Deaf children are placed in ordinary classes regardless of their degree of hearing loss and sign language capabilities. They are taught in the oralist tradition with school programs, manuals, and teaching materials used in mainstream schools for hearing students. There is no consideration whatsoever to the needs that deaf children may need in such educational process.

Those special schools are not supervised or funded by the Tunisian ministry of education but by the ministry of social affairs who, in its turn, relegates the duty to the Association Tunisienne d'aide aux Sourds (ATAS) which is a non-

governmental organization funded by the ministry of social affairs. To sum up this seemingly complicated situation, the education of deaf children in Tunisia is simply relegated to a non-governmental association that has no clear strategy or methodology as to the instruction of deaf students.

The implications of this unusual situation are two-fold. First, the government view of deafness is a pathological view. This means that the ministry of education is not qualified to initiate any D/deaf educational endeavor. Secondly, the ministry of education has no obligation whatsoever in the design, supervision, and implementation of the educational programs designed for deaf children. Such situation resulted in not only the recruitment of teachers and education personnel that have no training, experience, nor theoretical backgrounds knowledge to deaf children education, but also the literal adoption of mainstream education programs due to the absence of any D/deaf education professionals able to design and implement such education programs.

The repercussions of this pathological view of deafness are significant at the level of LST recognition and propagation. Deaf children who are taught in the oralist tradition in specialized schools are not allowed to use LST in the classroom. Most teachers in these schools have little to no competence at all in LST. Observations from our preliminary field study of the Tunisian educational context in 2020 show that classroom instruction is implemented in the majority spoken language, although there is still a considerable amount of research and observation as to what spoken variety is used in those classrooms and the use of LST is restricted to informal conversations among deaf students outside the classrooms. Such oralist formal educational environment has not only inhibited and restricted the propagation of LST, but also relegated its use to informal environments where it is considered as a second-class alternative means of communication compared to the majority language.

After 6 years of pseudo specialized primary education, Tunisian deaf students are integrated to mainstream secondary schools after an evaluation made by a committee within the ATAS. However, there is no information pertaining to the criteria of evaluation upon which a deaf student is deemed as fit or unfit to integrate mainstream schools. Parents of deaf students are simply informed that their child is fit or unfit to joint mainstream schools with no further explanations. Given the type of oralist education given to deaf children in the specialized primary school, one can safely assume that the criteria of evaluation are mainly related to the child's proficiency in lip-reading, speech, and literacy in MSA. Competencies in LST are not likely to be part of these evaluations.

Upon integration to mainstream secondary school, deaf students are put in ordinary classrooms. Those classes encompass a vast majority of hearing students and one or two deaf students. Deaf students are not provided with any type of help and/or supervision. Instruction is provided through AMS, ADT[2] and French. In this situation, deaf students are not only confronted to the written form of AMS but also to another foreign language in its spoken and written modalities in core subjects such as sciences, math, and technology in an education program exclusively designed for hearing students.

Such a model of secondary school education cannot even be considered as an oralist model since the oralist model assumes, whether implicitly or explicitly, that the subjects of instruction are deaf students, whereas in the Tunisian situation the condition of deafness is utterly ignored and denied. Deaf students are taught by mainstream teachers in mainstream schools with hearing students with little or no effort to accommodate or adapt the educational program. Even if teachers wanted to help deaf minorities in the classroom, neither the classroom conditions nor their training would allow them to do so. Such integration strategies, if the word strategies can apply in such a situation, directly contribute to the deaf illiteracy situation in the Tunisian context.

Although this situation of deaf illiteracy as well as the results of the oralist approach are not statistically documented in Tunisia, several daily articles as well as demonstrations of the deaf in Tunisia testify to the failure of the current deaf schooling system. Indeed, an article published in 2012 by Tunis Afrique Presse (TAP) documents the organization of a workshop entitled "The educational system of the deaf child" by the international research institute in SL (ICHARA)[3] at its headquarters in Tunis. The article reports a statement by Mr. Zekri Lotfi, audio-prosthetist and audiologist, on the objective of the workshop which boils down to convincing the supervisory authorities of the need to adapt the education system to consider the specific needs of deaf children and make the necessary educational reforms. He explains that "The generalization of the same educational programs based on an 'oralist' method to all school children without considering their differences and the specific needs of each, would be an erroneous approach." Dr. Zekri Lotfi declares that in 40 years more than 40,000 deaf children have been educated in special schools and that only seven of them have been able to obtain a higher education diploma.

This need for educational reform for the deaf was clearly underlined in a demonstration organized by the deaf Tunisians on October 23, 2017, in front of the municipal theater of Tunis to call for their rights for employment and education. The President of the association "Ibssar" of leisure and culture for the blind, visually impaired and deaf individuals was present at the demonstration in support of the Deaf community's struggle for the application of the law number 2005-83 of August 15, 2005, related to the protection and promotion of disabled people.[4] He explained to the TAP agency that "The deaf demand the

[2]**AMS** Modern Standard Arabic is a high and standardized variety of Arabic existing mainly in its written form and assumes the role of institutional and literacy language in the Tunisian context. **ADT** Tunisian Dialectal Arabic is a low and non-standardized variety of Arabic existing mainly in its the spoken form and is the vehicle for the Tunisian socio-cultural heritage transmission. More recently, ADT began to emerge and spread in an Arabic script written non-standardized versions.

[3]The **ICHARA** Institute was created in 2011 with the aim of undertaking, organizing, and promoting research in sign language in Tunisia for the acquisition of knowledge and the development of communication and education for the deaf.

[4]NGOs in the Tunisian context are liable to include individuals with more than one clear-cut sensory handicap. Correspondingly, associative work and manifestations include more than one NGO. Moreover, NGOS such as ATAS that target deaf members can also have visually impaired members.

application of the laws related to their employment, public transport, and the dissemination of SL (. . .) as well as the development of an education program adapted to the deaf situation in Tunisia and in accordance with the international conventions and the 48th article of the Tunisian constitution."

3 APPROACHES TO DEAF LITERACY DEVELOPMENT

The history of schooling and educational policy for deaf children traces nearly one hundred years of dichotomy between supporters of the oralist and the bilingual method. The oralist method proponents prioritized spoken language and speechreading learning for an absolute assimilation of deaf individuals into the majority hearing community insisting that SL does not equip deaf individuals with the necessary cognitive skills that the spoken language bestows. Supporters of the bilingual method, on the other hand, insist on SL learning for an optimized literacy development in the majority language with the conviction that SL provides the necessary cognitive and metacognitive skills that are inaccessible through spoken language (Millet and Estève, 2012). This conflict was further amplified as it started to encompass ideological and religious dimensions (Cantin, 2016) and mutated into one of the central causes of deaf illiteracy in France due to the stigmatization of SL and its users (Grosjean, 2008; Grosjean, 2010; Balosetti, 2011).

3.1 The Oralist Approach

The earliest forms of the oralist approach emerged in Europe in the 17th century under the form of religious preceptorship with l'abbé Jacob Rodrigues Pereire. His goal was to teach nobility deaf children to speak relying on articulation and lip-reading techniques (Bedoin, 2018). Later that century larger scale oralist forms of education for deaf children issued from modest families were founded by d'abbé Deschamps in Orleans and spread throughout Europe. The oralist method reached its peak after the Milan conference 1880 which claimed the oralist method supremacy and banned bilingual education as well as the use of SL in deaf education for more than 100 years.

3.1.1 Theoretical Backgrounds

One key question instigated by Cuxac (1983: 89) in his discussion of ideological conflict between the oralist and the bilingual approaches was: "to what does an educational practice ow its appearance?" In this sense, it is important to note that the prevalence of the oralist approach at the 17th century was not a product of a rigorously designed scientific method, but a by-product of prevailing medical, political, religious, and philosophical ideologies. From a clinical-pathological perspective, deafness was viewed as a handicap that must be cured through various medical procedure and interventions so that deaf individuals become "normal." This very same pathological view is rooted in the Greek philosophy since 384 B.C where philosophers such as Aristotle claimed that thought is intrinsically linked to language and therefore it is impossible to reason without the ability to hear.

3.1.2 Limitations of the Oralist Approach

It is difficult to statistically report the results of the oralist approach in the 17th century for there was no statistical studies conducted at that time. However, the testimonies of several deaf students as to the limitations of the method are echoing through deaf literature at that time. Cuxac (1983, 46) reports the testimony of Allibert, a deaf student of Jean Marc Gaspard Itard explaining that after having subjected him to unsuccessful medical treatments for 5 years to restore his hearing, he undertook the task of his education. Alibert explains that despite all Itard's oralist based methods of instruction, he could not grasp the subtle nuances of the French language. As an ultimate solution, Itard sent him every day to M. Ferdinand Berthier to ask him for explanations in sign language.

More recently, research evidence from Gallaudet Research Institute, which has been collecting data on deaf students' academic achievement over last 50 years, indicates that deaf students are in general underachieving. Similar findings are persistent not only over time but also across countries. In their large-scale academic achievement testing of American deaf and hard-of-hearing students, Qi and Mitchell (2012) found that over 30 years, a wide gap still exists between American deaf students and their hearing counterparts. The same results were reported in Spain by Domínguez and Alegría (2009) who examined the level of reading competence in a sample of fourteen adults with a profound prelingual hearing. The results demonstrated that their reading level was comparable to hearing students at the end of primary education. In kenya, Sambu et al. (2018) reported that the academic performance of learners with hearing impairments in special schools remained below average and that few deaf pupils graduate to high school and within the expected time period.

Based on a general consensus that the reported poor academic achievement performances are not a direct consequence of hearing loss (Marschark, 1993; Moores, 2001; Niederberger and Prinz, 2005; Convertino et al., 2009; Hall, 2015), several scholars centered their endeavor on the potential paths of linguistic and metalinguistic transfer offered by SL as a medium of instruction in deaf classrooms. Several of these studies reported adequate and increased academic performance of deaf students when exposed to SL as a medium of instruction in bilingual educational contexts (Nover et al., 1998; Rudner et al., 2015; Holmer et al., 2016; Hrastinski and Wilbur, 2016; Scott and Hoffmeister, 2017; Sambu et al., 2018; Allen and Morere, 2020; Lillo-Martin and Henner, 2021).

3.2 The Bilingual Instrumental Approach

3.2.1 Theoretical Backgrounds

The second half of the 17th century marked a very important period in terms of the ideological conceptions of speech and its relation to thought (Moody et al., 1998). The certainty which has long been established by philosophers like Aristotle and Plato

begun to be called into question in the 17th century by philosophers and linguists like Antoine Arnauld, Claude Lancelot and Pierre Nicole who gave birth to new linguistic theories such as the General and Rationalized Grammar also known as "universal grammar" (Cuxac, 1983).

The first bilingual approach to D/deaf education saw the light in the 1760s with l'abbé de l'Epée who, through his exposure to SL, began to discover its complexity as well as its communicative effectiveness. He then understood that the linguistic and communicative bases offered by SL are not inferior to those provided by the spoken one and can be used for learning written French language (Cuxac, 1983; Moody et al., 1998).

More recently, research development in Second Language Acquisition (SLA) theories provided a scientific framework though which a functional form of deaf bilingualism could operate. This view of literacy language and L2 allowed the exploitation of SLA research and theories as pertinent theoretical framework under which the task of deaf literacy development can be approached scientifically. Cummins (2006) states that during language learning, a child acquires a set of implicit metalinguistic skills and knowledge that can be used to learn another language of the same modality. This Common Underlying Competence (CUP) provides the basis for the development of both the first language (L1) and the second language (L2). According to Cummins, the mastery of L1 can only support L2 learning if adequate exposure to L2 exists as well as the motivation to learn. Conceptual and cognitive knowledge acquired in L1 can then be used to facilitate the acquisition of proficiency in L2 (Nover et al., 1998; Hrastinski and Wilbur, 2016; Allen and Morere, 2020; Lillo-Martin and Henner, 2021).

3.2.2 Pedagogic Implications

The idea of language learning stratification (SL/written language/spoken language), in which SL plays both a role of L1 and a metalinguistic mediator, has contributed to the rise of SL in the D/deaf educational sphere.

More recently, the transposition of L2 learning theories to the D/deaf educational context has reinforced this functional role of SL. The application of Cummins' Common Underlying Proficiency model (1981, 2006) in a bilingual educational model for deaf children implied that the development of language skills in SL must imperatively precede the development of skills in literacy skills. SL is, therefore, seen as an instrument for developing literacy skills as well as a point of reference for explaining and comparing the way meanings are expressed in writing (Padden and Ramsey, 2000; Niederberger, 2004). Along the same lines, Swanwick (2016), Henner et al. (2016) and Allen and Morere (2020) argue that the development of SL skills should be recognized as an anchor for literacy skills development. Allen and Morere (2020) explain that the Possession of strong ASL skills contribute significantly to future academic success. Other researchers such as Holmer et al. (2016), Bogliotti et al. (2020) and Lillo-Martin and Henner (2021) explain that earlier access and exposure to SL input results in better language and academic outcomes. Conversely, delay in access and exposure to SL may result in cognitive delays and limited health literacy (Hall, 2015).

3.2.3 Limitations of the Bilingual Functional Approach

Although the bilingual functional model aims at optimizing deaf literacy development, it does not seem to foster a balanced bilingualism where learning both languages is of equal importance (Grosjean, 2010). SL learning in this context is restricted to an instrumental role serving as a linguistic platform through which the primary objective, literacy in the majority language, can be achieved. Literacy development is the only scale upon which the success of this form of deaf bilingualism is attested. In fact, such functional bilingual model raises several questions as to the nature of bilingualism it proposes. How can we restrict the assessment of bilingualism to the assessment of only one language? Can we qualify this type of pedagogic models as a bilingual model? Doesn't this model rather suggest a subtractive model of bilingualism (Dalle, 2003; Perini, 2007; Perini and Leroy, 2008; Garcia and Perini, 2010; Grosjean, 2010; Perini 2013)? Can we confine SL to such an instrumental function?

Numerous researchers transcended the linguistic aspects to explains that deaf bilingualism is not limited to the linguistic and metalinguistic aspects of language learning (Dalle, 2003; Ohna, 2004; Leigh, 2009; Maxwell-McCaw and Zea, 2011; Grosjean, 2010; Bedoin, 2018). Several socio-cultural and ethnolinguistic factors intervene in the learning dynamics of SL as well as the majority spoken language. The neglect of such factors can result in difficulty or even refusal to learn SL or the majority language.

3.3 Bicultural Bilingualism

3.3.1 Theoretical Backgrounds

Bicultural bilingualism is viewed as a multifaceted process that cannot be confined to its linguistic components. Grosjean (2010) and Leigh (2009) explain that the definition of bilingualism transcends the linguistic components to include the sociocultural and ethnolinguistic dimensions of language learning. As a definition of a bilingual-bicultural person, Grosjean (2010:137) outlines three distinctive features:

a) s/he participates, at least in part, in the life of two cultures (two worlds, two major cultural networks, two cultural environments) and this on a regular basis.
b) s/he knows how to adapt, partially or more extensively his/her behavior, attitudes, and language to a given cultural environment.
c) s/he combines and synthesizes traits from each of the two cultures.

In the same vein, the education of the deaf in the North American context has followed the same development path as in the French context. Drasgow (1993) explains that the purely scientific approach to D/deaf education has unrealistically broken the link between language and the culture it represents. A realistic approach to D/deaf education would therefore include the cultural component. Researchers such as Barnum (1984), McIlroy and Storbeck (2011), and Ritzmann and Gore (2019)

explain that exposure to Deaf culture is of utmost importance for deaf children in the educational context. Such exposure would promote self-acceptance and high self-esteem and promote the perception of deafness as a difference rather than a handicap. In fact, the cultural component is an indispensable element for a successful model of education where deaf students will perceive themselves as different but fully capable learners.

Garcia and Perini (2010) transcend the classic definition of bicultural bilingualism to suggest that deaf bilingualism is of a diglossic nature. In this model, the nature of the relationship between SL and literacy language is complementary and osmotic. The authors (2010, 75) explain that this type of diglossic bilingualism makes "two languages of a different modality and typologically very distant coexist in a very constrained and very specific way." These two languages "are functionally and almost exclusively distributed. The spoken form is the SL and written form is the written French." This definition of the complementary and integrative nature deaf bilingualism does not only account for the functional distribution of the two languages but also accounts for the potential influence that both languages may exert on each other due to their permanent contact.

This same diglossic conceptualization of deaf bilingualism, at least at the linguistic level, is also highlighted in the North American context by Connor and Greenberg (2021) in their adoption of the lattice literacy model for deaf and hard of hearing (DHH) children literacy development. In fact, Connor and Greenberg (2021) draw an analogy between the literacy learning situation in the Arab world where children with typical hearing are confronted to a literacy language that is phonologically, syntactically, and semantically different from the majority spoken language, with the situation of DHH American children whose spoken language (ASL) is different from the literacy language (written English). Connor and Greenberg (2021) explain that even children who are fluent in ASL are confronted with the barrier of not knowing written English phonology, grammar, and vocabulary. However, unlike Garcia and Perini (2010) this diglossic conceptualization is of a purely linguistic nature.

To overcome the linguistic and modal disparities between ASL and written English that constitute major barriers to deaf literacy development, Connor and Greenberg (2021) put forward the lattice model for reading and literacy development. This model was initially developed for typically hearing children (Connor, 2016) and later adapted to reading development of DHH children. Based on evidence from previous research on reading for DHH as well as typically hearing children, this tripartite model attempts to explains how DHH children learn to read, identifies the potential restraints to proficient reading, and the instructional implications to overcome those restraints.

However, some theoretical underpinnings of the lattice must be approached cautiously. First, the linguistic and modal disparities outlined by Mayer and Wells (1996) between ASL and English making Connor and Greenberg (2021) assume that DHH signers have "to learn to translate ASL vocabulary and grammar to English vocabulary and grammar to be able to read written English" is a forcingly restrictive view SL, bilingualism, and the linguistic, cognitive, metacognitive, and sociocultural processes underlying SLA. Cummins (2006) asserts that cognitive and conceptual knowledge is as relevant to the development of literacy as the linguistic knowledge. He explains that the deaf child, like any other child, relies on his prior knowledge in the interpretation or production of written words. Cummins (2006) explains that L2 learning is not limited to the level of linguistic transfer as perceived by Mayer and Wells (1996), but it extends conceptually and cognitively. Indeed, a deaf child whose conceptual knowledge in SL as L1 is well developed has more cognitive abilities to bring to reading or writing in L2. Accordingly, DHH children do not simply proceed to a mere translation of ASL to English vocabulary and grammar (Nover et al., 1998; Hrastinski and Wilbur, 2016; Allen and Morere, 2020; Lillo-Martin and Henner, 2021).

Additionally, the psycho-social treatment of deafness in Connor and Greenberg's model seems to be primarily rooted in audiological deficiency premises rather than Deaf cultural premises. In fact, the social skills as well as social development of deaf children within a majority hearing community do not conform with patterns of typically hearing children (Glickman, 1993, Glickman, 1996), moreover, the social development and identity patterns may differ from a DHH child to another. Pathological descriptions of social distancing from hearing peers described as a hallmark of spoken language deficiency by Connor and Greenberg (2021:58) may translate into one of several Deaf social identification stages (Glickman, 1993; Ladd 2003; Leigh 2009).

Finally, one particularly relevant characteristic underlined by Connor and Greenberg (2021) is that they draw an analogy between the literacy learning situation in the Arab world where children with typical hearing sensitivity are confronted to a literacy language that is phonologically, syntactically, and semantically different from the spoken language. In fact, this diglossic situation has, indeed, resulted in low literacy rates all over the Arabic world including the Tunisian context. However, these low literacy rates are not only the product of purely linguistic differences but also the product of the social and cultural "alienation" that Modern Standard Arabic (MSA) learning imposes on children in the Arab educational contexts (Haeri, 2009). Haeri (2009), Myhill (2014) and Saiegh-Haddad and Joshi (2014) suggest that education in Dialectal Arabic in the first few years of schooling is the most effective way to teach literacy in MSA and avoid students 'sociolinguistic alienation.

Now if we are to apply to the Tunisian deaf context the diglossic analogy used by Garcia and Perini (2010) in the French deaf context and by Connor and Greenberg (2021) in the north American deaf context, then Tunisian DHH children are faced with what we might describe as a double diglossia. Tunisian deaf children are confronted to a literacy language that is phonologically, syntactically, semantically, and socioculturally different from the majority spoken language which, in its turn, is different from TSL.

Another particularly relevant model for deaf literacy, more particularly writing, within the sillage of the bilingual approach is the Strategic and Interactive Writing Instruction model (SIWI) put forward by Dostal et al. (2015). Unlike Connor and Greenberg (2021), Dostal et al. (2015) model's starting point is

Deaf culture. The SIWI model views and places deaf learners in their sociocultural and sociolinguistic context for a tailored and culturally sensitive classroom instruction.

Within the SIWI model framework, deaf students are not constantly compared and evaluated according to the hearing majority standards but are viewed as a population with linguistic developmental patterns that are distinct from the majority hearing population. Those different developmental linguistic patterns inherently imply the provision of instructional and evaluation methods different from the majority hearing standards.

From a methodology point of view, Dostal et al. (2015) explain that the written tasks are initially performed in SL before proceeding to a linguistic and metalinguistic comparison to the written form of the majority language. From this perspective, deaf students do not only engage their SL competencies but also their sociolinguistic and Deaf cultural backgrounds and visions. The ideas and visions initially formulated in SL are then compared to the cultural and writing standards of the majority language. One major advantage of the SIWI model is that not only it allows in concrete terms for the linguistic and metalinguistic comparison between SL and the written form of the majority language, but also for an implicit/explicit comparison between Deaf and hearing cultural values and standards. Bilingualism in this model is not restricted to the formal teaching of linguistic aspects of SL and writing but it is further extended to encompass the Deaf and hearing cultural components to language learning.

This steady progression from SL and Deaf cultural anchors to the written form of the majority hearing culture may also reduce alienation effects that deaf students may encounter when confronted to an already cognitively demanding writing task. This view of classroom instruction in the mother tong is analogous to Haeri (2009), Myhill (2014), Saiegh-Haddad and Joshi (2014) and Hall (2015). However, it is worth mentioning that although Dostal et al. (2015) SIWI model acknowledges the differences in SL proficiency among deaf children, it does suggest any preliminary SL teaching for deaf children with limited SL proficiency due to language depravation. Thus, the initial production SL writing versions is likely to be challenging for those students. In fact, preliminary SL classes would constitute a guarantee for success of model.

3.3.2 Limitations

This bilingual-bicultural model was designed and implemented in western predominantly monolingual or multilingual contexts with a dominant majority language. Its objective of providing deaf learners with a simultaneous and dual access to deaf and hearing cultures entails that each culture is represented by one language and each language represents one culture. In the Western context, the relative similarity of the written and spoken forms of the majority language allows the written form to function as a portal of access to the socio-cultural heritage of the majority hearing community. However, this might not be the case in the Arab speaking context where the "one language one culture" model does not apply. The diglossic situation characterizing Arab speaking countries thereby makes the adoption of the bilingual-bicultural model inadequate.

Although this model provides sound theoretical frameworks at the linguistic and sociolinguistic levels, as well as empirical evidence of its efficiency in deaf students' literacy skills development, its generalization and application without adaptation to the trilingual Arabic speaking contexts might not produce the expected effects.

4 APPLICABILITY OF THE BILINGUAL BICULTURAL APPROACH TO THE TUNISIAN CONTEXT

4.1 The Tunisian Sociolinguistic Context

Tunisia is situated in the Western region of North Africa also called the Arab Maghreb region. It is bordered by Algeria to the West and Southwest, Libya to the Southeast, and the Mediterranean Sea to the North and East.

The Tunisian cultural and linguistic heritage are the product of the succession, intersection, and rivalry amidst an array of different cultures and languages. From the Phoenician settlement and the establishment of Carthage (12th to seventh century BC), the roman empire occupation for more than 800 years (146 BC-697), the Muslim conquest (697-1574), the Ottoman occupation for over 300 years (1574-1881) and French colonization (1881-1957), a myriad of cultures, religions, and languages rose, flourished, declined.

Today, the least we can say about the Tunisian linguistic landscape is that it is complex and multifaceted. In the following three subsections two of its major characteristics, namely diglossia and multilingualism, will be discussed in terms of linguistic practices, variation, and contact phenomena as well as in terms of the status relegated to each language and/or variety in Tunisian education, in general, and D/deaf education, in particular. The final subsection will outline the potential incompatibilities with the bilingual bicultural approach in the light of the linguistic particularities outlined in the earlier sections.

4.1.1 A Diglossic Landscape

Tunisia is a diglossic country where there are not only two varieties H(igh) and L(ow) of the Arabic language as defined by Ferguson (1959: 336), but several distinct varieties of Arabic:

1) Classical Arabic (CA): variety used in its spoken and written form exclusively in religious contexts.
2) Modern Standard Arabic (MSA) used in institutional, media, administrative and political contexts in its spoken and written forms and is often indicative of high educational status.
3) Tunisian Dialectal Arabic (ADT) used in its spoken form in informal contexts and often representative of lower social and educational status. Unlike CA and AMS, ADT is not standardized and exists predominantly in the audio-vocal modality. (Abdel-Fattah, 2005; Hendriks, 2009). More recently, ADT started to gain more significance and its usage in a written form based on the Arabic script began

to acquire acceptance in a "post-diglossic" Tunisian community (Walters, 2003).

In a more detailed description of the Arabic varieties existing in the Tunisian context, Daoud (2011) enumerates two supplementary varieties of Arabic existing in the Tunisian context which are: Literary Arabic (LA) and Educated Arabic (EA). Such classification is beyond the scope of the current article but is used as an example to highlight the multiple versions and nuances of Arabic existing in the Tunisian context compared to the Fergusonian binary model of diglossia.

4.1.2 A Multilingual Landscape

Along with to the pervasive diglossic situation, the Tunisian linguistic context is also a multilingual linguistic environment where at least three languages come into contact. French was introduced to the Tunisian context during the French colonization (by the end of the 19th century). It was not only established as the institutional language and its dissemination was reinforced and sustained through an education system that heavily relied on the French language as a medium of instruction. This resulted in 63,6% of the Tunisian population being bilingual in Tunisian Arabic and French (Valantin and Gonthier, 2007).

Daoud (2011) superimposes a situation of diglossia in the French language including two varieties of French on the already existing Arabic diglossic situation in Tunisia. The first variety is the Metropolitan French variety, considered as the high form, used by a particular community of Tunisians both inside and outside the family context. According to Daoud (2011) this variety exists mainly within families who include an expatriate or a native French speaking parent or parents who were educated in the French school system tradition and opted for a French school education for their children. It is therefore representative of a high socio-educational status. The second variety of French is labelled by Daoud (2011) as the North African French variety. This variety does not constitute a fully-fledged register, but different levels of usage for different communicative purposes. Daoud (2011:14) explains that these two varieties of French display "a diglossic range of use that somewhat parallels that of Arabic." However, this analogy might seem confusing given that the use of the two mentioned varieties does not comply to the classic diglossic rules of usage, neither do they allow for the rule of mutual exclusivity that is a main characteristic trait of classic diglossia (see **Figure 2** below).

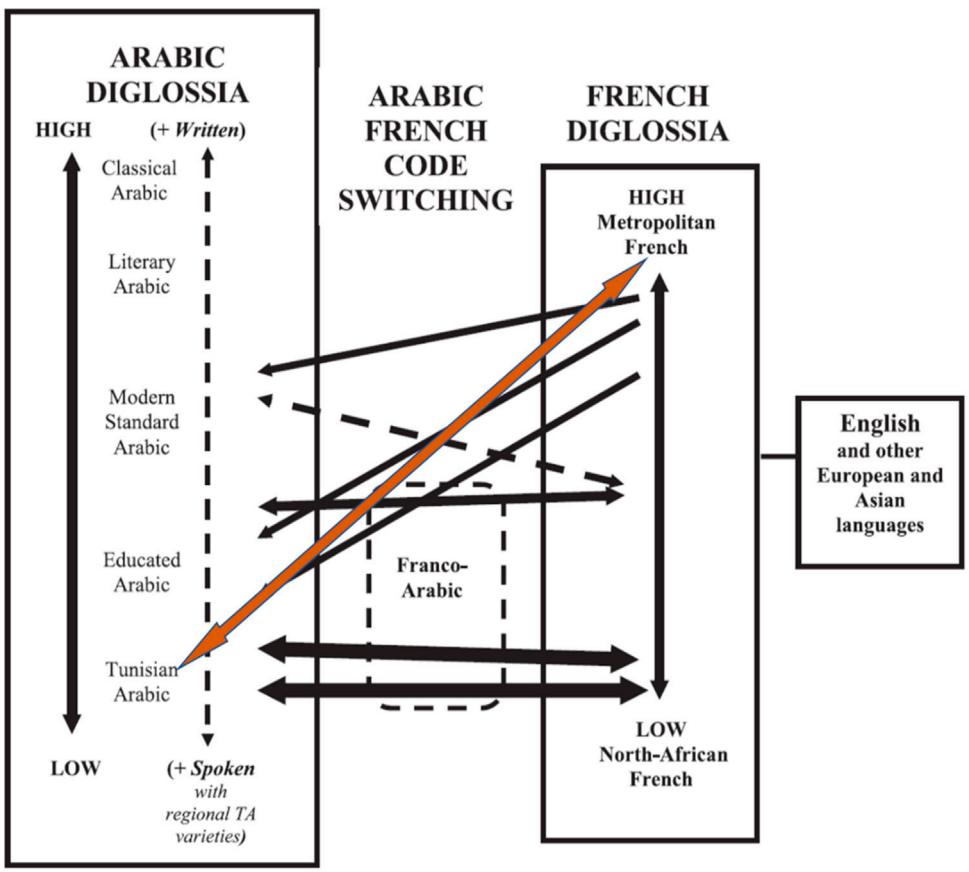


FIGURE 2 | Schematic representation of the current linguistic situation in Tunisia (Daoud 2011).

The existence of these two languages (Arabic and French) with their different varieties is accompanied with a heavy proportion of code-switching and code-mixing that extends beyond informal contexts to the educational and academic contexts where education in secondary school and university levels is oscillating between French and Arabic as media of instruction. Such interaction between the different varieties is displayed through Daoud's schematic representation of the current language situation in Tunisia. The representation seems to account only for instances of code switching and mixing between Tunisian Arabic and low North African French whereas code switching, and mixing seems to occur between higher varieties of Arabic and high metropolitan French.

Such schematization doesn't account for the situation where code switching and/or mixing occurs between Tunisian Arabic and high metropolitan French. Nevertheless, this is the situation of second and third generations of Tunisian immigrants to France who are only proficient in Tunisian Arabic and high metropolitan French, as they received an exclusively French education. This type of code switching, and mixing was added to Daoud (2011) model in a different color.

This linguistic landscape characterized by a high frequency of code switching and mixing is not restricted to the hearing community in the audio vocal modality, but it also extends to the Deaf community. In fact, the French colonization did not only result in a bilingual hearing community, but also in a bilingual Deaf community through the infusion of LSF in the Tunisian deaf context (Khayech, 2011). Mhimdi (2018) explains that the linguistic repercussion of the French colonization, namely bilingualism, was not restricted to the spoken language but also extended to sign language. She suggests an analogy between the status of the French language in the Tunisian hearing community and LSF in the Tunisian Deaf community explaining that code switching between LST and LSF is as frequent as that between ADT and French in the spoken modality.

In her study of code switching between LST and LSF, Khayech (2011) explains that LST displays a considerably high frequency of borrowings from LSF that it is in some instances virtually impossible to discern whether signs are in LSF or LST "The problem that arises in this type of contact is that the signs become ambiguous as to their origins and we find ourselves unable to judge whether it is really a sign of LST or rather of a sign borrowed from LSF." In the same sense, Mhimdi (2020) tried to establish a connection between LST and LSF through her observations of narrative skills of Tunisian deaf informants explaining that." According to the gestural production of the Tunisian narrative discourse, we can see that the deaf Tunisians have narrative skills similar to the French deaf. This shows the existence of a strong similarity at the level of gestural creation, based on a common process: the process of iconicization (Cuxac, 1983).

4.1.3 Status of LST, ADT, and AMS and Their Role in the Educational Sphere

The linguistic situation in the Tunisian context is complex, each language or linguistic variety plays a specific and exclusive sociolinguistic role to fulfill a distinctive function. This linguistic situation makes the linguistic development path of the deaf Tunisian child different and even more challenging than that of his western counterparts. Whereas in the western context the spoken and the written form of the majority language are sociolinguistically interchangeable, ADT and AMS are not.

ADT is situated at the lowest end of the Tunisian diglossic continuum and is the least prestigious variety of Arabic (Jabeur, 1999; Daoud, 2011; Khayech, 2011). This variety is not codified and exists predominantly in the audio-vocal modality. Although such definition by Tunisian linguistics suggests a low socio-cultural status of ADT, its sociolinguistic function is nonetheless of paramount importance. ADT is the sole linguistic vehicle of the Tunisian sociocultural heritage and identity. The first language that Tunisian hearing children and most deaf children come into contact with is the ADT[5]. It is through ADT that the hearing Tunisian culture and identity are built, sustained, and transmitted. Regardless of the socioeconomic or educational level, ADT usage encompasses the entire hearing Tunisian population.

However, this variety was excluded from the Tunisian educational sphere due to two main reasons. The first is of a socio-linguistic nature and is related to the low socioeconomic status that this variety is correlated with. The second reason is of a linguistic nature and is mainly related to the absence of codification and standardization. This absence of codification and standardization made ADT the least favorable candidate as a language of literacy compared to French and AMS.

Walters (2003) reports some wind of change as to the status of ADT explaining that there is an emerging new variety of ADT which is no longer stigmatized, and its written form is increasingly present in Tunisia. The manifestation of ADT writing begins to mark its presence in various contexts and for different purposes. Walters (2003) gives relevant examples of famous plays written in ADT using the Arabic script such as the play *Famiilya* (Al-Ja'aaiibii, 1997) and *Klaam Al-liil* (Al-Jabaalii, 1997), or the translation in ADT of the *Petit prince* from Saint-Exupery through which Balegh (1997) demonstrated that ADT could be used for literary purposes.

The recent changes at the educational and socio-cultural levels in the Tunisian context clearly demonstrate that Ferguson's classic definition of diglossia is no longer applicable to the Tunisian context which can be described as post-diglossic (Walters, 2003). The generalization of education as well as the inevitable contact between AMS and ADT led to the emergence of a new variety of ADT that not only exhibits an explicit convergence with AMS but which is also strong enough to project itself into the literary sphere.

[5]Ninety percentage of deaf children are born to hearing parents (Dubuisson and Grimard, 2006).

The AMS however, enjoys a high socio linguistic status as the language of literacy, education, and administration. As a highly codified and standardized variety, it represented the best candidate when decisions to assert the Arab Islamic identity were being formed in the Magrebin context. Such nationalist decisions of Arabizing education came as a means of distinguishing the Tunisian Arab culture that was being increasingly intertwined with the colonialist culture (Daoud, 2011). These hasty nationalist decisions (Daoud, 2011) had a deep negative impact in most Magrebin countries at least at the educational level due to a complete absence of a comprehensive language planning policy (Walters, 2003; Daoud, 2011). The primary goal of such decisions was of a glottopolitical nature rather than of a well-established language policy. Such policy was unable to dethrone French as a language of instruction at the university level as it remained the language of instruction for most of the scientific subjects. To sum up, although the AMS enjoys a high sociolinguistic status related mainly to political and nationalist endeavors, it is a language of literacy, administration, and political endeavors rather than a means of cultural transmission and dissemination.

The status of LST in the Tunisian context is at least complicated. At the surface level, LST seems to a well-established minority language. The Tunisian government recognized LST as a fully-fledged language in 2006, Tunisian news reports are translated in LST for deaf Tunisians, and the Tunisian initial report of compliance to the article 35 of the International Convention on the Rights of Persons with Disabilities (CRPD) highlights the efforts deployed by the Tunisian government to provide adequate education for deaf children.

Such initial inspection of the Tunisian context might put Tunisia as one of the most sensitive countries to deafness. However, except for news flashes translation, LST is completely excluded from the educational sphere. Its use is not allowed in formal educational contexts and its propagation seems to be inhibited by a hostile educational context.

The only contexts where LST seems to enjoy recognition and valorization is within Tunisian non-governmental organizations such as the Académie Sportive et Educative des Sourds de Tunis (ASEST). Such organizations not only promote LST usage within the Deaf community, but also within members of the hearing community who are in contact with deaf individuals. Hearing parents are offered LST courses to help them bridge and extend communication channels with their deaf children. The valorization of LST is part of a global valorization process encompassing the entire Deaf community's culture in the Tunisian context. The use of LST in such ONG's is not restricted to the communication process but it is extended as a medium of instruction in support study groups. Students who are encountering academic difficulties within the ATAS's specialized schools and secondary school's integration classes are taught different core subjects in LST.

It is important to note that communication in such classes is subjected to a wide range of linguistic variations due to the incorporation of LST. Students do not only display instances of unimodal and bimodal code switching but also instances of code blending (Khayech, 2011). As explained in Section 4.1, the Tunisian linguistic landscape is not only diglossic but also multilingual. This linguistic plurality created a profusion of linguistic contact phenomena in Tunisian deaf classrooms. Khayech (2011) delves into the characteristics of linguistic contact phenomena particular to the deaf Tunisian community in an endeavor to delineate the different instances of code switching and blending occurring among Tunisian deaf signers.

Khayech (2011) did not only identify instances of code switching from LST to LSF but also instances of intermodal code blending LST/Spoken Arabic and LST/Spoken French. She also stresses on the fact that these two linguistic practices are not mutually exclusive but can take place simultaneously. For instance, a deaf signer can display instances of code switching from LST to LSF and at the same time produce vocalized or labialized Arabic or French words. Such instances are outlined in her revised inter/intramodal continuum adapted from Estève (2006) (see **Figure 3** below).

Khayech (2011) model stands as a valuable attempt to the describe and categorize the various linguistic contact phenomena taking place in the Tunisian deaf context. Although the focal point of her study was to highlight the Tunisian multilingual deaf environment, one major component of this linguistic continuum

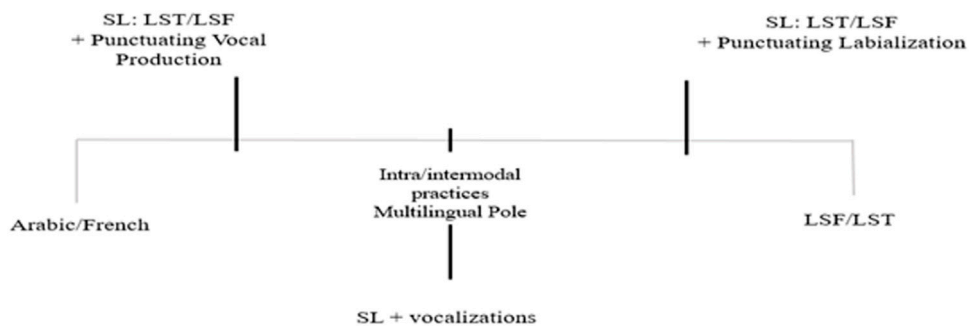


FIGURE 3 | Khayech (2011) inter/intra model continuum.

was not described thoroughly. This component is referred to as Arabic in the first end of her adapted continuum. In fact, variation at the first end of the continuum can be further extended to include AMS and ADT and the potential code switching that is likely to occur between French, ADT, and AMS. The figure below represents our proposition to extend Khayech (2011) inter/intra model continuum (see **Figure 4** below).

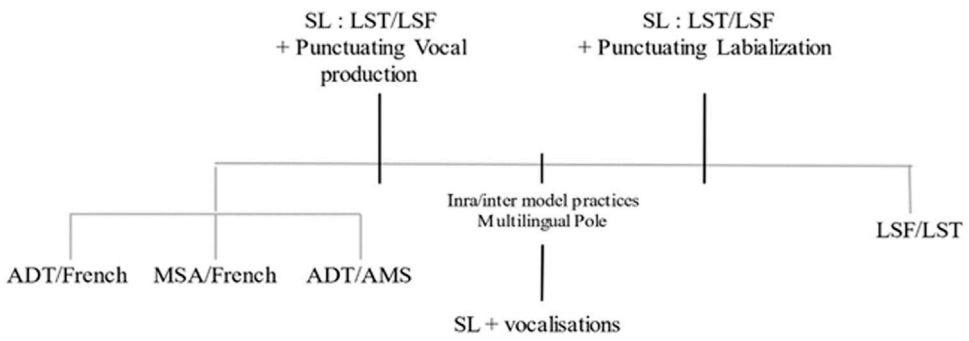


FIGURE 4 | Revised version of Khayech (2011) inter/intra model continuum.

Although the Tunisian educational system does not seem to acknowledge or to consider this plethora of linguistic variation in the deaf context, there seems to be the seeds of a bilingual-bicultural educational approach within non-governmental deaf organizations such as the ASEST. On the other hand, the absence of any D/deaf education professionals in those organizations makes the establishment of any scientifically based teaching method as well as the design of teaching/learning materials nearly impossible. In fact, the use of LST as a medium of instruction in deaf non-governmental organizations is not the product of scientifically based research but rather it is rather emerging from the conviction that LST is the natural language of deaf Tunisians and that the learning process is far easier with LST as a medium of instruction compared to the oralist approach that Tunisian deaf students are enduring rather than appreciating.

This situation of deaf learners in Tunisia is a reminder of what Allibert, the deaf student of Jean Marc Gaspard Itard, was experiencing in the French context in the 17th century at a national level. Our aim is not to depict a gloomy picture of the current Tunisian situation or situate the actual Tunisian deaf movement in the 17th century compared to its French counterpart, but it is to underline the urgent need for scientifically based educational interventions. Such interventions should be designed by D/deaf education professionals to support and orient such bilingual-bicultural emerging movements towards a culturally sensitive and efficient educational approach rather than proposing a mere reiteration of the western bilingual model that would potentially prove its inadequacy to the Tunisian deaf context.

4.2 Limitations of the Bilingual-Bicultural Approach in the Tunisian Context

The western bilingual-bicultural model is based on a relatively simple and stable monolingual linguistic situation (Harguindeguy and Cole, 2009) or a multilingual situation with one dominant official language. The conceptualization of this model implies the existence of three basic factors: 1) the existence of a hearing majority community using one dominant language, 2) the spoken form of the majority language community corresponds to the written form, and 3) the majority language in its oral and written form is a carrier of culture and, consequently, the two forms (spoken and written) constitute a gateway to the majority hearing culture. In this case, the spoken and written forms are interchangeable when it comes to providing direct access to the hearing majority culture.

The bicultural bilingual model represents a comprehensive and relevant theoretical basis for an educational approach that deals not only with the linguistic aspect of literacy development, but also the socio and psycholinguistic aspects. Nonetheless, its application, in its current form, to the Tunisian sociolinguistic context may prove unproductive due to linguistic, sociolinguistic, and psycholinguistic limitations.

4.2.1 Linguistic Disparities Between the Western and the Tunisian Context

For the majority deaf children born from hearing parents, the ADT is only partially accessible[6] and therefore cannot be considered as a mother tongue (Duhayer, Frumholtz, and Garcia, 2006; Delamotte, 2018). Nonetheless, ADT stands in the immediate environment of the Tunisian deaf child as a representative of the majority hearing culture. Delamotte (2018) explains that deaf literacy development is intrinsically associated to a process of acculturation in the majority hearing culture that the language represents. However, a question can be raised: what if this point of convergence between culture and the written form of the majority language ceases to exist? If the most obvious element, that is, the correspondence between culture and the

[6]ADT is visually accessible through lip reading.

written form of the majority language is no longer the operational basis for the bilingual bicultural approach? Is the application of the bilingual bicultural approach still possible in a context where the written form does not necessarily endorse the role of cultural representative?

The Arabic-speaking context in general, and Tunisian in particular, is a context where these questions are particularly relevant. However, before moving further in the discussion, it is necessary to note that the classical nomenclature of the "written" and "spoken" forms of the majority language is not applicable in the Tunisian context. In the western context, the spoken and the written forms correspond to one language. For example, the French language which is the majority language exists into two forms spoken and written. If we want to apply this nomenclature to the Tunisian context, the majority language would correspond to the ADT, the spoken form is the ADT and the written form is the AMS. It is also important to note that (ADT) is not a standardized variety and exists predominantly in the spoken form although more recently Arabic script based varieties of ADT started to gain momentum through media, arts, and literature (Walters, 2003).

The encounter of the deaf Tunisian child with the written form does not happen through ADT, which represents his/her initial linguistic contact with the hearing majority culture, but through AMS, a language different from ADT (Daoud, 2011). This linguistic disparity between ADT and AMS burns the bridges through which family and cultural values can be transferred from the spoken to the written form. This cultural transferability stands as an element of crucial importance in the conceptualization of the bicultural bilingual educational approach in the western context. In the Tunisian case, the spoken form is dissociable from the written form and the socio-cultural transfer between both forms marks its absence when Tunisian deaf children engage in a literacy development process.

4.2.2 Sociolinguistic Limitations

Tunisian deaf children initially evolve in a family and a social environment that exclusively uses ADT. Upon entering school, Tunisian deaf and hearing children are confronted to AMS, a language that is unfamiliar to them and that exists mainly in a written form. The written form in this case is not capable of using the community's social and cultural values that the spoken form stands for. From the first day of schooling, deaf children are confronted not only to a written form that is already problematic at the linguistic level, but also with literacy in a foreign language with which they have no socio-cultural connections.

The motivation for integrating the majority hearing community which is first built within the hearing family environment, and which increases as the environment of the deaf child expands (Grosjean, 2010; Delamotte, 2018) is only applicable to the spoken form in the Tunisian context. We can go as far as to assert that the written form in the context of deaf and hearing children in Tunisia can only retain an instrumental value. But unlike his hearing counterpart, the Tunisian deaf child still wonders about his deafness, his identity, and his family environment where deafness has already fragilized the primary identification between child and parents (Tardy, 2012).

From this sociolinguistic perspective, learning to write is no longer limited to the difficulties highlighted in the literature on cognitive aspect of language learning and the construction of a bilingual linguistic model through SL and the literacy language. In fact, the spectrum of difficulties is extended to include the weak socio-cultural representation of the literacy language which only increases the refusal of its learning within a conflict of socio-cultural representations.

5 PROPOSED TRILINGUAL-BICULTURAL MODEL

As explained in the previous section a classical bilingual SL/written MSA model in the Arabic-speaking context does not allow the access to the majority hearing culture, which can result in a more difficult and even unattainable literacy development process. The approach that we propose in this article assumes that the inclusion of a written form ADT based on the Arabic script as a language of learning and language to be learned along with LST in deaf Tunisian classes will result in more effective and fluid literacy development process in ADT.

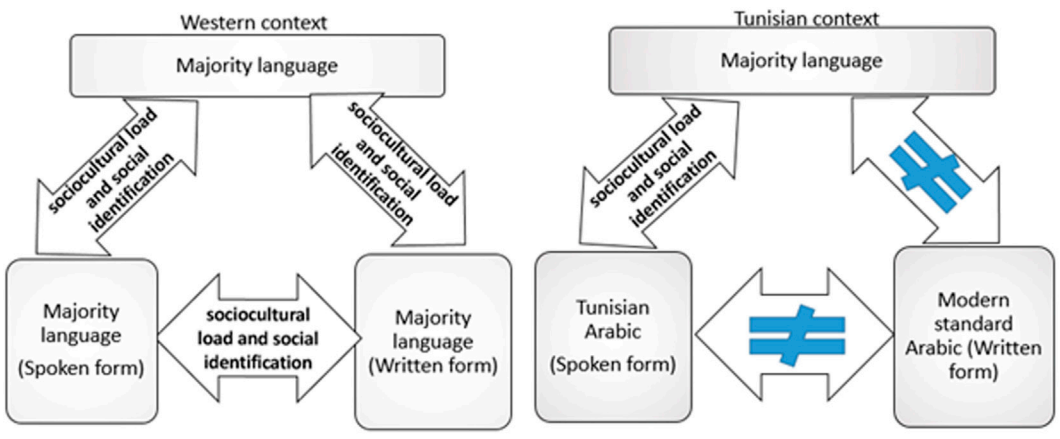


FIGURE 5 | Difference in the socio-cultural and social identification value of literacy language in the Tunisian and the Western context.

5.1 Theoretical Backgrounds

The bilingual-bicultural approach treats the linguistic as well as the socio-cultural aspect of language learning through the incorporation of two languages (SL and the written form of the majority language) on the basis that there is a direct correspondence between the written form of the majority language and the majority culture. This correspondence, which provides the literacy language the necessary socio-cultural load to stand as a representative of the hearing community, does not exist in the Arabic-speaking Tunisian context. As explained in **Section 4.1**, the spoken form exists predominantly in the spoken form and the written form is not representative of the hearing majority sociocultural heritage (see **Figure 5**).

The proposed model constitutes an attempt to bridge the gap between the western and the Arabic-speaking research in the design of a relevant D/deaf educational approach, an approach that takes into consideration the sociocultural components of the deaf and hearing communities to which the deaf child belongs to optimize literacy in a third language (written AMS) in the case of deaf children in the Arabic-speaking context.

5.2 Pedagogic Implications

The sociolinguistic contribution of this model is achieved through the inclusion of two languages, the minority language (LST) and the majority language written (ADT). This model offers the Tunisian deaf child the possibility of building a bicultural identity (Glickman, 1993; Dalle, 2003; Ohna, 2004; Leigh, 2009; Grosjean, 2010; Maxwell-McCaw and Zea, 2011; Dostal et al., 2015; Bedoin, 2018) along with development in a third language representing the literacy language.

In addition to the simultaneous identification, this model will allow a simultaneous exchange not only at the level of the relationship between LST and written ADT, but also at the level of the relationship between written ADT and written AMS as they share the same modality and script. In fact, due to this script similarity we might also expect a more fluid transition from written ADT to written AMS.

On the other hand, the relationship between LST and written ADT in this model remains relationship of a sequential bilingualism. L1 (LST) provides underlying metalinguistic and metacognitive and sociocultural basis (Nover et al., 1998; Niederberger, 2004; Rudner et al., 2015; Holmer et al., 2016; Hrastinski and Wilbur, 2016; Scott and Hoffmeister, 2017; Sambu et al., 2018; Allen and Morere, 2020; Lillo-Martin and Henner, 2021). At a second level, written ADT will play the role of a "linguistic bridge" to literacy development in AMS through a unified modality and script (Arabic script) (Hall, 2015; Belkadi, 2019).

This linguistic bridge method was designed to facilitate literacy development among illiterate women in Morocco in an educational project entitled "Advancing Learning and Employability for a Better Future" (ALEF). In this Moroccan American project, professionals in education and educational policies decided to exploit written dialectal Moroccan Arabic (DMA) and its potential transferability as a gateway for women's literacy in MSA.

The "bridge" literacy approach represents the first instance in the Arab world where mother tongue is officially approved as a medium of instruction targeting literacy development in MSA (Hall 2015). Although instruction in Dialectal Arabic was recommended by several scholars (Myhill, 2014; Saiegh-Haddad and Joshi, 2014). Hall (2015) summarizes the method used in exploiting DMA as a bridge to literacy in MSA as learning to identify and represent phonemes in DMA [. . .] using Standard Arabic orthography before transitioning to MSA grammar and vocabulary. Consequently, instead of using MSA as the exclusive language of instruction, students in Passerelle based literacy programs use their mother tongue as the primary language of communication and instruction in the classroom.

Hall explains that the bridging education method consisted in integrating DMA literacy education into the already existing government program to compensate for the linguistic and psychological gap that learners are facing in learning MSA. During the first phase of instruction "pre-literacy" phase that consists of 60 contact hours of class, adult women were taught how to correspond sounds in DMA to letters in the MSA alphabet. During the "pre-literacy" phase, women are taught a simplified version of the MSA writing system in which only the letters of the MSA alphabet and numbers are introduced. In the pre-literacy phase discussions about social topics are conducted in DMA students express their sociocultural knowledge through their mother tong to inductively elicit classroom material based on the interests and knowledge and social identification of learners. After the discussions, teachers present the MSA letter to be studied that session and ask students to recall words from the discussion that contain the sound represented by that letter. In the second phase, "literacy phase" of 300 h in which they complete two Standard Arabic primers of the normative government literacy program. One important sociolinguistic property of this approach as (Hall 2015) puts it, is that it breaks the shackles of culturally independent views of literacy and acknowledges both the cultural and linguistic contextuality of literacy development. The use of MSA as a learnt language as well as a primary medium of instruction in the discussion of MSA grammar and phonology allows learners to rely on the metalinguistic and metacognitive knowledge acquired in their mother tong as an L1, but also.

Hall (2015:64) reports that the 2-year pilot study 2005-2007 to evaluate the design and effectiveness of the Passerelle methodology in four regions of Morocco: Grand Casablanca, Chaouia Ourdigha, Meknès-Tafilalt, and Oriental showed not only better results in literacy development compared to the governmental programs, but also higher rates of enrollment: "During the first pilot year, 1,600 women participated in the study. During the second test year, enrollment increased to a total of 8,240 women. An evaluation of second test year of the Passerelle approach conducted in 2006–2007 showed that adult learners enrolled in Passerelle-based classes had higher retention rates and outperformed students who had been enrolled in the normative government program (Amrani, 2008)".

At the end of the ALEF Project, the Department for the Fight against Illiteracy (DLCA) of the Ministry of National Education released on May 13, 2008, in Rabat the results of the Passerelle approach literacy. The program concerned 10,000 women in four regions of the Kingdom. The results showed that the program

drop-out rate did not exceed 2%, while it was between 15 and 20%, on a national average in 2006–2007. The women who completed the 60 h of pre-literacy phase acquired a level of literacy similar to that obtained after 100 h of lessons in the regular program. This translates to a considerably higher efficacy rate of 40% compared to mainstreaming programs. Additionally, the attendance rate of students was found to be over 90%, while it was around 70% in conventional courses (Amrani, 2008). In 2007–2008 this bridging method was extended to the level of the Regional Academy of Education and Training of Grand Casablanca where 24,000 women are taking literacy courses based on the bridging approach. And at the end of 2009, the Ministry of education announced the adoption of the pre-literacy phase in its mainstream programs.

In the same vein, the proposed model in this article is not only based on SL's linguistic support for literacy development in AMS, but also proposes the integration on a written form of ADT as a medium of instruction in Tunisian deaf classes. This written version will provide students with the cultural support and identification and will also play the role of a linguistic bridge to literacy *in AMS*. In this scenario, transfer errors from LST to written AMS can potentially be reduced trough the mediation of written AD. This dynamic of complementarity where LST and written ADT come together in a single model may have more effective results at the linguistic and metalinguistic level than a binary linguistic approach that is restricted to LST for literacy development in AMS. The model below illustrates the expected dynamic between LST, written ADT and written AMS (see **Figure 6** below).

5.3 Feasibility

The empirical verification of the validity of the proposed model entails a longitudinal comparative study in literacy skills development between two deaf classes taught in the two different models. Given that the majority of deaf Tunisian school children enter the first year of school with little or no competence in LST, a 2-to-3-year instruction period in LST is necessary for them to build an operational linguistic and metalinguistic basis. After acquiring the necessary linguistic skills in LST students will then be introduced to ADT and MSA in their written forms. Another challenging task in this study will be the design of curricula, teaching materials, and testing instruments in both LST and ADT given the fact that both these languages are neither codified nor standardized. The design of such materials for at least 3 years of instruction will be necessary.

Although the design and implementation of such experiment may seem strenuous and time consuming, the major barrier to the implementation of the trilingual model is not of a scientific or infrastructural nature but it is rather of an attitudinal nature. In fact, the assessment of the empirical validity of a trilingual or even a bilingual model depends on two major factors. The first factor is the acceptance and endorsement of the LST as the language of instruction by the various actors in the education of deaf children as well as the parents of deaf children. The second factor is the existence well trained teachers who are competent in LST and who are willing and capable to create a trilingual school environment for Tunisian deaf children.

The Tunisian sociolinguistic context is not only complex but also loaded with attitudes and assumptions towards ADT and LST. Therefore, the application of any remedial educational approach to deaf literacy development should first begin with a preliminary study of attitudes toward an educational model including two languages that do not possess a written form and did not undergo any formal process of standardization.

Even though the Tunisian context constitutes a favorable ground for D/deaf educational reform, it is essential to explore the applicability of our model not only at the theoretical and

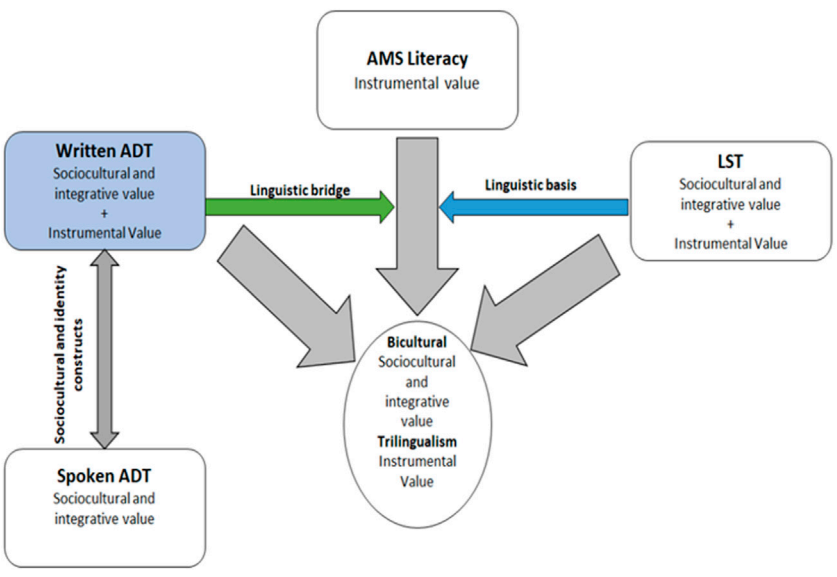


FIGURE 6 | The trilingual bicultural model.

scientific level, but also at the sociolinguistic and glottopolitical level. In fact, D/deaf educational reform in Tunisia must be conducted at two distinct levels. The first is the sociolinguistic level where attitudes of the different stakeholders in D/deaf education must be explored and analyzed extensively (Gardner and Lambert, 1972; Gardner et al., 1977; Gardner, 2000; Gardner and Masgoret, 2003). The second level is the scientific and pedagogic level which would support the creation of a D/deaf educational model adapted to the Tunisian linguistic context with its various linguistic peculiarities. Any reform attempt that fails to consider the sociolinguistic aspect as well as the linguistic ideologies revolving around the D/deaf educational sphere in Tunisia is likely to face partial or total failure.

In this respect, the history of western D/deaf education offers valuable lessons as to the struggle of science against linguistic ideology and glottopolitics. This fight has lasted for several centuries and does not seem to have an end. In this same fight against language ideology, D/deaf educational reform went from a total failure in the Milan conference in 1880 against a fierce monolingual protective language policy that reigned over the European continent, to partial success through the inclusion of the SL as a linguistic bridge in the case of the French context in 2006 under a more lenient language policy. Even under lenient language policies and with the empirical support of a multitude of empirical studies supporting the effectiveness of the bicultural deaf model, its generalization in the French context remains a subject of debate. In this particular case, we can safely assume that it is not the scientific component that stands as a barrier to a D/deaf educational reform in favor of a bicultural bilingual model, but the attitudes of stakeholders in D/deaf education in France. Consequently, the priority in this study is not only to support the theoretical and empirical validity of the proposed model but to examine a component that has not been sufficiently investigated by previous studies and which may constitute a major obstacle to the applicability of a trilingual bicultural model in the Tunisian context.

In fact, despite their scientific value, Western studies have partially succeeded in changing the D/deaf education landscape for the simple reason that D/deaf education and literacy development are not exclusively dependent on the scientific component, but they are also subjected to influence of language ideologies and policies. Such ideologies manifest themselves through the attitudes of the various actors in deaf children education. These attitudes are not only measurable but also scientifically exploitable when it comes to D/deaf education reform.

To conclude, the successful deployment of a trilingual bicultural model is not only dependent on the theoretical or even empirical validity of the model itself, but it is also strongly dependent on the attitude of the different actors in the education of deaf children in the Tunisian context. Correspondingly, any attempt to the application of D/deaf educational models targeting deaf literacy development in the Tunisian context should first begin with an analysis of the attitudes towards the languages that the model encompasses as well as an analysis of the potential linguistic ideologies governing the diglossic and multilingual Tunisian context.

6 CONCLUSION

Illiteracy seems to be a common denominator when it comes to the description of eastern and western deaf communities. However, this common problem does not always entail common solutions. The current article exposed the magnitude of the common illiteracy problem characterizing both eastern and western deaf communities as well as the different approaches to deaf literacy development in the western context. We showed that research in the western context is in favor of a comprehensive bilingual bicultural approach that enables a simultaneous cultural and linguistic development of the deaf child. We have also explored the limits of the bilingual bicultural approach in terms of its applicability to the Tunisian diglossic multilingual context.

Finally, a trilingual bicultural model based on the theoretical premises of the bilingual bicultural approach but adapted to the Tunisian sociolinguistic context is put forward and discussed in terms of scientific validity as well as in terms of attitudes towards languages and language varieties it encompasses. In fact, the application of such model might be relevant not only to the Tunisian deaf context, but also to other Arab Maghrebin countries such as Algeria, Morocco, and Libya where the pervasive diglossic situation seems to be one major shared linguistic characteristic preventing the applicability of a classical bilingual/bicultural D/deaf education. In fact, the potential generalization of the proposed model across Maghrebin countries may be appealing given their shared sociolinguistic backgrounds. However, a fully-fledged empirical analysis of language policies and attitudes towards SL, dialectal Arabic, and MSA in each country is of paramount importance to delineate and determine the ways in which such model can be deployed in each country.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

AN, LB, and NG contributed to conception and design of the study. AN wrote the first draft of the manuscript. LB and NG wrote sections of the manuscript. LB and NG contributed to manuscript revision, read, and approved the submitted version.

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Attitudes Toward Signing Avatars Vary Depending on Hearing Status, Age of Signed Language Acquisition, and Avatar Type

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The use of virtual humans (i.e., avatars) holds the potential for interactive, automated interaction in domains such as remote communication, customer service, or public announcements. For signed language users, signing avatars could potentially provide accessible content by sharing information in the signer's preferred or native language. As the development of signing avatars has gained traction in recent years, researchers have come up with many different methods of creating signing avatars. The resulting avatars vary widely in their appearance, the naturalness of their movements, and facial expressions—all of which may potentially impact users' acceptance of the avatars. We designed a study to test the effects of these intrinsic properties of different signing avatars while also examining the extent to which people's own language experiences change their responses to signing avatars. We created video stimuli showing individual signs produced by (1) a live human signer (Human), (2) an avatar made using computer-synthesized animation (CS Avatar), and (3) an avatar made using high-fidelity motion capture (Mocap avatar). We surveyed 191 American Sign Language users, including Deaf ($N = 83$), Hard-of-Hearing ($N = 34$), and Hearing ($N = 67$) groups. Participants rated the three signers on multiple dimensions, which were then combined to form ratings of Attitudes, Impressions, Comprehension, and Naturalness. Analyses demonstrated that the Mocap avatar was rated significantly more positively than the CS avatar on all primary variables. Correlations revealed that signers who acquire sign language later in life are more accepting of and likely to have positive impressions of signing avatars. Finally, those who learned ASL earlier were more likely to give lower, more negative ratings to the CS avatar, but we did not see this association for the Mocap avatar or the Human signer. Together, these findings suggest that movement quality and appearance significantly impact users' ratings of signing avatars and show that signed language users with earlier age of ASL acquisition are the most sensitive to movement quality issues seen in computer-generated avatars. We suggest that future efforts to develop signing avatars consider retaining the fluid movement qualities integral to signed languages.

Keywords: sign language, avatars, signing avatars, deaf, virtual humans

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INTRODUCTION

Virtual human avatars who use signed languages could improve digital infrastructure for accessing information, learning signed languages, or other aspects of signed interactions (Naert et al., 2020), especially in situations when face-to-face communication is not possible. Signing avatars could also help disseminate emergency-related information quickly and uniformly throughout a community in the case of evacuations, public health crises, or missing person alerts. While signing avatars are unlikely ever to match the responsiveness and natural movements of an actual human signer, signing avatars have potential benefits for increasing accessibility and use of signed languages in everyday life. For instance, the flexibility and interactive nature of signing avatars mean that an avatar's signing speed or appearance can be changed, content can be repeated on demand, and simple interactions can be programmed according to user needs. With sufficient development, signing avatars can allow semi-automated interaction, much like the ubiquitous customer service chat-bots which have become common in recent years. In this paper, we describe the results of a sizeable online rating study to examine the determinants of American Sign Language (ASL) users' responses to different types of signing avatars.

With appropriate scaling and development of digital tools, signing avatars could be used across various domains when live signers are unavailable or impossible to use. For instance, signing avatars could be used to translate content on a website automatically (Kennaway et al., 2007), translate educational content alongside a textbook (Adamo-Villani and Anasingaraju, 2016), provide time-sensitive information in public spaces (e.g., flight updates at an airport), or teach signed language lessons in virtual reality (Quandt et al., 2020). In these situations, the benefits of signing avatars over pre-recorded actual human signed videos include the ease of editing and automatic production of new signed information. However, sign language users are likely to have different opinions, or acceptance, of signing avatars in some spaces compared to others, and not all potential uses or engineering approaches of signing avatars will be worth the investment of research, time, and money. Additionally, some uses of signing avatars may be geared toward non-signers, such as using avatars for signed language instruction in virtual or mixed reality (Quandt et al., 2020; Shao et al., 2020), and developers creating avatars for different populations should be mindful of how different groups respond to different avatars. It is critical to note that the use of signing avatars may not be feasible, appropriate, or worthwhile in many situations (e.g., formal education, providing interpreting in face-to-face meetings; WFD and WASLI, 2018).

However, it is essential to identify the specific situations in which signing avatars can benefit and provide added value. Gaining a firm understanding of what makes a signing avatar comprehensible and likable will help guide future development in the field. Preliminary work has shown that deaf signers would welcome signing avatars in public locations where information-sharing is vital (e.g., train stations, hospitals; Kennaway et al., 2007). One area that could benefit from signing avatars is some health settings where patients share confidential information with a provider, such as during psychological assessments. Interaction with signing avatars in situations where a person may not want to divulge information to multiple parties would allow a signer to minimize the number of people involved in their care, which may ease discomfort in the presence of interpreters (Barber et al., 2010).

Developers can create signing avatars using several different processing pipelines. One of the significant distinctions between types of virtual human animation depends on whether the movement is based on recorded motion capture from actual human signers or whether the movements are based on computer-synthesized motions, programmed to result in signed language production. In the latter case of computer-synthesized motions, developers can use manual or automatic keyframe animation. Each of these engineering approaches has significant benefits and drawbacks (Gibet, 2018; Naert et al., 2020), and each approach has seen significant progress in recent years. Motion capture recordings tend to provide more realistic human movements (Alexanderson and Beskow, 2015; Quandt et al., 2020) but require costly investments of time to process and clean. Computer synthesized animations are more efficient since they can be programmed but result in a limited and less natural movement of the hands and reduced fluency in meaningful facial expressions. More recent innovations use machine learning to generate highly realistic signs from estimations of skeletal poses trained on existing video data (Saunders et al., 2020; Stoll et al., 2020). These newer animations are pushing the envelope of how accurate and realistic synthesized signing can look, and as such, it is more important than ever to assess how different factors affect end-users' views of signing avatars.

As signing avatars have continued to gain traction in recent years as a potentially powerful accessibility tool for signed language users, researchers have examined which intrinsic or extrinsic factors may contribute to how users perceive and accept the avatars. Intrinsic factors include characteristics of the avatar itself: appearance, type of movement, or facial expressions. Extrinsic factors that may impact receptivity or comprehension include the user's own fluency with a signed language, their attitudes toward technology, or their language and education history. Prior research has examined many of these factors (Kacorri et al., 2015) and identified specific factors which appear to be most important for predicting the reaction to signing avatars. Several prior studies have examined how signers perceive and rate signing avatars, using self-reported ratings and eye-tracking metrics (Huenerfauth and Kacorri, 2016). Prior work has shown that grammaticality ratings and natural motion can be associated with specific areas of eye fixation (Huenerfauth and Kacorri, 2016).

General attitudes toward signing avatars are best assessed in the context of other viable alternatives. For instance, one could compare signing avatars to written text or a video showing a human signer to examine how people react to different information-sharing modes in a specific context. One research study compared human and avatar signers who presented math problems to Deaf young adults and compared their performance and attitudes toward the signers (Hansen et al., 2018). While

participants all preferred the human signer, their mathematics performance was equal in response to questions posed by both signers. Users reported dissatisfaction with the avatar's lack of facial and body expression, and across many research studies, overall appearance and facial expressions are critical considerations for acceptable signing avatars.

Intrinsic characteristics of signing avatars themselves can influence how potential users respond to them. These aspects could include appearance, form, movement, or details regarding their production of signed language. Virtual human characters can range in appearance from highly realistic to highly stylized or cartoonish, and these appearances may impact users' reactions to the avatars. While appearance alone could impact users' comprehension of signing avatars, one study found that was not the case, and legibility was the same between highly realistic and stylized signing avatars (Adamo-Villani et al., 2015). However, comprehension is not the only important measurement for a signing avatar. People's emotional, holistic impressions of the characters may also be critical for successful interaction with a signing avatar, going beyond simply the need to comprehend signs. In the Adamo-Villani et al. study, users found the stylized avatar significantly more appealing than the realistic avatar, likely reflecting the effect of the uncanny valley (Mori et al., 2012; Shin et al., 2019). In another study, users preferred natural-style avatars over anime-style avatars (Brock et al., 2018). These subjective measures of preference and attitude toward avatars provide valuable insight into the multidimensional factors that impact avatars' success.

Extrinsic factors, such as the viewer's own language use and hearing status, may also contribute to the acceptance of and responses to signing avatars. Given the wide diversity of people who use American Sign Language, individual differences may profoundly change how people view and respond to signing avatars. For instance, prior work suggests that the language environment in which a sign language user grows up, or their level of fluency with ASL, may impact their likelihood of responding positively or negatively to signing avatars—for instance, more use and knowledge of ASL predicts harsher ratings of signing animations (Kacorri et al., 2015). The type of school that the signer attended also was correlated with subjective judgments of signing animation—attending a residential Deaf school (where everyone's primary mode of communication is signed language) was linked to harsher ratings of signing animations. Thus, both intrinsic and extrinsic factors are critical when developing and deploying signing avatars in any sector of society.

While other work has focused on either the intrinsic factors or extrinsic factors driving attitudes toward signing animations, here we attempted to identify both kinds of factors. For instance, if higher ASL proficiency is related to harsher criticisms of a signing avatar—is that true for different kinds of signing avatars?

Our research group has developed a motion-capture-based signing avatar for use in an immersive virtual reality ASL learning system. During development, we identified key features of the signing avatar that would teach users basic ASL signs (Quandt et al., 2020). Through prior work on signing avatars and embodied learning, we designed an ASL teacher avatar that has the following features (1) produce fluid, biologically plausible movements that resemble native ASL signers' movements as much as possible; (2) display the facial expressions critical to correct ASL grammar, in a manner as close as possible to a native ASL signer; (3) be aesthetically pleasing, falling at the right point on the cartoon-to-realistic spectrum of animation styles; and (4) present as an "ideal" ASL teacher—knowledgeable, competent, kind, and professional. Using these guiding principles, we sought to examine intrinsic and extrinsic factors contributing to users' reactions to signing avatars in the current study. For signing avatars to gain traction and acceptance in online or community spaces (e.g., signing avatars providing information in a train station), it will be critical to understand who will be most likely to attend to signing avatars, as well as identifying what features of the signing avatars will make them most successful.

Our pre-registered hypothesis was that signing avatars created from motion capture recordings would elicit more positive attitudes and impressions, higher comprehension, and more natural signing ratings than computer-synthesized avatars (https://aspredicted.org/3e5hg.pdf). We also examined how ratings of the avatars varied based on hearing status, age of sign language acquisition, and self-reported ASL fluency measures. Analyzing the data through these multiple types of analyses allows us to better understand the effects of hearing status, language environment, culture, and fluency—as they relate to signers' perceptions of signing avatars. Past work has suggested that both a signer's fluency and their language environs, such as whether they attended a residential school for Deaf children, affect how signers rate avatars (Kacorri et al., 2015). However, prior work has not gathered large datasets from a wide variety of signers rating different types of signing avatars. Given the tremendous amount of variability in ASL users' language backgrounds and cultural identities and the proliferation of different types of signing avatars, we designed a study to capture more of this variability. Based on prior work, we predicted that a younger age of acquisition and higher ASL fluency would result in less favorable views of signing avatars overall, whereas people who learn ASL later in life or are less fluent will be more accepting of, and give higher ratings to, motion-capture avatars.

To test these hypotheses, we conducted an online rating survey in which 184 ASL users rated two different types of signing avatars on an array of different dimensions, along with real human video control. We chose these three signers to sample the many possible signing avatars developed to date. We especially wanted to compare two different processing pipelines against a human benchmark, so we included one motion capture avatar (Mocap) and one computer-synthesized avatar (CS). We recruited a sample of raters from across the country, with a wide range of variations in ASL fluency, including deaf, hard-of-hearing, and hearing ASL users.

METHODS

ASL Signs

We selected eight individual ASL signs as the stimuli for this experiment: MILK, FRENCH-FRIES, TOILET, LIBRARY,

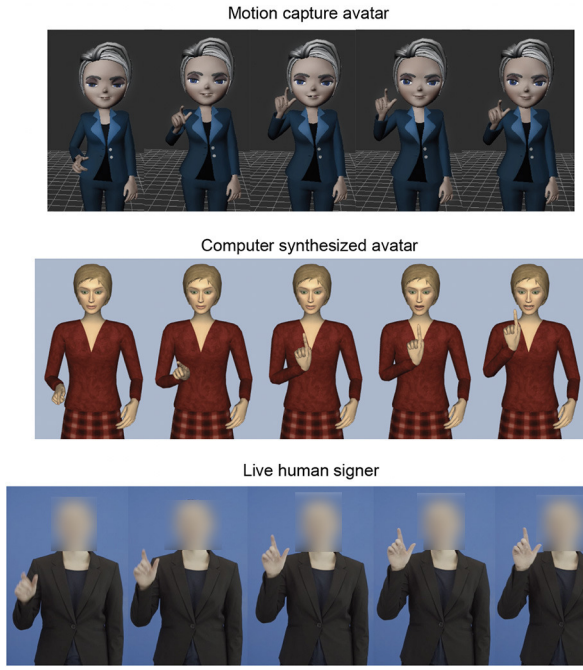


FIGURE 1 | The three Signers producing the ASL sign LIBRARY. Top: avatar created using motion capture (Mocap avatar); middle: avatar created using SigML coding on the JASigning system (CS avatar); bottom: human signer. For this figure, one still frame was captured every three frames starting from approximate sign onset.

SPAGHETTI, BACON, MUSEUM, and WEDDING (links provide corpus representations of the signs, Caselli et al., 2016). The first four signs listed are produced with one hand, whereas the last four are symmetrical signs produced using two hands.

Video Stimuli

We created three types of video stimuli for the experiment (see **Figure 1**). Example videos of the three stimulus types are available at: https://doi.org/10.6084/m9.figshare.16877131.v2.

Human Signer

A female native ASL user was recorded against a blue background, producing each of the eight selected signs with natural sign production and facial expression. Each video clip started with 0.5 s of neutral body pose with arms at side, and then she signed one word. The clip ended at the end of the sign.

Computer-Synthesized Avatar

The same female native ASL user recorded for the human stimuli also coded the eight signs for the CS condition. She coded the movements of the computer-synthesized signing avatar ("Anna" character), created by JASigning, to produce the same eight signs as above. She used SigML-based coding input, which relies on the Hamburg Notation System (HamNoSys; Elliott et al., 2004). We recorded the screen to obtain video clips of each sign production, and each clip started with 0.5 s of neutral body pose and ended after the sign was complete.

Mocap Avatar

We created the motion-capture signing avatar according to methods described in more detail in Quandt et al. (2020). The motion capture data was recorded using a 16-camera Vicon motion capture system (Vicon Industries, Inc., Hauppauge, NY) with a custom-built Faceware Pro HD Mark 3.2 Headcam (Faceware, Austin, TX) facial expression camera. According to industry standards, one hundred twenty-three markers were placed on the signer's body, with labeling managed by Vicon Blade. Twenty-five markers were placed on each hand to ensure fidelity of hand movement information. The same female native signer who created the other stimuli produced eight signs during motion capture recording. We created eight video clips in which each clip started with ∼0.5 s of a neutral body pose and ended after the sign was complete.

Task

Participants took the survey online. Study data were collected and managed using REDCap electronic data capture tools hosted at Gallaudet University (Harris et al., 2009, 2019). REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies. The presentation of the signers and the specific sign rating items was randomized, and two different forms were created with different randomized orders. All items mentioned here are presented in detail in the Variables section. At the start of the survey, participants completed an informed consent form approved by the Gallaudet University Institutional Review Board. Next, participants answered several sets of questions. Before seeing any stimuli, participants answered questions about their general interest in signing avatars. Next, they saw a brief clip of each of the three Signers producing a short phrase (e.g., "Nice to meet you") and rated their overall attitudes toward each Signer. In the next section, they saw the video clips of each Signer producing individual signs (described in section Video Stimuli). For each sign, they rated comprehension and naturalness. Following the individual sign ratings, each Signer was shown again, and participants gave ratings about their impressions of the Signer and rated them on several presumed characteristics. Finally, participants provided demographic information [birth date, sex, hearing status, preferred forms of communication, age of acquisition of ASL (Age of Acquisition), and self-reported fluency in ASL].

Participants

Participants were recruited via online advertising, and we compensated them with a gift card in exchange for their time. Participants self-reported their hearing status, and we used those responses to group the participants. Eighty-three deaf, 34 hard-of-hearing, and 67 hearing ASL users were included in the sample. **Table 1** shows participant demographics for each of the three groups. The table shows that Age of Acquisition and self-reported ASL fluency differed significantly between groups, with large effect sizes. On average, deaf participants reported the earliest Age of Acquisition and highest fluency with ASL. Hearing participants reported the latest Age of Acquisition, and *post-hoc*

TABLE 1 | Participant demographics for three groups and statistical comparisons between groups.

	Deaf	Hard-of-hearing	Hearing	$F_{(2,181)}$	*p*	eta2
N	83	34	67	–	–	–
Age of ASL acquisition, years. M (SD)	5.74 (6.57)	10.66 (6.34)	17.21 (8.88)	43.72	<0.001	0.326
Self-reported ASL fluency; 1–5; M (SD)	4.56 (0.68)	3.76 (0.86)	3.76 (0.89)	23.23	<0.001	0.204
Age; M (SD)	31.25 (10.81)	29.44 (8.25)	28.96 (8.59)	1.23	0.294	0.01
				χ^2		
Sex count; male, female, other	34, 47, 2	17, 15, 2	15, 50, 2	10.7	0.030	–

tests revealed the Hearing group had equivalent self-ratings of fluency as the Hard-of-Hearing group ($t = 0.021$, $p_{Tukey} = 1.00$).

Variables

A short introduction regarding signing avatars was presented: "*Virtual human characters can be made to communicate using signed languages. These "signing avatars" could potentially be used in many different areas of life. For example, a signing avatar may be able to translate spoken languages into sign language. In the future, you could see signing avatars when taking exams, watching the news, or when interacting with customer service.*" We then asked five questions regarding overall interest in signing avatars: *Signing avatars could be helpful...* (1)*...for understanding information on a website* [website]; (2)*...for communicating information in a public place (e.g., airport, train station)* [public place]; (3)*...as interpreters in a face-to-face meeting* [face-to-face]; (4) *I would enjoy seeing or interacting with signing avatars* [personal enjoyment]; (5) *Other people would enjoy seeing or interacting with signing avatars* [others' enjoyment]. These responses were given as 1-5 ratings, with Strongly Disagree as 1, Neutral as 3, and Strongly Agree as 5.

In line with our *a priori* predictions, we derived four new variables (Attitude, Impressions, Comprehension, and Naturalness) from the questionnaire by averaging responses to specific survey questions. The Attitude variable reflects averaged responses to the following, all of which were rated from 1 (strongly disagree) to 5 (strongly agree): *I would feel comfortable interacting with this signer*; *I would feel confident about receiving important information from this signer (e.g., news about COVID-19 or hurricanes)*; *I would trust the information I received from this signer*; and *I feel like I could share personal information with this signer (e.g., feelings, secrets, medical history).* Cronbach's alpha showed high reliability between the individual items that made up the Attitude variable for all three Signers [Human: 0.76 (CI: 0.70–0.81); CS: 0.91 (CI: 0.88–0.93); Mocap: 0.90 (CI: 0.87–0.92)].

The Impressions variable reflects averaged responses to the following, using the same 1–5 rating scale as above: *This signer signs like a fluent deaf signer*; *This signer would be a good model of ASL for people who are learning to sign*; *This signer has appropriate use of facial expressions*; *This signer has appropriate use of body language*; *This signer's movements look clear.* Cronbach's alpha showed high reliability between the individual items that made up the Impressions variable for all three Signers [Human: 0.83 (CI: 0.79–0.87); CS: 0.93 (CI: 0.91–0.94); Mocap: 0.85 (CI: 0.81–0.88)].

In line with prior work (Kacorri et al., 2017), we calculated the Comprehension variable by averaging the responses to *This signing was easy for me to understand* for each of the eight individual signs produced by each signer. Cronbach's alpha showed high reliability between the individual items that made up the Comprehension variable for all three Signers [Human: 0.92 (CI: 0.90–0.94); CS: 0.94 (CI: 0.92–0.95); Mocap: 0.83 (CI: 0.79–0.86)]. The Naturalness variable was calculated by averaging the responses to *This signing looked natural* for each of the eight individual signs produced by each signer. Both questions used the same 1–5 rating scale described above. Cronbach's alpha showed high reliability between the individual items that made up the Naturalness variable for all three Signers [Human: 0.90 (CI: 0.88–0.92); CS: 0.98 (CI: 0.97–0.98); Mocap: 0.89 (CI: 0.87–0.91)].

As documented in our pre-registration, our analyses included within-group conditions based on the type of signer: Human signer, Mocap avatar, CS avatar. There were no between-group experimental condition assignments; however, we sorted the data into three groups based on self-reported demographics (Deaf, Hard-of-Hearing, Hearing). To conduct exploratory analyses, we also used the response to *What age were you when you first learned a sign language?* as the independent variable Age of Acquisition.

Analyses

We analyzed data using JASP 0.14 analysis software (JASP Team, 2021). To examine the factors influencing overall interest in signing avatars, first we ran a two-way mixed ANOVA with one between-subjects factor (Group: Deaf, Hard-of-Hearing, Hearing) and one within-subjects factor (Scenario: Website, Public Place, Fact-to-Face). We then ran an exploratory Spearman's correlation between Age of Acquisition and overall attitudes toward signing avatars. We included the factors of Age of Acquisition, Website, Public Place, Face-to-face, Personal enjoyment, and Others' Enjoyment. Using a correlation allowed us to examine the continuous variable of Age of Acquisition to answer whether increasingly later Age of Acquisition is associated with any specific changes in interest or enjoyment of avatars.

To examine between-group differences and test our pre-registered predictions, we conducted a two-way mixed ANOVA with one between-subjects factor (Group: Deaf, Hard of Hearing, Hearing) and one within-subjects factor (Signer: Human, Mocap, and CS avatar) for each dependent variable based on our

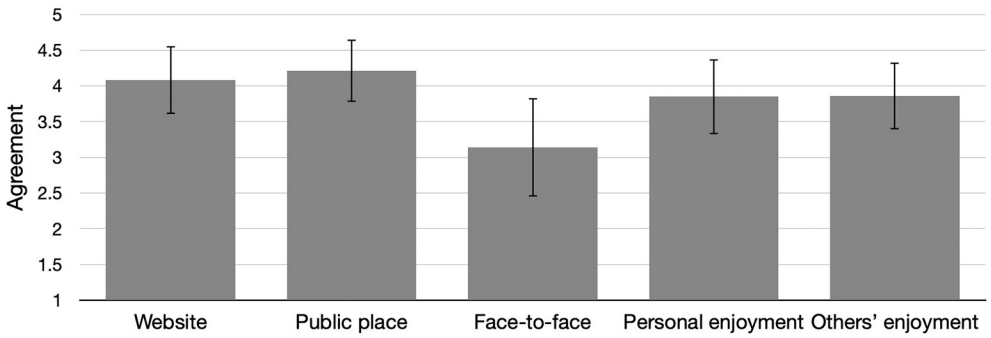


FIGURE 2 | Responses across all participants, on agreement that signing avatars could be helpful for understanding information on a website, communicating information in a public place, or acting as an interpreter in a face-to-face meeting. The fourth and fifth columns show average responses across all respondents to whether the respondent would enjoy or expect others to enjoy seeing or interacting with signing avatars. 1 = strongly disagree - 5 = strongly agree, for all variables. Error bars show standard deviations.

TABLE 2 | Spearman's correlation between age of acquisition and overall acceptance of signing avatars.

Spearman's correlations							
Variable		**Age acq.**	**Website**	**Public place**	**Face-to-face**	**Personal enjoy**	**Others enjoy**
1. Age acq.	Spearman's rho	—					
2. Website	Spearman's rho	0.065	—				
3. Public place	Spearman's rho	0.030	0.408***	—			
4. Face-to-face	Spearman's rho	0.116	0.377***	0.178*	—		
5. Personal enjoy	Spearman's rho	0.190**	0.498***	0.374***	0.395***	—	
6. Others enjoy	Spearman's rho	0.170*	0.413***	0.383***	0.274***	0.566***	—

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

a priori predictions (Attitudes, Impressions, Comprehension, and Naturalness). Our data did not match the assumption of sphericity for these ANOVAs, so Greenhouse-Geisser-corrected *p*-values are shown for all analyses to account for this violation. To conduct an exploratory analysis on the relationship between Age of Acquisition and the ratings of the different signers, we conducted a Spearman's correlation, including the Age of Acquisition, and Comprehension, Naturalness, Attitude, and Impressions scores for all three signers. As above, using a correlation allowed us to examine the continuous variable of Age of Acquisition in more detail.

We also conducted two-way mixed ANOVAs using the between-subjects factor of self-reported Fluency in ASL (from 1 to 5 with 1 being not at all; 5 being extremely). We excluded any respondents who answered "1" from the dataset. We conducted these ANOVAs on the four planned primary dependent variables. Finally, we conducted an exploratory two-way mixed ANOVA on the ratings of how "creepy" each signer was because creepiness has a close link to the extensive literature on the uncanny valley effect (Mori et al., 2012; Kätsyri et al., 2015) and is commonly identified as one of the limiting factors of interacting with humanoid characters (Ho et al., 2008; Inkpen and Sedlins, 2011).

RESULTS

Overall Ratings

Figure 2 shows the mean ratings across all participants for overall interest in signing avatars, both in three different scenarios, and the expectation of enjoyment for self and others. A two-way mixed ANOVA showed no significant differences between Groups on expressions of overall interest. There was a significant difference in interest regarding signing avatars in three different scenarios: Website, Public Place, and Face-to-Face [$F_{(1.67,\ 303.45)} = 58.16$, $p < 0.001$, eta2 = 0.12]. A Bonferroni-corrected *post-hoc* test revealed that Face-to-Face interest was significantly lower than either of the other two scenarios (*p*s < 0.001), while there was no difference between interest in Website or Public Place. The exploratory correlation between Age of Acquisition and overall interest ratings revealed a significant correlation between Age of Acquisition and ratings of personal enjoyment and others' enjoyment (see **Table 2**). In other words, people who acquired ASL later were more likely to express interest and enjoyment of avatars, whereas earlier learners reported less interest and enjoyment.

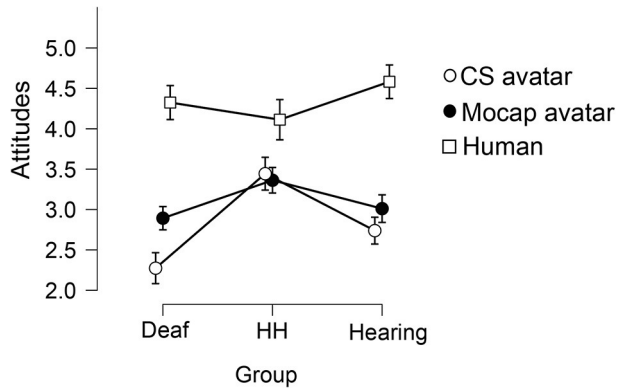


FIGURE 3 | Average ratings of Attitudes toward the three Signers, between three Groups. The attitude rating reflects a respondent's willingness to accept important information from the signer and willingness to share information with the signer (for details, see Variables). Ratings could range from 1 (negative attitude) to 5 (positive attitude). Error bars show 95% confidence intervals.

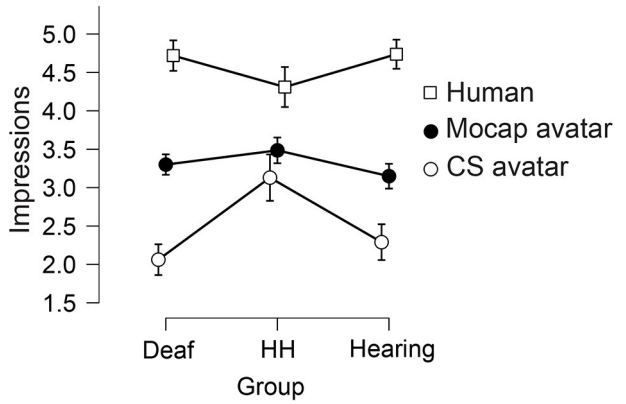


FIGURE 4 | Average ratings of Impressions of the three Signers, between three Groups. The impression rating reflects a respondent's overall judgments of the signer's ASL fluency, movement quality, and expressiveness (for detail, see Variables). Ratings could range from 1 (negative impression) to 5 (positive impression). Error bars show 95% confidence intervals.

Planned Analyses: Attitudes, Impressions, Comprehension, and Naturalness

A two-way mixed ANOVA was used to examine the effect of Signer type and Group on Attitudes, Impressions, Comprehension, and Naturalness. There was a small significant between-subjects effect of Group on Attitude ratings [$F_{(2, 181)} = 7.46$, $p < 0.001$, eta2 = 0.03], in which the Deaf group gave lower Attitude ratings overall (M = 3.17) than the Hard-of-Hearing group (M = 3.65) or Hearing group (M = 3.44). A Bonferroni-corrected *post-hoc* test revealed that while the Deaf group's Attitude ratings were significantly lower than the Hard-of-Hearing and Hearing groups ($p = 0.001$ and 0.03, respectively), the Hard-of-Hearing and Hearing groups did not differ. We observed a large significant within-subjects main effect of Signer [$F_{(1.72, 322.40)} = 185.764$, $p < 0.001$, eta2 = 0.32], in which the Human signer garnered the highest Attitude score (M = 4.40, SD = 0.617), followed by the Mocap avatar (M = 3.02, SD = 1.01), and the CS avatar garnered the least favorable Attitude score (M = 2.647, SD = 1.12). A Bonferroni-corrected *post-hoc* test revealed that Attitude ratings for all three Signers were statistically different from one another (all $p < 0.005$). We also observed a small significant interaction effect on Attitude ratings between Group and Signer [$F_{(3.56, 322.40)} = 9.03$, $p < 0.001$, eta2 = 0.03; see **Figure 3**]. A simple main effect follow-up test showed that the effect of Signer was significant for Attitude ratings of all three Groups (all $p < 0.001$). Simple main effects follow-up tests also showed that Attitude ratings varied significantly by Group for CS and Human Signers ($p = 0.001$ and 0.008, respectively), but not for the Mocap Signer ($p = 0.09$).

There was a small significant between-subjects effect of Group on Impression ratings [$F_{(2, 181)} = 3.47$, $p = 0.03$, eta2 = 0.008], in which the Hard-of-Hearing group gave higher Impression ratings (M = 3.65), while the Deaf group (M = 3.37) and the Hearing group (M = 3.39) gave lower ratings (see **Figure 4**). A Bonferroni-corrected *post-hoc* test revealed that the only significant difference between groups was that the Deaf group's Impression ratings were significantly lower than the Hard-of-Hearing group ($p = 0.036$), while other group comparisons were not significantly different. We observed a large significant within-subjects main effect of Signer [$F_{(1.67, 302.57)} = 278.00$, $p < 0.001$, eta2 = 0.46], in which the Human signer garnered the highest Impression score (M = 4.67, SD = 0.50), followed by the Mocap avatar (M = 3.28, SD = 0.05), and the CS avatar garnered the least favorable Impression score (M = 2.33, SD = 1.21). A Bonferroni-corrected *post-hoc* test revealed that Impression ratings for all three Signers were statistically different from one another (all $p < 0.001$). We also observed a small significant interaction effect on Impression ratings between Group and Signer [$F_{(3.43,302.57)} = 10.05$, $p < 0.001$, eta2 = 0.03; see **Figure 4**]. A simple main effect follow-up test showed that the effect of Signer was significant for Impression ratings of all three Groups (all $p < 0.001$). Simple main effects follow-up tests also showed that Impression ratings varied significantly by Group for CS and Human Signers (both $p < 0.001$), but not for the Mocap Signer ($p = 0.163$).

There was a small significant between-subjects effect of Group on Comprehension ratings [$F_{(2, 181)} = 4.67$, $p = 0.01$, eta2 = 0.012], in which the Hearing group (M = 3.86) gave higher Comprehension ratings, while the Deaf group (M = 3.57) and the Hard-of-Hearing (M = 3.61) group gave lower ratings. A Bonferroni-corrected *post-hoc* test revealed that the only significant difference between groups was that the Deaf group's Comprehension ratings were significantly lower than the Hearing group ($p = 0.01$), while other group comparisons were not significantly different. We observed a large significant within-subjects main effect of Signer [$F_{(1.39,250.96)} = 239.76$, $p < 0.001$, eta2 = 0.42], in which the Human signer garnered the highest Comprehension score (M = 4.62, SD = 0.56), followed by the Mocap avatar (M = 3.79, SD = 0.72), and the CS avatar garnered the lowest Comprehension score (M = 2.62, SD = 1.13). A Bonferroni-corrected *post-hoc* test also revealed that

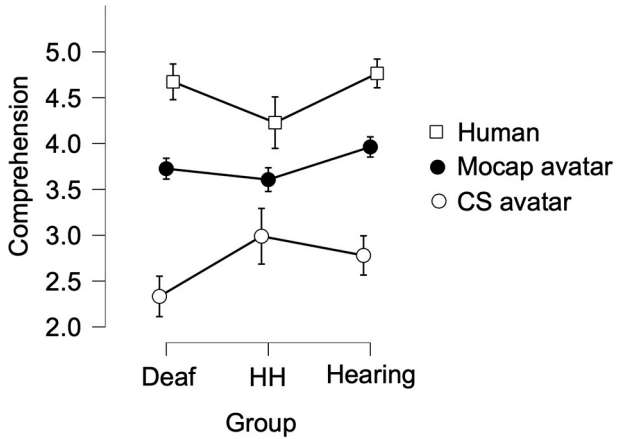


FIGURE 5 | Average ratings of Comprehension of the three Signers between three Groups. The comprehension rating reflects the degree to which the respondent could understand each of the eight signs produced by each signer (for detail, see section Variables). Ratings could range from 1 (did not understand) to 5 (easy to understand). Error bars show 95% confidence intervals.

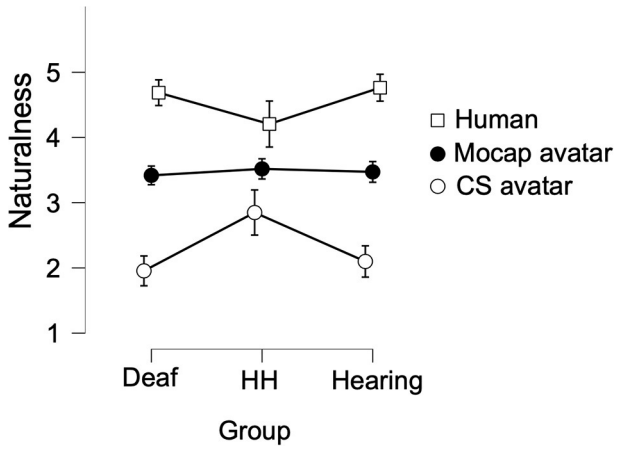


FIGURE 6 | Average ratings of Naturalness of the three Signers, between three Groups. The naturalness rating reflects the degree to which each of the eight signs produced by each signer looked natural (for detail, see Variables). Ratings could range from 1 (unnatural) to 5 (natural). Error bars show 95% confidence intervals.

Comprehension ratings for all three Signers were statistically different from one another (all $p < 0.001$). We also observed a small significant interaction effect on Comprehension ratings between Group and Signer [$F_{(2.77,\ 250.96)} = 6.72$, $p < 0.001$, eta2 $= 0.02$; see **Figure 5**]. A simple main effect follow-up test showed that the effect of Signer was significant for Comprehension ratings of all three Groups (all $p < 0.001$). Simple main effects follow-up tests also showed that Comprehension ratings varied significantly by Group for all three Signers: CS ($p = 0.006$), Human ($p < 0.001$), and Mocap ($p = 0.03$).

There was no main effect of Group on Naturalness ratings [$F_{(2,181)} = 1.062$, $p = 0.348$ eta2 $= 0.003$]. We observed a large significant within-subjects main effect of Signer [$F_{(1.59,287.42)} = 272.55$, $p < 0.001$, eta2 $= 0.45$], in which the Human signer garnered the highest Naturalness score (M $= 4.62$, SD $= 0.56$), followed by the Mocap avatar (M $= 3.46$, SD $= 0.87$), while the CS avatar received the lowest Naturalness ratings (M $= 2.17$, SD $= 1.28$). A Bonferroni-corrected *post-hoc* test revealed that Naturalness ratings for all three Signers were statistically different from one another (all $p < 0.001$). We also observed a small significant interaction effect on Naturalness ratings between Group and Signer [$F_{(3.18,\ 287.42)} = 8.54$, $p < 0.001$, eta2 $= 0.03$; see **Figure 6**]. A simple main effect follow-up test showed that the effect of Signer was significant for Naturalness ratings of all three Groups (all $p < 0.001$). Simple main effects follow up tests also showed that Naturalness ratings varied significantly by Group for the Human and CS Signers (both $p < 0.002$), whereas there was no difference based on Group for Naturalness ratings of the Mocap Signer ($p > 0.8$).

We conducted two-way mixed ANOVAs to examine the relationship between Fluency and ratings on the four primary dependent measures (see **Figure 7**). For all four dependent measures (Comprehension, Naturalness, Impression, and Attitude), we observed a significant effect of Signer, in results that echo the consistent findings throughout this study. The Human garnered the highest ratings for all measures, the Mocap Signer was next highest, and the CS Signer was rated lowest. Of particular interest here, we asked to what extent these ratings varied based on the rater's self-reported ASL fluency. There was a small significant interaction effect on Comprehension ratings between Fluency and Signer [$F_{(4.142,\ 211.496)} = 3.628$, $p = 0.006$, eta2 $= 0.02$]. As seen in **Figure 7**, a Bonferroni-corrected simple main effects comparison showed that for only the CS Signer, Comprehension ratings decreased with increasing fluency [$F_{(3,\ 12.37)} = 3.31$, $p = 0.021$]. There was a small significant interaction effect on Impression ratings between Fluency and Signer [$F_{(4.879,292.715)} = 2.33$, $p = 0.044$, eta2 $= 0.02$; see **Figure 7**], but simple main effects comparisons did not yield any significant findings. For Attitude and Naturalness, there was no significant interaction effect.

Exploratory Analysis: Creepiness

There was no main effect of Group on Creepiness ratings [$F_{(2,\ 181)} = 0.319$, $p = 0.727$, eta2 < 0.001]. We observed a large significant within-subjects main effect of Signer [$F_{(1.92,\ 483.25)} = 137.98$, $p < 0.001$, eta2 $= 0.31$], in which the Human signer garnered the lowest Creepiness score (M $= 1.46$, SD $= 0.98$), followed by the Mocap Signer (M $= 2.54$, SD $= 1.30$), while the CS Signer received the highest Creepiness ratings (M $= 3.61$, SD $= 1.35$). A Bonferroni-corrected *post-hoc* test revealed that Creepiness ratings for all three Signers were statistically different from one another (all $p < 0.001$). We also observed a small significant interaction effect on Creepiness ratings between Group and Signer [$F_{(3.85,483.25)} = 2.84$, $p < 0.026$, eta2 $= 0.01$; see **Figure 8**]. A simple main effect follow-up test showed that the effect of Signer was significant for Creepiness ratings of all three Groups (all $p < 0.001$). Simple main effects follow up tests also showed

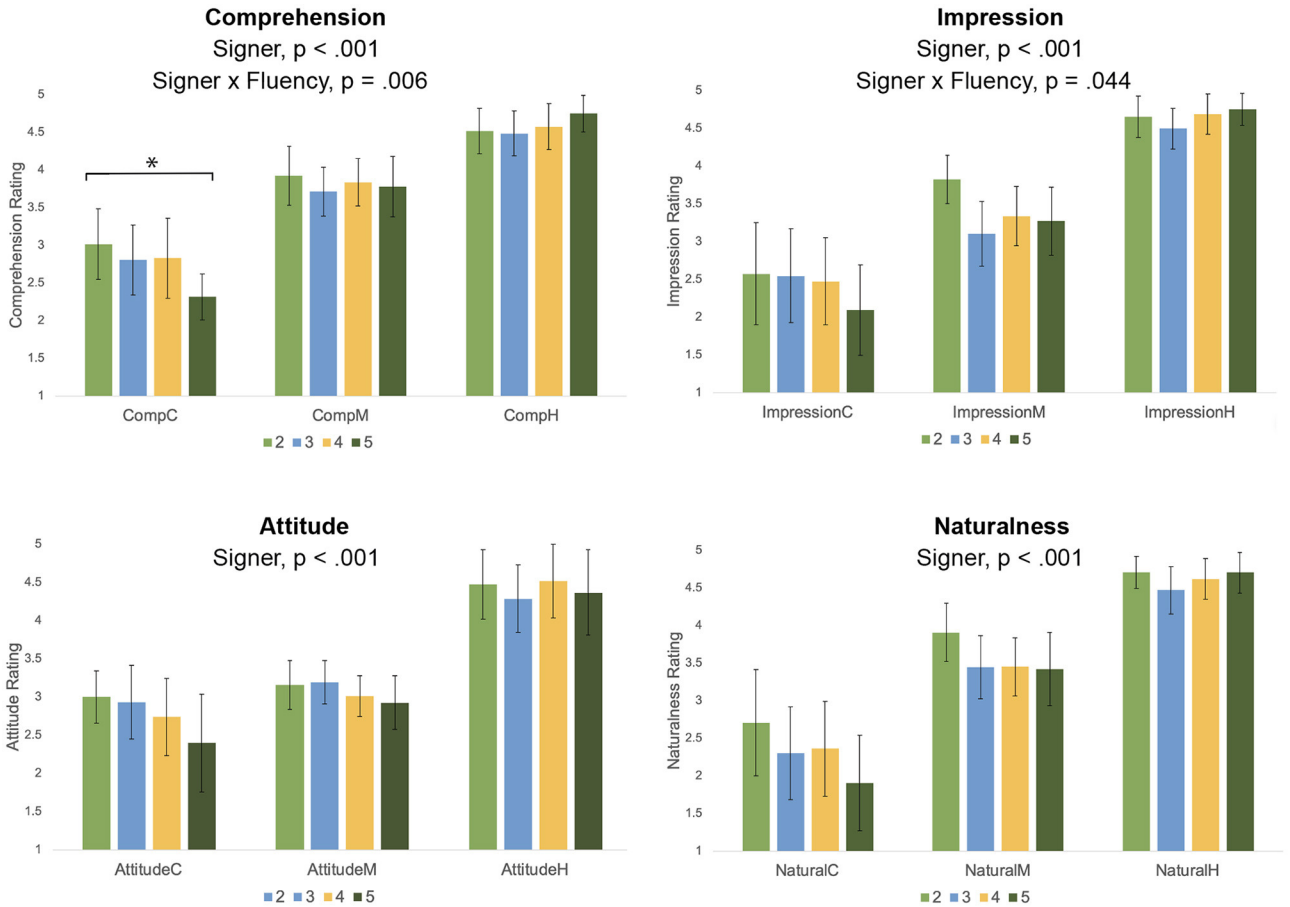


FIGURE 7 | Fluency ratings (self-reported 1 = not at all to 5 = extremely; respondents who reported 1 were excluded) and ratings on Comprehension, Impression, Attitude, and Naturalness, for the three types of Signers (CS avatar, C; Mocap avatar, M; Human signer, H). Error bars show standard deviations. Asterix represents a significant effect of Fluency on Comprehension for the CS signer only.

that Creepiness ratings varied borderline-significantly by Group for the CS Signer ($p = 0.045$), whereas there was no difference based on Group for Naturalness ratings of the Human or Mocap Signers (both $p > 0.1$).

Exploratory Analysis: Age of Acquisition

We ran an exploratory correlation between the four primary variables and users' Age of Acquisition to disentangle the age of ASL acquisition from Group membership and self-rated Fluency. The correlation showed that Age of Acquisition is significantly negatively correlated with Comprehension and Impression ratings of the Human signer; as the age of acquisition increases, the average Comprehension and Impression scores of the Human signer decreased (p-values of < 0.01; see **Table 3**). We also observed a significant positive correlation between Age of Acquisition and Attitude rating toward the Mocap avatar ($p < 0.05$). All four ratings of the CS signer (Comprehension, Naturalness, Attitude, and Impressions) were higher when the Age of Acquisition was later (p-values < 0.001). In other words, those who learned ASL later in life were more likely to give high ratings to the CS signer.

DISCUSSION

The current study's purpose was to understand better what determines ASL users' responses toward signing avatars, considering both group-membership based on hearing status, and language background. We also wanted to see how different types of signing avatars would be judged by a heterogenous sample of signers. We designed an online rating study to gather responses from a large, diverse sample of ASL users, gathering information about their responses to different types of signers, as well as information about their own language use. Our primary hypothesis was that signing avatars created from motion capture recordings would elicit more positive attitudes and impressions, higher comprehension, and more natural signing ratings than computer-synthesized avatars (https://aspredicted.org/blind.php?x=uv6m9w). We also predicted that earlier Age of Acquisition and higher self-reported ASL fluency would result in less favorable views of signing avatars overall than people who learn ASL later in life or are less fluent.

The results presented here reflect a diverse array of responses. Participants included signers across a wide range of ASL fluency

levels, and we gathered data from ASL users who were hearing, hard-of-hearing and deaf. The sample of participants was not limited to any one region or university, so it is unlikely that the cultural norms of a particular signing community are systematically over-represented. Taken together with the relatively large sample size, the wide variety of respondents means that our results may be more broadly generalizable than results from a study collected at a single location with a smaller sample size.

Overall Responses to Signing Avatars

We investigated in which situations people were most interested in seeing or interacting with signing avatars. We asked participants to rate whether signing avatars would be helpful for understanding information on a website or for communicating information in a public place, and on average, respondents agreed that signing avatars would be helpful in those situations (see **Figure 2**). However, compared to other scenarios, a signing avatar acting as an interpreter in a face-to-face meeting was rated significantly worse, which we did not find surprising due to face-to-face interactions' fluid and personal nature. These findings reinforce the notion that signing avatars hold the most promise—and stand to be most accepted by the community—in circumstances where rote, impersonal information is being shared (WFD and WASLI, 2018; Bragg et al., 2019). There was no significant difference between groups on these ratings. There were no significant relationships between Age of Acquisition and responses to the situation-related questions, suggesting that perceptions of helpfulness in different scenarios do not differ based on language background and hearing status. The correlation did reveal a higher likelihood of enjoying interactions with signing avatars as the Age of Acquisition increases (see **Table 2**), suggesting that later ASL learners are generally more open to signing avatars.

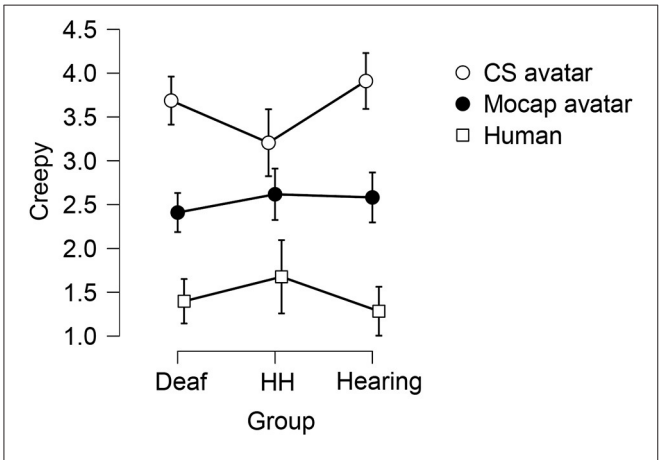


FIGURE 8 | Average ratings of the Creepiness of the three Signers between three Groups. The creepiness rating reflects the degree to which each signer was judged to be "creepy" (for detail, see Variables). Ratings could range from 1 (strongly disagree) to 5 (strongly agree). Error bars show 95% confidence intervals.

What Determines Responses to Signing Avatars?

Intrinsic Factors

In this study, we compared three types of signers: a human native ASL user (Human), an avatar created using computer-synthesized motion (CS Signer), and an avatar created using motion capture recording (Mocap Signer). We included these three signers to compare two examples of different types of avatars against a high-level control of a native human signer, whom we expected to garner relatively high ratings on all dependent measures. Across the four primary variables (Attitudes, Impressions, Comprehension, and Naturalness), respondents gave the human signer the highest ratings, the Mocap avatar the next highest, and the CS avatars the lowest ratings. For these four variables, the within-group differences

TABLE 3 | Correlation between age of acquisition and comprehension, naturalness, impression, and attitude ratings for the three signers.

Variable	Age acq.	CompH	NaturalH	AttitudeH	ImpH	CompM	NaturalM	AttitudeM	ImpM	CompC	NaturalC	AttitudeC	ImpC
1. Age acq.	—												
2. CompH	−0.20**	—											
3. NatH	−0.13	0.80***	—										
4. AttH	−0.08	0.55***	0.57***	—									
5. ImpH	−0.23**	0.69***	0.71***	0.53***	—								
6. CompM	0.07	0.35***	0.32***	0.28***	0.26***	—							
7. NatM	0.09	0.09	0.14	0.15*	0.04	0.71***	—						
8. AttM	0.17*	−0.22**	−0.12	0.10	−0.16*	0.40***	0.62***	—					
9. ImpM	0.03	−0.10	−0.03	0.11	−0.04	0.44***	0.65***	0.65***	—				
10. CompC	0.39***	−0.42***	−0.37***	−0.15*	−0.40***	0.38***	0.38***	0.50***	0.34***	—			
11. NatC	0.35***	−0.53***	−0.43***	−0.19*	−0.45***	0.15*	0.39***	0.52***	0.39***	0.84***	—		
12. AttC	0.39***	−0.44***	−0.36***	−0.13	−0.40***	0.11	0.39***	0.62***	0.42***	0.65***	0.77***	—	
13. ImpC	0.33***	−0.51***	−0.46***	−0.20**	−0.48***	0.12	0.34***	0.51***	0.43***	0.77***	0.85***	0.71***	—

*Asterisks denote p-value thresholds: * < 0.05, ** < 0.01, *** < 0.001.*

between Signers were quite large. These findings confirm our pre-registered predictions that signing avatars created from motion capture recordings would elicit more positive attitudes and impressions, higher comprehension, and more natural signing ratings than computer-synthesized avatars. On all factors, people rated the Human significantly higher than the Mocap avatar, suggesting that while they viewed the Mocap avatar more positively than the CS avatar, fluid motion alone is not sufficient to garner higher responses; visual appearance matters as well. Even when an avatar moves like a human, people respond less positively if it does not look human. Taken together, the differences between the avatars suggest that this Mocap avatar presented a significant advantage over the CS avatar, while at the same time, neither avatar is viewed as positively as a real human signer.

Attitudes, Impressions, Comprehension, and Naturalness each garnered similar patterns of responses. The Attitudes variable included questions about whether people would feel comfortable sharing or receiving information from the signer (see section Variables). Respondents had very positive attitudes toward the human signer (M = 4.40 out of 5), whereas they reported significantly less interest in exchanging information with either kind of avatar. The Impressions variable measured visual judgments of how the signer moved, looked, and signed (see section Variables). Respondents had very positive impressions of the Human's movements and signing (M = 4.67 out of 5), and the Mocap avatar garnered lower Impression responses, which were still significantly better than Impressions of the CS avatar. The Comprehension and Naturalness measures showed how well each Signer was understood and whether their sign production was natural or not. Both the Comprehension and Naturalness variables followed the same pattern again, with large significant differences between signers. Lastly, we conducted the exploratory analysis on Creepiness and found that as predicted, the CS avatar was judged as the creepiest, while the Mocap avatar was less creepy, and as expected, the Human signer garnered very low creepiness ratings. Taken together, we see resounding support for the predicted differences between avatars. We show that compared to the CS avatar, ASL users overall had more positive attitudes and impressions of the Mocap Signer, who they also found to be more comprehensible and natural.

Extrinsic Factors

We were particularly interested in how a person's own language background would influence their ratings of the avatars. Overall, we saw significant effects of Group on Attitude, Impression, and Comprehension, but no effect of group on Naturalness or Creepiness. The Deaf group gave significantly lower Attitude ratings than the other two groups. In contrast, for Impression ratings, the difference was driven by the Hard-of-Hearing group giving significantly higher ratings than the Deaf group. For Comprehension, the difference was driven by the Hearing group giving significantly higher ratings than the Deaf group.

Overall, we see that while hearing status is related to people's responses to signing avatars, the exact nature of that relationship varies depending on what type of characteristic they are judging. For example, the Hearing group's higher Comprehension ratings may reflect their lower ASL fluency, resulting in more forgiveness for unclear or unnatural movements because they lack the necessary knowledge to discriminate between different productions of a sign. In the current work, we had about half as many Hard-of-Hearing respondents ($N = 34$) as we did in the Deaf and Hearing groups. This smaller group size, as well as the wide range of experiences which may lead people to identify as hard-of-hearing (Luey et al., 1995; Israelite et al., 2002), means that the responses from this group are hard to interpret in comparison to either the Deaf or Hearing groups.

Intrinsic and Extrinsic Factor Interactions

To understand signers' feelings toward signing avatars more thoroughly, we also looked at interactions between intrinsic and extrinsic factors. Specifically, we asked how people's language background and hearing status are related to the ratings of the different types of signers. These analyses were motivated by the idea that more fluent signers, especially deaf signers, may be more sensitive to signing avatars' movement dynamics and facial expressions than people who are newer or less fluent users of ASL, as has been suggested by prior literature (Kacorri et al., 2015, 2017). We observed small but significant Group x Signer interactions for all four primary factors and the exploratory factor of Creepiness. Though many specific differences were driving the interactions (see **Figures 3**–**7**; section Planned Analyses: Attitudes, Impressions, Comprehension, and Naturalness), the Hard-of-Hearing group showed different responses for many variables. For Attitudes, Impressions, Naturalness, and Creepiness, the Hard-of-Hearing group responded more positively to the CS Avatar than the other two groups and more negatively to the Human signer. We observed that the Hard-of-hearing group displayed a different profile of responses than the Deaf group, but the interpretation of these differences is limited due to the diversity of the sample and the smaller size Hard-of-Hearing group as noted above. Comprehension ratings showed that the Deaf group judged the CS Avatar less comprehensible than the other two groups.

In addition to analyzing Group differences, we also conducted analyses using self-reported Fluency as an independent variable and correlations with the Age of Acquisition variable. While Group and Fluency are certainly related, as seen in the significantly higher Fluency ratings for the Deaf group on average (**Table 1**), analyzing by Fluency gives us a clearer picture of how proficiency in ASL, rather than hearing status alone, is related to the perceptions of signing avatars. This distinction is important because, within the Groups, fluency varies widely—for instance, the Deaf group includes many people whose first language is ASL and who are highly fluent, yet also includes later, less proficient Deaf learners of ASL. From the Group x Fluency analyses, we observed that higher Fluency was related to lower Comprehension ratings for the CS Signer (see **Figure 7**). For Impressions, we saw the same pattern in which people with higher ASL fluency had more negative Impressions toward the CS Signer.

The correlation between Age of Acquisition and the four primary variables mirrored this finding. For all four variables, people with an earlier Age of Acquisition rated the CS avatar

more negatively (see **Table 3**). These findings are essential because they show that more fluent and earlier signers are particularly sensitive to the odd movements of the CS avatar. In contrast, Fluency was not related to Comprehension or Impression ratings for the Mocap avatar (confirmed by *post-hoc* testing, *p*-values of 0.80 and 0.15, respectively), suggesting that those ratings of the Mocap avatar do not differ based on the viewer's own fluency. We suggest that this may be because the Mocap avatar's movements come from a recording of a human native signer. While she does not look realistically human, and there may be features of her appearance that people find odd, her sign production reflects the authentic signing movements of a native Deaf signer. This finding adds to prior work suggesting that people are highly sensitive to the motion characteristics of humanoid agents (White et al., 2007; Saby et al., 2011; Thompson et al., 2011). This work also echoes past findings in the field, which demonstrated that ASL users who attended Deaf Residential schools (where ASL is the primary language) were more harsh judges of computer-synthesized ASL animations (Kacorri et al., 2017).

The different experiences of Deaf, Hard-of-Hearing, and Hearing people who use ASL and the differences based on their fluency in ASL are critical to consider when developing signing avatars. Users' language experiences appear related to their responses to signing avatars, and critically, certain types of signing avatars may be more prone to negative responses from particular groups of people. When developing signing avatars, one key aspect of design considerations must be who the intended audience or user will be (Bragg et al., 2019). Our data show that deaf or fluent signers are likely to have more negative views of signing avatars, especially when animated with computer-synthesized motion. At the same time, developers must consider the vast diversity of the deaf experience when designing signing avatars for use in any particular situation. For instance, many deaf and hard-of-hearing people do not grow up in an environment where signed language is used (Mitchell and Karchmer, 2004) and do not receive signed language exposure during early developmental years (Kushalnagar et al., 2011). Some of them may later choose to learn sign language, and people in this group represent an important demographic for signing avatars. As later ASL learners, as shown by our data, those people may have a more accepting view of signing avatars.

These complex relationships between the user's background and the avatar they see are essential to understand if avatars are used in high-stakes educational, medical, or face-to-face settings. The work we present here echoes work from other domains of human-computer interaction, in which the preference for more authentic human experience drives the acceptance of virtual human assistants (Chérif and Lemoine, 2019; Fernandes and Oliviera, 2021).

LIMITATIONS AND FUTURE DIRECTIONS

This study replicates specific findings from the literature, particularly the more negative responses from more fluent signers (Kacorri et al., 2015) and the complex multidimensional factors which affect users' views of signing avatars (Kipp et al., 2011). We also go beyond prior work to better portray the complex relationship between people's own language background and the way they approach and react to different types of signing avatars. However, our results only represent the specific virtual human avatars used here, so extrapolation beyond these instances should be taken with caution. Dozens of different signing avatars have been developed over the years, and it is beyond the scope of the study to draw conclusions about those not included in this study. Another limitation of the current work is that most ratings were given in response to individual words, so more work is needed to understand how signers respond to transitions between signs and grammatical aspects of avatar signing.

Signing avatar technology changes quickly. Since the stimulus creation in 2019-early 2020, advances in motion capture, facial expression recording, and computer synthesis of signed language have all continued to accelerate rapidly, so newer versions of signing avatars may not encounter the same responses like the ones included here. Achieving greater success with signing avatars may come from cross-disciplinary collaboration, such as ensuring that technical development occurs with meaningful input from signed language linguistics (Bragg et al., 2019). Researchers in signed language linguistics have had a long ongoing discussion on best representing signed languages in notation systems (Miller, 2001; Hochgesang, 2014). Continued collaboration between sign linguists and avatar developers may allow for improved representation of sign language by virtual humans. Our current findings, as well as several ethical considerations recently discussed in the field (Bragg et al., 2019; De Mulder, 2021; Krausneker and Schügerl, 2021; Quandt and Malzkuhn, in review[1]), suggest that deaf signers should serve as the models for signing avatars to ensure quality and cultural relevance. Finally, it would be helpful to carry out a similar study with a cross-design in which avatars varied by appearance and movement type. Such a study would allow for comparison between responses to two avatars who look the same but whose motions are different and compare responses to two avatars who look different but whose motions are the same.

CONCLUSION

In the work presented here, we found that movement quality and appearance significantly impact users' ratings of signing avatars and that signed language users with earlier Age of Acquisition (and more fluency) are the most sensitive to the movement quality issues seen in avatars based on computer-synthesized motions. Given that this sensitivity was not evident for the Mocap avatar, we suggest that developers of signing avatars must retain the fluid movements integral to signed languages. Since people who learn ASL earlier are more likely to rely on it as a primary language, interference of computer-generated movements into signed content is unlikely to be met with acceptance by the users for whom signing avatars may be the most useful.

[1]Quandt, L. C., and Malzkuhn, M. (in review). The Way Forward for Signing Avatars: Seven Principled Recommendations.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Gallaudet University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LQ conceptualized and supervised the study, conducted formal analysis and visualization, acquired funding, drafted and wrote the work. AW contributed to the conceptualization, methodology, investigation, and review/editing of the work. MS contributed to conceptualization, methodology, data curation, and review/editing of the work. KW contributed to the methodology, investigation, and review/editing of the work. RF contributed to investigation and review/editing of the work. All authors contributed to the article and approved the submitted version.

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New Insights Into Mouthings: Evidence From a Corpus-Based Study of Russian Sign Language

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While some aspects of mouthings have been previously investigated, many topics in the use of this cross-modal contact phenomenon in sign languages remain un(der)studied, and not much is known about mouthings in Russian Sign Language (RSL), in particular. This article examines various aspects of mouthings as these are used by native RSL signers and aims to contribute new insights into the use and origin of mouthings in this sign language. Based on novel data from the online RSL Corpus alongside additional elicited data, we describe the distribution, forms, functions and spreading patterns of mouthings. Our findings furthermore show that sign languages exhibit more extensive variation in the use of mouthings than has previously been thought. Moreover, we – thus far uniquely – describe mouthings also as a written-language-based contact phenomenon. This study has the potential to provide a better understanding of the nature of such contact-induced features as mouthings in sign languages in general and reveals a complex interplay of the modalities of signed, spoken and written languages.

Keywords: mouthings, corpus analysis, Russian Sign Language, multimodality, language contact phenomenon, mouth actions

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INTRODUCTION

The focus of the present study is on mouthings, that is, on mouth actions that resemble the articulation of spoken language words (Boyes-Braem and Sutton-Spence, 2001). For instance, while producing the sign WATER in Russian Sign Language (henceforth, RSL), the signer articulates (a part of) the Russian word *voda* 'water'. These mouth actions have to be differentiated from mouth actions that have nothing to do with words from the surrounding spoken language. As an example of the latter, when producing the RSL sign CAN, the signer usually closes their mouth as if making the sound [ap] (Kyuseva, 2020, p. 8). This type of mouth action is called a mouth gesture (Boyes-Braem, 2001). Mouth gestures are different from mouthings and are considered to be a sign language inherent category. In the majority of their uses, they either constitute a nearly obligatory semantically empty component of a sign (as in the example CAN above), or convey an adjectival (e.g., 'thick' or 'thin') or adverbial (e.g., 'intensely') semantic information additional to that specified by the manual sign(s) (Crasborn et al., 2008).

Mouthings have been a subject of linguistic research for over 30 years now (see the pioneering works of Vogt-Svendsen, 1981; Schermer, 1990). Present in nearly all studied sign languages (with one reported exception in the case of Kata Kolok; see de Vos and Zeshan, 2012), mouthings contribute significantly to the formal and semantic aspects of these languages. By studying them, we can gain a special window onto what goes on in the mind of the signer when producing and processing sign language (Vinson et al., 2010).

Even though studies attest that mouthings comprise the largest category of all mouth actions (Crasborn et al., 2008), their linguistic role, their functions in discourse, their spreading patterns

and the principles governing their occurrence in native signing have still not been thoroughly investigated. We still lack descriptions of the mouthings in a great number of sign languages, including in RSL. Only a few Deaf[1] community sign languages, such as especially the British (BSL), Australian (Auslan), Swedish (STS), German (DGS), and Dutch (NGT) ones, alongside a small number of other, mostly European sign languages, have been analyzed with respect to their mouthings (Ebbinghaus and Heßmann, 1995; Sutton-Spence and Day, 2001; Bank et al., 2011; Mohr, 2014; Johnston et al., 2016; Mesch and Schönström, 2021). Although, so far, most sign language research has focused on ASL, it is interesting to note that the vast bulk of the research carried out on mouthing has been for European sign languages, while ASL researchers have largely ignored mouthing for many years (an exception is Nadolske and Rosenstock, 2008).

This paper contributes to the field by presenting the first detailed corpus-based description of mouthings in RSL. The paper is structured as follows. Section "Research on Mouthings in Sign Languages" establishes the necessary background on research into mouthings in different sign languages; Section "Russian Sign Language" provides sociolinguistic information about RSL. Section "Materials and Methods" discusses the methodology adopted in this study and introduces the three research questions that we pose. These questions are subsequently answered in sections "New insights into the distribution patterns of mouthings," "New insights into the functions of mouthings," and "New insights into the origin of mouthings." Specifically, section "New insights into the distribution patterns of mouthings" investigates the form and distribution of mouthings, section "New insights into the functions of mouthings" explores the functions of mouthings, and section "New insights into the origin of mouthings" deals with the origin of mouthings. The paper concludes with section "Discussion," which presents a discussion of the implications that the analyzed data have for linguistic typology and theoretical accounts of mouthings.

Research on Mouthings in Sign Languages

Several authors have explored the phenomenon of mouthing using data from various sign languages, yet mouthing patterns and their grammatical functions are still not fully understood. After the two pioneering studies on mouthings, namely in Norwegian Sign Language (Vogt-Svendsen, 1981) and in NGT (Schermer, 1990), a book edited by Boyes-Braem and Sutton-Spence (2001) laid the groundwork for further research into this unique phenomenon. The book standardized the terminology 'mouthings' and 'mouth gestures' for two different types of mouth actions and brought together papers on mouthings in nine different sign languages (Ajello et al., 2001; Bergmann and Boyes-Braem, 2001; Bergman and Wallin, 2001; Ebbinghaus and Heßmann, 2001; Rainò, 2001; Schermer, 2001; Sutton-Spence and Day, 2001; Vogt-Svendsen, 2001; Zeshan, 2001). Recently, there have also been four thorough corpus studies on mouthings in Irish Sign Language, NGT, Auslan and Hungarian Sign Language (Bank, 2014; Mohr, 2014; Johnston et al., 2016; Racz-Engelhardt, 2016).

Boyes-Braem and Sutton-Spence (2001) have defined mouthings as silent articulations of words from the surrounding spoken language. Correspondingly, it is widely accepted among linguists that mouthings originated as borrowings through imitation of the lip movements that are made when pronouncing words of the surrounding spoken language.

Mouthings are omnipresent in deaf native signing (Bank, 2014). A DGS corpus study revealed that more than 80% of all utterances involved at least one mouthing. That is to say that every second manual element in a typical signed utterance in DGS is accompanied by a mouthing (Ebbinghaus and Heßmann, 1995). In the Auslan data, more than 70% of all mouth actions were mouthings and, in the NGT data, 80% of mouth actions were mouthings. The NGT and Auslan corpora are similar in the genres they encompass and are well suited for comparison with the RSL corpus (Bank, 2014; Johnston et al., 2016).

There is quite some debate in the sign language literature about the linguistic status of mouthings. A disputed question is whether mouthings are constitutive elements of sign languages or instances of code mixing (see Bauer, 2019 for an overview). The opinions range in terms of ascribed status from mouthings as part of a sign's phonological description in line with the other phonological formational categories of hand configuration, location and movement (Ajello et al., 2001; Bergman and Wallin, 2001; Boyes-Braem, 2001; Rainò, 2001; Sutton-Spence and Day, 2001; Vogt-Svendsen, 2001; Crasborn et al., 2008; Hosemann, 2015; Steinbach, 2016) to mouthings as instances of online code-blending, where signers can freely and simultaneously combine elements from a spoken and signed language (Ebbinghaus and Heßmann, 2001; Hohenberger and Happ, 2001; Vinson et al., 2010; Bank et al., 2011, 2016; Johnston et al., 2016; Giustolisi et al., 2017; Perniss et al., 2020). Many studies have contributed to this debate and there are good arguments in favor of each view. The question of the linguistic status of mouthings thus remains unresolved, and we doubt that it will be definitively answered in the near future.

In this study, we treat mouthings as integrally constitutive of sign language use and a result of complex processes of cross-modal language contact (cf. Capek et al., 2008). We observe that mouthings are perceived by deaf native signers in monolingual contexts as a necessary and vital part of their language (also in ISL by Mohr, 2012, 2014). The metalinguistic awareness study by Fontana and Ferrara (2019) has demonstrated that signing without mouthings is interpreted by native signers as being non-fluent and inauthentic. We believe there are important questions that need to be resolved first, namely: how are mouthings used in signed discourse (what are the manual forms they occur with and which form do they have in which contexts: reduced, inflected, spread etc.) and how do they contribute to the overall meaning of a signed construction (i.e. what functions do mouthings perform)? Therefore, the analysis presented in this

[1]We follow the convention of using "Deaf" to refer to sign language users who are also part of a cultural minority. Uncapitalized "deaf" is used to refer solely to audiological status or in cases where linguistic and cultural status is not being highlighted.

paper deliberately stays outside of the debate on the linguistic status of mouthing and does not aim to contribute to this scholarly discussion.

Mouthing Forms

In terms of form, mouthings may be regarded as standard, fully articulated, inflected, temporally reduced or spread across neighboring manual signs. Mouthings that are time-aligned with, and have a similar meaning to, the signs they accompany are known as standard mouthings (Bank et al., 2011; Bank, 2014).

Mouthings are typically observed in their uninflected citation forms (Boyes-Braem, 2001; Hohenberger and Happ, 2001). However, some studies have reported on the occurrence of inflected mouthings with examples of tense marking on verbs or plural marking on nouns (Mohr, 2014; Racz-Engelhardt, 2016). Bauer (2019), moreover, has shown that mouthings in RSL can be inflected for case, gender, number, and aspect.

A mouthing is considered to be reduced when only some of its parts are visible, as in the DGS examples *wi(chtig*) 'important,' *fer(tig)* 'ready,' NGT *aksp* 'accepteren = to accept' or RSL *sob(aka*) 'dog' or *Novosib(irsk)* (Boyes-Braem, 2001, p. 104; Bank, 2014, p. 24; Bauer, 2019, p. 22).[2] Not much research has been done on the use of reduced mouthings in different sign languages. Mesch and Schönström (2021) have shown that reduced mouthings are used much more often by deaf L1 signers than by L2 learners of Swedish Sign Language (STS). L2 signers tend to use full mouthings while signing. Ebbinghaus and Heßmann (1995) observed that, in DGS, reductions occurred more often for verbs than for nouns. They assume that a reduction of a German verb does not impair the understanding of the meaning in the same way that the reduction of a noun can. Johnston et al. (2016, p. 21) reported that 95% of mouthings in the Auslan corpus were fully articulated and less than 4% were reduced. The results for NGT appear to be mixed. While some signs, such as TALK, appear to be reduced in 80% of instances in the NGT corpus, other signs (e.g. PREVIOUS or HEARING) show a preference for the full two-syllable citation form (Bank et al., 2011, p. 261). What all reduced mouthings appear to have in common is that they are overwhelmingly initial segments of a lexical word of the surrounding spoken language. This means that only the first part of the corresponding word is visible[3], as shown in (1–2). Mouthings may even be reduced to a single syllable or to a very short mouth movement mimicking articulation of only the first sound, as observed in RSL mouthings for *ždu* 'wait' or *babuška* 'grandmother' reduced to only *ž* or *b* respectively (also found in ISL, as reported by Mohr and Leeson, in press).

Sandler and Lillo-Martin (2006, p. 105) have argued that reduced mouthings conform to the rhythm of the monosyllabic form of the co-occurring manual sign, while Bank et al. (2011) have shown that unstressed syllables are reduced more often than are stressed ones. All mouthings in the latter study's analyzed NGT data contained stressed syllables. The authors therefore suggest that temporal reduction typically happens in the form of deleting word-final consonants, while reasoning that signers have knowledge of the rhythmic structure of Dutch words (ibid.: 264). Although the authors did not give a detailed explanation of how this happens, the hypothesis appears to be plausible. Stressed syllables are usually longer and more strongly articulated and with less vowel reduction than are unstressed syllables (Grice and Baumann, 2007). This entails that the stressed part of the spoken-language item is the most visible one to the interlocutor during lip reading. By recognizing the stressed syllable, signers can perceive the rhythmic structure of spoken words. Given this state of affairs, the phenomenon of reduced mouthings calls for more research. RSL lends itself well to verification of the stressed syllable hypothesis by Bank et al. (2011). In Russian, the stress can occur in various positions within a word. This means that the stress is distinctive, i.e. two words can be distinguished based only on their stress pattern. Additionally, due to the vowel reduction phenomenon in spoken Russian, vowel quality varies greatly depending on whether a vowel occurs in a stressed or an unstressed syllable (Yanushevskaya and Bunčić, 2015). Section "New insights into the origin of mouthings" of this article evaluates the above claims and gives answers as to which parts of the respective spoken words are typically articulated in RSL mouthings and explains how this finding may yield insight into the origin of mouthings.

A mouthing is considered to be spread when its duration extends over more than one manual sign. Research on spreading revolves around the following topics: the direction of spreading, the scope of spreading, the source and goal signs of spreading and the functions of spreading. In terms of direction, spreading can be progressive or regressive. Progressive spreading starts together with the semantically congruent sign and extends over the next manual sign (or signs). Regressive spreading starts before the semantically congruent sign and then extends over it. See example (1), with progressive, and (2), with regressive spreading, below:

(1) progressive spreading pattern [RSL]

Mouth:	*v(së)rav(no)*	*na(do)*
Gloss:	SAME	NEED
	*vrač*_____	*na(do)*
	DOCTOR GO	NEED

Translation: 'Regardless, I need to go to the doctor'.

(RSLM-s2-s12-a13.eaf)

(2) regressive spreading pattern [RSL]

Mouth:	mg[4]_	mg_____
Gloss:	IX-1	THROW.AWAY
	*vd(rug)*_____	
	IX-1	SUDDENLY

Translation: 'What if they throw me away?'

(RSLM-s1-s16-a15.eaf)

In (1), the mouthing of *vrač* 'doctor' extends over both its designated manual counterpart and the next classifier predicate 'go.' In (2), the mouthing of *vdrug* 'suddenly' begins during a pointing sign and extends over the following sign, its manual

[2]The segments in brackets are not mouthed.

[3]Meaning it is visibly articulated by the signer.

[4]Mouth gesture.

counterpart SUDDENLY. Languages have been reported to differ with respect to the direction of spreading they prefer. Crasborn et al. (2008) showed that British Sign Language (BSL) and NGT abide by the progressive pattern, while STS allows for both directions.

In terms of scope, a mouthing can extend over one or more additional signs. Existing research suggests that, although spreading over several signs is possible, spreading over just one additional sign is much more frequent. For example, out of 810 spreadings in the NGT corpus, only six percent are spread over several signs, while 94 percent are spread over a single immediately adjacent sign (Bank, 2014).

Irrespective of the scope and direction of spreading, mouthing usually extends from nouns, verbs, adverbs and adjectives to pointing signs/indexes, possessive pronouns, determiners, classifiers, palm-up and prepositions (Crasborn et al., 2008). In other words, the starting point signs tend to be content words, and the end point signs tend to be functional words. Pointing signs are the most frequent end point signs in spreading, which is probably due to the fact that they are prosodically light and consist of a simple articulatory representation (Sandler, 1999). Crasborn et al. (2008) discussed an exception to this generalization and provided an example in SSL where a mouthing is spread from one content word over another content word. In their example, the mouthing of *mål,* paired to the nominal sign MÅL 'goal,' is spread rightward over the noun LINJE 'line,' thus constituting a morphological compound MÅLLINJE 'finish line'. The RSL data presented here will expand the list of exceptions and show interesting examples, such as where a mouthing is spread from a function word to a content word (section "Spreading Patterns"). We will argue that this pattern has a specific function associated with it, which will be discussed in the next section.

Mouthing Functions

Mouthings appear to play an important role in facilitating understanding in sign languages and are known to have various grammatical, lexical, prosodic, stylistic and sociolinguistic functions (Boyes-Braem, 2001; Mohr, 2014; Safar et al., 2015).

In most cases, mouthings correspond exactly to a manual sign both in terms of temporal alignment and semantic congruency. This semantically congruent type of mouthing, the standard mouthing, is the most frequent one (Schermer, 1990; Boyes-Braem, 2001; Bank et al., 2011). It is illustrated by the RSL example in (3).

(3) [RSL]

Mouth:		*san(kt-petersburg)*		*mg*		*u___*	
Gloss:	IX-1	ST. PETERSBURG		TO-BE:PAST		VISIT	
Mouth:	*ses(try)*	*vo_*		*v(re)m(ja)*	*u(čit')*	*lvc_*	
Gloss:	SISTER	IX	V-O	TIME	LEARN	LVC	

Translation: 'I was in St. Petersburg visiting my sister who was studying at the lyceum at the time.'

(RSLN-d2-s8-s9.eaf)

In (3), the mouthed parts of the words *san(kt-petesrburg)*, *ses(tra)* 'sister' and *u(čit')* 'to learn' have the same meaning as the manual signs they co-occur with. Mouthing can also add meaning to a sign by indicating a more specific reading of it, as, for example, in the DGS sign SIBLING with the German mouthings *Schwester* 'sister' or *Bruder* 'brother'. Such simultaneous mouthings seem to be obligatory in order to disambiguate or further specify the sign in question (Boyes-Braem, 2001). Examples of RSL polysemous signs that are disambiguated by mouthing are NEUDOBNO 'uncomfortable' versus NEVKUSNO 'not tasty,' and KOŠKA 'cat' versus LASKA 'tenderness' (see also the examples in section "Mouthing and Degrees of Lexicalization"). Such cases are rare in the RSL corpus.

Mouthing appears to fulfill a word-class marking function in sign languages. Mouthings are reported to accompany nouns and morphologically simpler signs more frequently than they do verbs or morphologically more complex signs (such as classifiers) (Kimmelman, 2009). In the studies of noun–verb pairs in Austrian Sign Language (ÖGS) and Auslan, it was noticed that mouthing is much more likely to occur with nouns than with verbs. In Hunger's (2006) study of ÖGS, 92% percent of nouns and only 52% of verbs were accompanied by mouthing. In Auslan, about 70% of the nouns studied were accompanied by mouthing, whereas only 13% of the verbs were (Johnston and Schembri, 2007). Bank et al. (2011), however, found no word-class specific pattern in their study of NGT mouthings.

The spreading of a mouthing is reported to serve as one of the building blocks of the prosodic structure of sign language phrases. Sandler (1999) has argued that mouthing can bind a host content word and a cliticized pointing sign to form a prosodic phrase. Since the prosodic structure is believed to reveal part of the invisible syntactic structure, some examples of mouthing spreading can be analyzed as instances of syntactic binding. For instance, Boyes-Braem (2001) provided examples wherein mouthings bind constituents of a noun phrase, as well as verbs with subjects in Swiss German Sign Language. Crasborn et al. (2008) gave examples of verb–adverb combinations (e.g. 'lay silent'), verb–object clusters (e.g. 'see field') and nominal compounds in SSL. The RSL data presented in this paper will reveal another function of mouthing that has not been discussed before. We call it the "discourse function," since it is connected with the phenomenon of turn-taking.

Summary

As we have seen, mouthings represent a ubiquitous yet heterogenous phenomenon within the world's sign languages. They occur in standard, fully articulated and inflected forms and may be temporally reduced or spread across neighboring manual signs. Their functions range from the grammatical, lexical, and prosodic to the stylistic, sociolinguistic and even discursive, as will be shown below. Particular to mouthings as a category of mouth actions is that they reproduce segments of the surrounding spoken language, which is commonly held to be their ultimate origin. This hypothesis will be challenged in the following (see section "New insights into the origin of mouthings"), based on our findings from a corpus-based study of RSL, while we additionally take up the question of which syllables become discarded in reduced mouthings and why. Overall, our findings stand to contribute to the 'state-of-the-art'

presented here with regard to the form, frequency, functions and origin of mouthings.

Russian Sign Language

Russian Sign Language is used by Deaf and hard-of-hearing people in Russia and several other formerly Soviet countries. According to the latest census in 2010, 120,000 people in the Russian Federation use this sign language. Although it evidently has a higher number of signers as compared to many other European sign languages, it still remains considerably understudied.

The emergence of RSL is attributed to the foundation of the first Russian school for deaf children in Pavlovsk in 1806. Some researchers believe RSL to be related to French Sign Language (LSF), as the first teachers in the Pavlovsk school had been trained in France and Vienna. This issue, however, remains open to debate. Bickford (2005), who carried out a lexical comparison of East European sign languages, found no evidence in favor of this hypothesis.

Russian Sign Language has been legally recognized as a full-fledged language of the Deaf in Russia and received its official status on December 30, 2012. This means that any time Deaf or hard-of-hearing people contact state, municipal and judicial authorities, they have the right to receive the services of an interpreter trained in RSL. Official recognition of a sign language should help to improve the quality of life and education for the Deaf, though, as the history of sign language development shows, it takes time from the moment of official recognition before real measures of state support become implemented.

Russian Sign Language is unfortunately still largely ignored in the education system for the Deaf in Russia. Deaf people in Russia are primarily taught to write and read standard Russian. In the first decades of the 20th century, the oral method of Deaf education prevailed in Russia. But due to the growth of urban Deaf communities via significant migration flows from villages to cities and the need to provide the Deaf with the basics of knowledge in a short time, numerous evening schools and workshops to eliminate illiteracy (so called *likbezy*[4]) have appeared. Quite obviously, it is impossible to succeed in such tasks without the use of sign language. Therefore, in 1938 at the All-Russian Conference of Deaf Educators, the "purely oral method" was declared unacceptable. After that, both deaf and hearing teachers with knowledge of sign language were allowed to work. However, at the very beginning of the 1950s, there was a major step backwards. In one of his publications, Stalin argued that sign language is not a proper language. And although Joseph Stalin was not an expert in either education or linguistics, this publication was deeply influential, and the purely oral method prevailed again: the deaf were required to learn to speak. Many doctors and educators considered the deaf to be defective, while sign language as a means of interpersonal communication was also regarded extremely negatively – it was banned even outside of school hours at educational institutions. Unfortunately, the echoes of this discriminatory attitude toward the Deaf community and their language is still palpable, and the prejudiced notion that the use of sign language prevents mastery of spoken Russian is still very common among teachers and professionals, as well as among hearing parents in Russia (Zajceva, 2000).

A general scientific interest in RSL arose only in the 1980s (Zajceva, 1987; Grenoble, 1992). Most of the research on the structure of RSL has, so far, been conducted by Zajceva[5], a distinguished sign language researcher, interpreter and educator, who has studied RSL mostly from a pedagogical perspective (Zajceva, 2000). Selected aspects of RSL grammar have also recently been described (Prozorova and Kibrik, 2007; Kimmelman, 2009, 2012, 2014; Prozorova, 2009; Burkova, 2012, 2015; Burkova and Varinova, 2012; Korol'kova, 2013; Filimonova, 2016; Burkova and Kimmelman, 2019; Kyuseva, 2020). In many respects, RSL appears to be typologically similar to the other urban sign languages described so far. However, RSL is in closer contact with its surrounding spoken and written language, Russian, and is expected to be more deeply affected by it. Studies on mouthings in RSL are, nevertheless, still very scarce (Bauer, 2018, 2019).

MATERIALS AND METHODS

This study constitutes the first detailed description of the forms and functions of mouthings in RSL. In particular, we are interested in possible differences in the characteristics of mouthings that are co-articulated with various lexical types of signs, namely the set of core, fully-lexicalized signs, the open class of more spontaneous, partially-lexicalized signs and fingerspelled signs. An adequate description of this sort requires investigating the natural occurrence of the phenomenon in a variety of contexts. To achieve this goal, we conducted a corpus analysis of RSL mouthing. This section explains the methodology of that study. It describes the two corpora that served as our data sources ("The Russian Sign Language Online Corpus" and "The 'Spot-the-Difference' Corpus") and discusses the research questions that will be answered in the remainder of this article (see section "Research Questions").

The Russian Sign Language Online Corpus

The Russian Sign Language online corpus[6] is a currently maintained documentary corpus of RSL and was used as the main data source for our study. The RSL Corpus was built by Svetlana Burkova (Novosibirsk University) and her research group during a documentation project funded by the Russian Foundation for Basic Research (Burkova, 2012, 2015). The corpus currently includes over 230 texts filmed from 43 RSL signers – men and women aged from 18 to 63 years, with varying degrees of deafness: deaf and hard-of-hearing. A large proportion of the signers currently resides in Novosibirsk, a significant number also in Moscow. Since only little research has been done on dialectal variation in RSL, the signing in Novosibirsk and Moscow is

[4]Russ. *likvidacija bezgrammotnosti* 'elimination of illiteracy'.

[5]Another attested spelling of this name in English is *Zaitseva*.

[6]http://rsl.nstu.ru/

not considered to represent different RSL dialects. Burkova and Varinova (2012) have shown that the lexical variation in the signing used in Novosibirsk and Moscow is low and restricted to just some lexical domains (e.g., food and kinship). Moreover, variation occurs only in certain parameters (mostly in movement) and is noticed mainly among younger signers.

The corpus consists of various text-types. It contains spontaneous language production (narratives and dialogues) and texts filmed on the basis of stimulus materials (cartoon retellings, picture-based storytelling). The corpus reflects the true everyday language use of different groups of RSL signers in a variety of situations. While recording the data, in order to maximally exclude the influence of spoken Russian, the signer's addressee was always a native RSL signer.

For the present analysis of mouthings, 136 video files from 35 native RSL signers were analyzed. Six of the signers were from Moscow and 29 from Novosibirsk. There were 15 women and 20 men. Seven of the signers were hard-of-hearing, one deafblind and 27 deaf. The total duration of the RSL corpus data annotated for the present analysis is 4 hours and 35 minutes. These and other annotations are planned to be made available online.

All mouth activity was carefully examined, and all mouth actions were categorized and annotated using ELAN annotation software (see **Figure 1** for a screenshot from this software). We conducted a statistical analysis of this data using R, with a multivariate logistic regression model being used to identify predictors of mouthing and mouth gestures in the data. The RSL corpus is annotated with sign glosses in tiers for the right and left hand, as well as in Russian translation. For the analysis of the mouthings, additional ELAN tiers were added to describe the produced mouth actions. Apart from annotating mouth gestures and cases with no mouth action, the following types[7] of mouthings were annotated on extra tiers in line with earlier investigations of mouthings in NGT (Bank et al., 2011), for better comparability.

full mouthing	a manual sign is combined with a complete (i.e. unreduced) mouthing and the whole word is mouthed clearly, e.g., the RSL sign WINDOW is accompanied by the mouthing *okno* 'window';
reduced mouthing	a form of mouthing in which only some syllables or even just some elements/sounds of a lexical item are mouthed, e.g., the RSL sign GIRLFRIEND is accompanied by the mouthing *pod(ruga)* 'sister'; the part of the lexical item in brackets is not visible on the lips (see **Figure 1**);
standard mouthing	the form of mouthing that occurs most frequently, where the mouthed lexical item and the co-occurring manual sign denote the same semantic concept, e.g. the RSL sign HOUSE is accompanied by the mouthing *dom* 'house';
free mouthing	a mouthing without a co-occurring manual sign, e.g., *a* 'but' and *nu* 'well.'
variant mouthing	a form of spoken lexical item that differs from the standard mouthing, e.g. the sign HOUSE is accompanied by the mouthing *domašnjaja* 'domestic' and not the standard (most frequently occurring in the corpus) *dom* 'house';
inflected mouthing	a form that resembles an inflected Russian lexical item, e.g. *dom-a* 'house-GEN.SG' with the sign HOUSE;
overlapping mouthing	a spread mouthing, i.e. when a mouthed form anticipates or extends past the manual production.

The "mouth actions" tier contains 27,377 annotations. At this number, the RSL dataset appears to be larger than the corpora of previous studies on mouthings in Auslan (17,002) or NGT (11,905). The additional "mouthing" tier reflects the exact visible articulation of Russian lexical items or their parts.

All of the annotations of mouth actions were initially made by two annotators: a Deaf native RSL signer also fluent in Russian and a professional sign language interpreter. All annotations were double checked and all cases of doubt[8] reviewed and discussed with the first author.

For a subset of 2000 randomly chosen signs in the corpus, we added a part-of-speech tier and annotated the belonging of each sign to its respective grammatical class. The tagging was mostly influenced by the semantics of the sign's use. This way, mouthings can be analyzed in relation to grammatical class for sign glosses.

The 'Spot-the-Difference' Corpus

The 'Spot-the-difference' corpus, developed by Kyuseva (2020), served us as an additional source for partially-lexicalized signs. Following Brennan (1992), Johnston and Schembri (1999), and Sutton-Spence and Woll (1999) we define partially-lexicalized (or productive) signs as signs that change their form depending on the context and which form their meaning in a compositional way out of the meanings of their various parts. Partially-lexicalized signs exhibit multiple differences to fully-lexicalized signs (see e.g.,

[7]In the numerous cases where the categories overlap (e.g., reduced and inflected mouthing overlap often, as well as full and variant mouthing etc.), both were annotated.

[8]One example of such debatable cases is a mouth movement *shhhhh* [ʂ:] produced by some RSL signers in the corpus together with the manual sign ŠKOLA 'school,' which starts with a postalveolar fricative in spoken Russian. The Deaf native RSL signer was sure to annotate it as a mouthing, whereas the hearing assistant wanted to mark it as a mouth gesture. Because this mouth action accompanied a morphologically simple sign, we decided to annotate it as a mouthing in the RSL corpus.

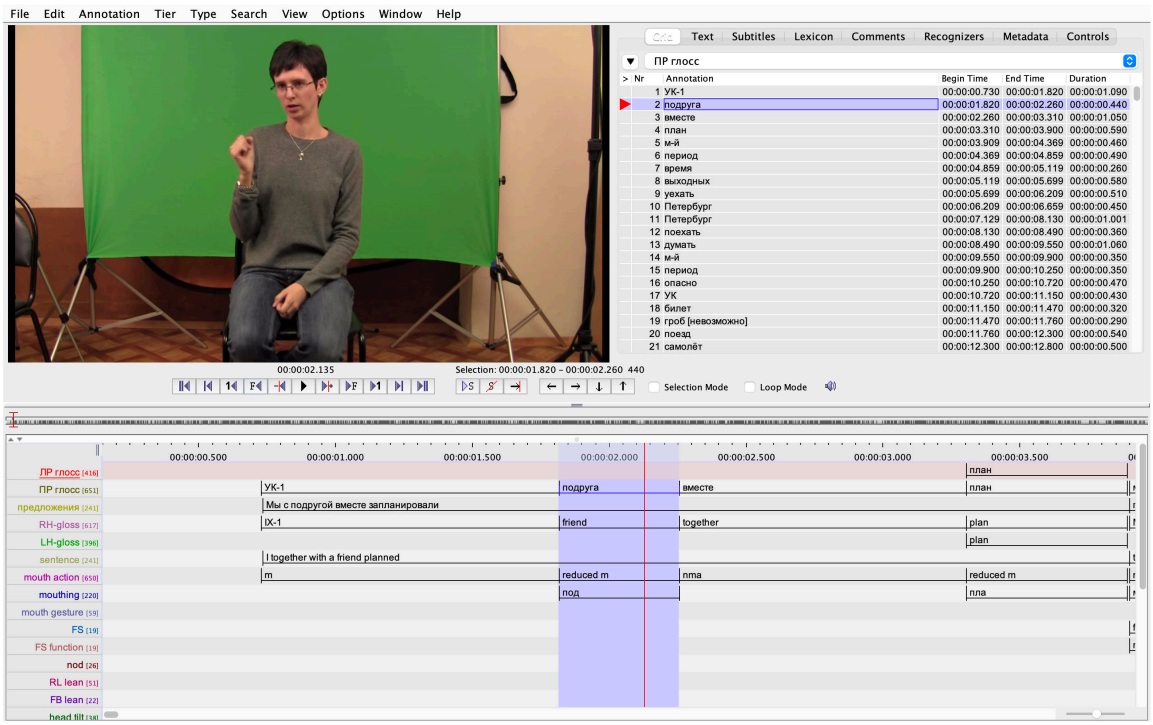


FIGURE 1 | ELAN screenshot. Reproduced with permission from Svetlana Burkova (Novosibirsk State Technical University), available at the online corpus of Russian Sign Language, http://rsl.nstu.ru/.

Aronoff et al., 2003). However, the extent of these differences has not been studied in detail with respect to mouthing. The current study aims to provide a description of mouthing as it appears in both fully- and partially-lexicalized RSL signs in order to capture potential qualitative differences between the two groups.

Our study focuses on one of the most understudied types of partially-lexicalized signs, namely size and shape specifiers, or SASSes. These are signs that describe the visual characteristics of objects, such as 'thin,' 'thick,' 'round,' 'angular' etc. Since these signs do not occur in general conversation often, the RSL online corpus presently does not contain a sufficient quantity of them for our purposes. As a complimentary data source, we used recordings of semi-spontaneous signing collected in the study of RSL SASSes by Kyuseva (2020). These data were collected on the basis of the communicative game 'Spot-the-difference.' In this game, two participants are presented with a different version of a cartoon-like picture. They have to collaborate to find 10 differences between the images without looking at each other's pictures. The stimuli were developed by Kyuseva (2020) to elicit various size and shape descriptions.

This corpus has the same annotational format as the RSL online corpus and includes sentence translations, left- and right-hand glosses and a similar detailed description of mouth actions. For this study, 6 video recordings with a total duration of 28 minutes were used. The signers were four deaf women and two deaf men, native RSL users from the Moscow area. This corpus contributed 598 SASSes to our sample set. It serves as the main data source for the discussion in section "New insights into the functions of mouthings" on the functions of mouthings.

Research Questions

Based on the corpus data described above, this paper aims to answer the following research questions:

(1) Are mouthings as frequent in RSL as they are in other sign languages? Do they exhibit the same features over all types of signs?
There is anecdotal evidence from Deaf RSL signers to the effect that RSL uses significantly less mouthing than do some other urban sign languages, such as DGS or NGT. Section "New insights into the distribution patterns of mouthings" of this paper explores this point by analyzing the RSL online corpus. It presents the general frequency of RSL mouthings, as well as their distribution by grammatical classes and by different types of signs.

(2) Do mouthings perform the same functions in RSL as they do in other sign languages that have previously been described?
The functions of mouthings in sign languages have been explored mainly based on data pertaining to core, fully-lexicalized signs. The current study includes partially-lexicalized signs into the sample set, which has led to the discovery of a new function. Section "New insights into the functions of mouthings" provides a detailed discussion of this issue.

(3) How and why does the reduction of mouthings occur in RSL? Is the stressed segment of the spoken Russian word always mouthed in RSL?

Being surrounded by a spoken language with variable stress and concomitant vowel reduction, RSL is well-suited to contribute to the existing studies on the reduction of mouthings. Section "New insights into the origin of mouthings" presents a statistical analysis of the reduction patterns of RSL mouthings, which results in new insights into the origin of mouthings.

NEW INSIGHTS INTO THE DISTRIBUTION PATTERNS OF MOUTHINGS

An initial analysis of mouthings in RSL on the basis of a set of twenty frequently occurring signs (Bauer, 2019) has indicated that RSL differs from other recently studied sign languages with respect to the proportions of signs found to co-occur with mouthings. Bauer (2019, p. 27) demonstrates that RSL mouthing rates are quite low when compared with Auslan or NGT. In this section, we expand upon the previous description of mouthings in RSL based on a larger dataset (see "The Russian Sign Language Online Corpus" for a description of the analyzed data) and present new insights into mouthing by showing how frequently mouthings occur in RSL, how they are distributed over different parts of speech and sign types and which spreading patterns are most prevalent.

Frequency of Mouthings

Our RSL data show that mouthings often accompany manual signs, but they occur far less frequently than has been reported for other sign languages. At the same time, the overall distribution of mouth actions is not unlike that of the other sign languages described to date (see **Figure 2**). 88% of all manual signs in the RSL corpus are accompanied by some mouth activity, either a mouthing or a mouth gesture. In contrast, the mouthing rate in our RSL data is 44%. This means that only 44% of manual signs were accompanied by mouthings, which is significantly lower than the rates reported by comparable corpus-based studies with several similar text-types, i.e. monologues, dialogues and elicited language production: for NGT, 73% (Bank et al., 2011) and, for Auslan, 56% of all manual signs were reported to co-occur with mouthings (Johnston et al., 2016). Excluding all sign tokens with no mouth action, the mouthing rate becomes 50%, which is still quite low as compared to NGT (80%) or Auslan (73.6%) (Bank et al., 2011; Johnston et al., 2016).

We analyzed the form of RSL mouthings to find out how frequently they are affected by temporal reduction. RSL mouthings came in a reduced form in 75% (n = 8904) of all cases (n = 11886). This finding is also quite surprising, because an opposite tendency has been reported for Auslan and STS, where fully-articulated mouthings were found to be the most common category (Johnston et al., 2016; Mesch and Schönström, 2021). In RSL, full mouthings are generally short, being no longer than two or three syllables. Exceptions to this are mouthings that accompany fingerspelled signs. Those that co-occur with fingerspelling are always fully articulated in RSL.

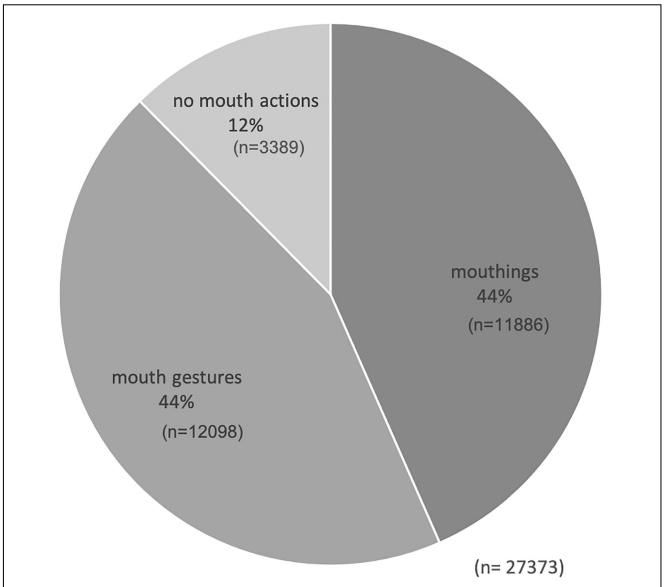


FIGURE 2 | Mouth actions in the RSL corpus.

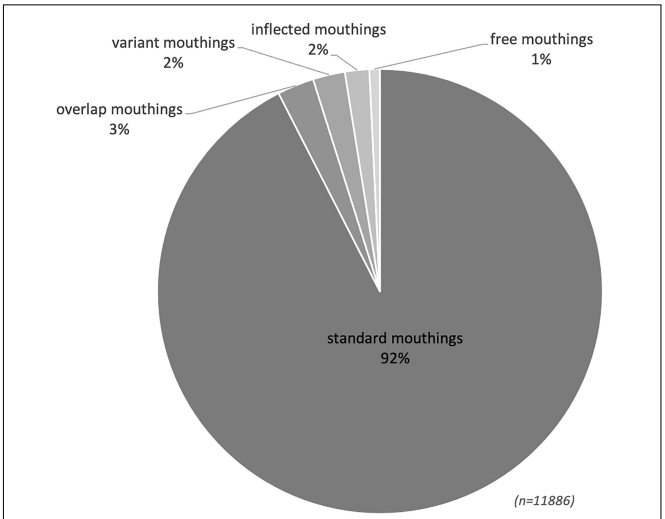


FIGURE 3 | Types of RSL mouthing.

Figure 3 shows that the overwhelming majority of signs pair with a standard mouthing. 92% of all mouthings in the RSL corpus denote the same semantic concept as their co-occurring manual sign. In 3% of all cases, the mouthing was spread regressively to the previous manual sign or progressively to the following manual sign. Cases of variant mouthing[9], i.e., when the form of the spoken lexical item differs from the standard mouthing, were quite infrequent. Inflected mouthings occurred in only 2% of all cases. These were mostly inflected for case

[9]Cases of polysemous signs differentiated by mouthing were also included in the category of variant mouthing.

(e.g. *škol-u* 'school-ACC.SG' together with the sign SCHOOL). 1% of all mouthings in the RSL data were free mouthings. These are isolated words or even short phrases that occur without an accompanying manual sign, or while the hands are resting. Referred to as solo mouthings elsewhere (Bank, 2014), they are often used as a backchannel, i.e., as a short feedback cue, e.g., when a signer mouths *da* 'yes.' Further examples of mouthings without accompanying manual signs are *tože* 'also,' *a* 'but' and *nu* 'well.'

Distribution Over Grammatical Class and Sign Type

The grammatical class of a sign is known to be a significant factor in predicting the co-occurrence of a mouthing (Kimmelman, 2009; Johnston et al., 2016). Some grammatical classes, such as nouns, prepositions and conjunctions, favor the use of mouthings, while others, such as verbs or pronouns, disfavor their use. Our study partly replicated the design of Johnston et al. (2016), in which the distribution of Auslan mouthings was investigated over signs of various grammatical classes. Our results confirm earlier findings. Mouthing rates in RSL vary significantly according to the grammatical class of the accompanying manual sign (see **Figure 4** and **Supplementary Table 1**). Based on RSL corpus data, mouthings co-occur with nouns more often than with verbs. Apart from with nouns, the highest mouthing rates in the RSL corpus were with function words (auxiliaries, prepositions, conjunctions and *wh*-question words) and numbers. Spatial verbs, discourse markers, interjections, negators and locatives most strongly disfavored the use of mouthings (see **Figure 4**). This distribution of mouthings over signs of different grammatical classes is comparable to that of other sign languages.

Not only the grammatical class of a sign but also its type appears to be a significant predictor of the use of mouthing. The study of Auslan has already shown that different sign types (e.g., core lexicon, productive lexicon, and gestural elements) exhibit very different rates of coarticulated mouth actions (Johnston et al., 2016). This is also true for RSL. The presence of mouthings varies in accordance with the type of the sign that it accompanies.

To demonstrate this, let us contrast two sign types which differ extremely in their rate of co-occurrence with mouthings: fingerspelled items[10] and SASSes (see **Figure 5**). Similar to findings on Auslan, fingerspelling most strongly correlates with the use of mouthings. In the corpus data, RSL signers mouthed 98% of their fingerspelled items. Occasionally, a particular type of fingerspelled elements, loan signs, occurred without mouthings, which accounts for the remaining 2% of cases. The mouthings that accompany fingerspellings appear to obligatorily be standard mouthings, which are fully articulated.

By contrast, only 18% of SASSes in the corpus were accompanied by a mouthing (see **Figure 5**). Interestingly, although SASSes prototypically denote physical characteristics, the mouthings that do accompany them never represented Russian adjectives of size or shape. Instead, they were silent articulations of Russian nouns for concrete objects (e.g. *doska*

[10]We are aware of the unique status that fingerspelled items have in the sign language lexicon and of the potential implications that this status has on their interaction with mouthing. They violate the phonological structure of the native lexicon (which SASSes do not). Nevertheless, following Johnston et al. (2016), we consider fingerspelling to be a separate sign type.

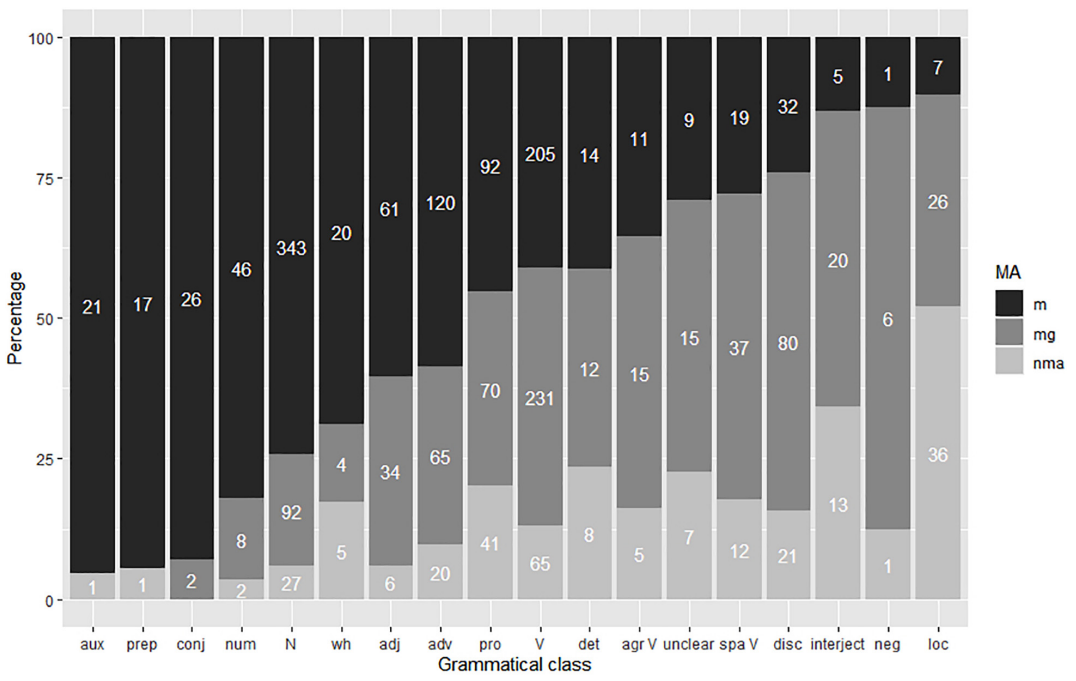


FIGURE 4 | Mouth action rates by grammatical class (ranked by decreasing % of mouthing).

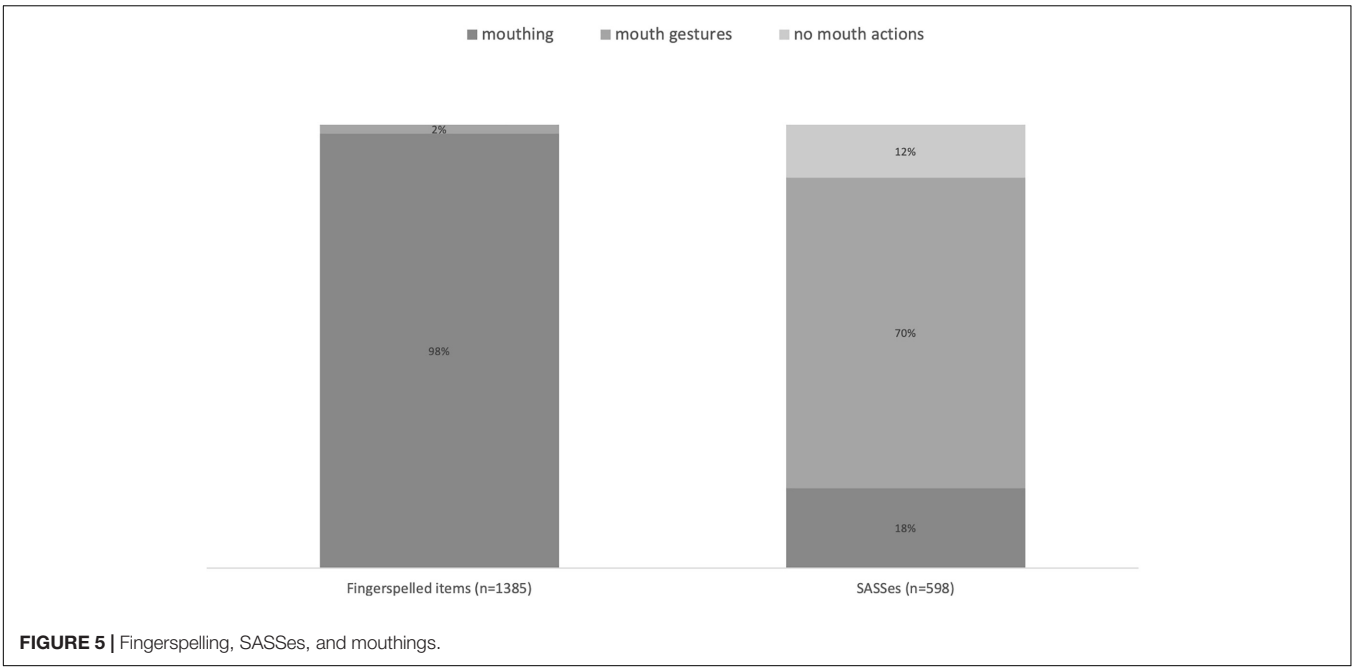


FIGURE 5 | Fingerspelling, SASSes, and mouthings.

'plank,' *mjač* 'ball' or *rama* 'frame'). The resulting sign functions as a noun that denotes an object of a particular shape, as seen in example (4).

(4) [RSL]
Mouth: *stena*_____
Gloss: LOC IX-1 SASS:FLAT-VERTICAL
oranž(evyj)
ORANGE
Translation: 'There I have an orange wall.'
(SASScorpus-s2-f1.eaf)

In (4), the SASS describing a flat vertical object is accompanied by the mouthing *stena* 'wall' and thereby denotes a flat vertical wall. In section "New insights into the functions of mouthings," we argue that mouthings in examples like this signal that the SASS has lost its compositional semantics and should be interpreted as a fully-lexicalized sign.

In contrast to their behavior in the case of fingerspelled signs, the mouthings that accompany SASSes frequently exhibit reduction. Full mouthings appeared only when the Russian word in question had no more than two syllables (as in *doska* 'plank,' *krug* 'circle,' *stupen'* 'step'). Most of the mouthings accompanying SASSes are standard in RSL (in terms of their semantic congruence with the manual sign). Variation was encountered only in two tokens, namely the variants *dom* 'house' versus *budka* 'cabin' accompanying a SASS denoting a three-dimensional object with a pointed end, and the variants *doroga* 'road' versus *tropa* 'small path' accompanying a SASS denoting a long narrow object.

Spreading Patterns

For a subset of eight randomly chosen files from the RSL corpus (3406 tokens), we counted all instances of spreading. Overall, we observed 52 spreading. Out of them, 41 mouthings were spread from the source sign over just one other adjacent sign, as in (5), three instances saw the mouthing spread from the source sign over several sequentially adjacent signs, as in (6), and eight instances were spreading of a mouthing without a manual source over an adjacent sign, as shown in (7).

(5) [RSL]
Mouth: *vra(č)*_____ mg_____
Gloss: IX DOCTOR SPEAK
Translation: 'The doctor is speaking.'
(RSLM-s1-s16-a15.eaf)

(6) [RSL]
Mouth: *Moskvu*_____
Gloss: MOSCOW COME LOC
Translation: 'We came to Moscow.'
(RSLM-s2-s12-a13.eaf)

(7) [RSL]
Mouth: *a*___ mg_____ *zaka(z)*
Gloss: IX-1 ANYWAY ORDER
mg_ *a*_____mg__ mg___
CHOOSE HEARING EQUAL
Translation: 'I was choosing orders anyway. The same as hearing people.'
(RSLM-s3-s18-a19.eaf)

In example (5), the mouthing of *vrač* 'doctor' is spread from its source over an adjacent pointing sign preceding it. In (6), the mouthing of *Moskvu* 'Moscow.ACC' is spread from its source sign over two subsequent signs, namely to the classifier predicate 'to come' and a locative marker with the meaning 'there.' Finally,

in example (7), the second instance of *a* 'but, and' is a free mouthing which does not have a manual counterpart. This mouthing is spread over two signs, CHOOSE and HEARING, on the boundary of two phrases. This latter type of spreading is not often discussed in the literature. However, our data suggest that it has a function similar to some of the more "typical" spreading examples and should therefore be included in the sample set.

Out of 44 instances where a mouthing was spread from a co-occurring manual sign, 31 were progressive, 12 were regressive and 1 was mixed, in that it exhibits spreading over two additional signs, both before and after the source sign. The free use of regressive spreading sets RSL apart from such languages as NGT and BSL and brings it closer to SSL, which also exhibits occasional use of regressive spreading (Crasborn et al., 2008; Mesch and Schönström, 2021). **Tables 1.1** and **1.2** show the source and target signs of spreading in order of their frequency.

Previous research on sign languages has indicated that mouthings spread for the most part from content signs to functional signs (Sandler, 1999; Boyes-Braem, 2001; Crasborn et al., 2008; Bank, 2014). To an extent, our data confirm these observations: the most frequent sources of spreading were nouns, verbs and adverbs; and the most frequent target of spreading was a pointing sign. However, contrary to the stated generalization, mouthing can also spread to a content word, such as a verb (six instances), a noun (six instances) or an adjective (three instances). Strikingly, it can even spread from a functional sign, such as a conjunction (six instances) or a *wh*-word (one instance). We argue that these mismatches in the direction of spreading are connected to the function that the spreading performs in the sentence. We will now turn to the functions of spreading attested in our data.

As we discussed in section "Mouthing Functions," the spreading of a mouthing is considered to be one of the markers of phonological constituents in sign languages. In other words, it contributes to breaking a series of articulated signs into patterns of rhythmic and intonational structure. Some of the phonological phrases formed by the spreading of mouthings are isomorphic to syntactic structures. Indeed, in our data, mouthing binds such elements as compounds (COUNTRYSIDE HOUSE; mouthing *dača* 'country-house'), noun phrases [FIRST DAY; mouthing *perv(yj)* 'first'], verb phrases [CANNOT APPLY; mouthing *mo(žet)* 'can'] and predicates with their subjects [IX-1 REFUSE 'I refused'; mouthing *otkaza(las')* 'refused.F']. These spreading, for the most part, have a progressive direction.

The observed type of prosodic binding that does not conform to the syntactic structure of the sentence is represented

TABLE 1.1 | Source signs of spreading.

Part of speech	Tokens
Noun	15
Verb	11
Adverb	6
Conjunction	6
Adjective	3
Numeral	1
Pronoun	1
WH-word	1

TABLE 1.2 | Target signs of spreading.

Part of speech	Tokens
Pointing sign	19
Verb	6
Noun	6
Palms up	4
Classifier predicate	3
Adjective	3
Fingerspelled word	1
Negative marker	1

exclusively by spreading to pointing signs. These spreading can be progressive or regressive; see (8–9).

(8) [RSL]
Mouth: *no* *čuv(stvovat')*_____ Rossija
Gloss: BUT IX-1 FEEL PU RUSSIAN
Translation: 'But I feel Russian [power].'
(RSLN-d2-s8-s9.eaf)

(9)
Mouth: *opjat'*_____ *vse_* *mg__*
Gloss: AGAIN IX ALL RISE
Translation: 'All this is rising again.'
(RSLM-s2-s12-a13.eaf)

In (8), the mouthing of *čuv(stvovat')* 'to feel' binds the head of the verb phrase without the argument and the subject. Since the subject, which is represented by a pointing sign, occurs prior to the verb, the spreading has a regressive direction. In (9), the mouthing of *opjat'* 'again' progressively binds the index subject and the adjunct of the predicate.

In 19 examples from our sample set, the spreading not only bound signs from a single phrase, but rather connected two clauses. In (10–11), below, the mouthing starts at the last sign of the first phrase and is spread over the first sign of the second phrase:

(10) [RSL]
Mouth: *vsë* _____ *v dru(gih)*
Gloss: ALL MORE OTHER
go(rodax) mg_____
CITY BE.NEG
Translation: 'Is this all? Have you been to any other cities?'
(RSLN-d2-s8-s9.eaf)

(11) [RSL]
Mouth: *by(t')*____ *vpered(i)_a*_____
Gloss: THREE IX-1 BE AHEAD CL:PERSON-2
*dv(a)*___ mg_____
CHAT
Translation: 'There were three of us. I was (walking) ahead.
And the other two people were chatting.'
(RSLM-s2-s12-a13.eaf)

In (10), the mouthing of *vsë* 'all' starts at the only manual sign of the first phrase, ALL 'Is this all?,' and is spread from there over

the first sign of the second phrase, MORE. In (11), the mouthing of *a* 'but, and' starts at the last sign, AHEAD, of the phrase 'I was (walking) ahead' and is spread over the first sign, CL:PERSON-2 (a classifier predicate denoting two people), of the following phrase '. . . the other two people were chatting.' This example [as well as example (7), above] shows the spreading of a mouthing that does not have a designated manual source. Note that both signs, AHEAD and CL:PERSON-2, have their own semantically congruent mouthings which accompany them. The mouthing *a* 'but, and' finds a place between them, connecting the end of the sign AHEAD and the beginning of the sign CL:PERSON-2.

The mouthing of *a* is a silent articulation of the Russian conjunction *a*, which can denote coordination (the meaning 'and') or contrast (the meaning 'but'). When used at the beginning of a sentence, the Russian word *a* can perform the discursive function of the connective, ensuring the coherence of the narrative and marking the continuation of the speaker's turn. In this sense, it is functionally close to the English markers *and, but* and *or* (Schiffrin, 1987; Chafe, 1994; Fraser, 1996). Examples like (11) allow us to put forward a preliminary hypothesis that RSL has borrowed this strategy of connecting utterances. In order to signal that the turn of the speaker is still not over, a signer can mouth the conjunction *a* 'but, and' over the sentence boundary, or just spread the mouthing from the last sign of the first phrase to the first sign of the next phrase, as in example (10). Only in this function is the spreading of a mouthing that does not have a designated source sign possible. Moreover, in this function, a mouthing can spread from a functional sign to a content sign. In our sample set, we attested multiple instances of mouthings spreading regressively from the conjunction BUT (the first sign of a following sentence) to verbs, adverbs and nouns.

The crucial difference between the use of such markers in spoken Russian and the RSL strategy lies in their corresponding frequencies. While Russian speakers use connectives such as *a* 'and, but,' *i* 'and' or *no* 'but' on a regular basis, RSL users do not seem to do so very frequently. It is possible that the spreading of a mouthing as a discursive connective has a secondary status to such sign language internal markers as, for example, the weak hand hold (see Kimmelman, 2014). More data is needed in order to confirm the function of this type of spreading and to establish its role in RSL discourse.

Summary

To sum up the findings of this section, we have seen that mouthings in RSL are relatively infrequent (with a 44% occurrence rate) when compared to other sign languages for which comparable corpora exist. We interpret this as an indication of cross-linguistic variation in the domain of mouthing. Another interesting finding is the prevalence of reduced mouthings in the RSL corpus (75% of all instances).

Emulation of the Auslan study enabled a cross-linguistic comparison of the distribution of mouthings in RSL over signs of different grammatical classes. Our RSL data in many ways confirm earlier findings on the occurrences of mouthing in relation to grammatical class. To demonstrate that different sign types also exhibit very diverse rates of co-articulation with mouth actions, we contrasted the frequency of their occurrence in tandem with fingerspelled elements versus with SASSes. While fingerspelled signs strongly favored co-articulation of mouthings, SASSes were only very seldom accompanied by them.

With regard to spreading patterns, we found that the most common type observable for mouthings in RSL is the progressive one, but mouthings were also observed to be spread regressively. Moreover, we showed that mouthings are spread, for the most part, from content signs to functional signs. However, we also attested instances of spreading in the opposite direction, which can be connected to a specific function that this spreading performs in the discourse as a means of indicating that one's turn is not yet over.

NEW INSIGHTS INTO THE FUNCTIONS OF MOUTHINGS

The previous section described various aspects of the form of mouthings in RSL and placed them in a typological context. This section focuses on the functions that mouthings perform in RSL. It firstly enumerates the functions that have already been established in the data from other sign languages and then discusses an additional function that has not been attested before, namely disambiguation between different sign types.

Mouthing and Degrees of Lexicalization

Russian Sign Language mouthings serve a wide range of functions, most of which have already been attested in other sign languages. These are the phonological function, the prosodic function and the grammatical function. The phonological function, i.e. lexical disambiguation, can be illustrated by means of the RSL sign in **Figure 6**, below. The manual part of this sign involves two vertical flat hands that simultaneously move towards and away from each other several times.

Depending on the accompanying mouthing, this sign can have the meanings: 'weather' (with a mouthing of *pogoda*), 'climate' (mouthing: *klimat*) or 'fate' (mouthing: *sud'ba*). While the first two meanings are connected by a metonymic relationship (a temporal versus a permanent property) and can be interpreted as two meanings of a polysemous sign, the third one does not have an obvious semantic relationship to the former two and therefore represents a clear case of a different lexeme.

The prosodic function of syntactic binding was discussed in Section "Spreading Patterns" on spreading patterns, above. Examples (5–9) showed how the spreading of mouthings contributes to breaking up a chain of signs into rhythmically and intonationally coherent chunks. Finally, the grammatical function could be seen in the distribution patterns of mouthings with different parts of speech (**Figure 4**). Similar to in Auslan and NGT, mouthings in RSL have a tendency to co-occur with nouns and adjectives. This is in line with the finding of Kimmelman (2009) that, in RSL, mouthings constitute one of the phonological mechanisms that help to distinguish between nominal and verbal signs.

The inclusion of partially-lexicalized manual signs in the sample set allowed us to discover a new function that mouthings can have in a language, namely that of disambiguating between

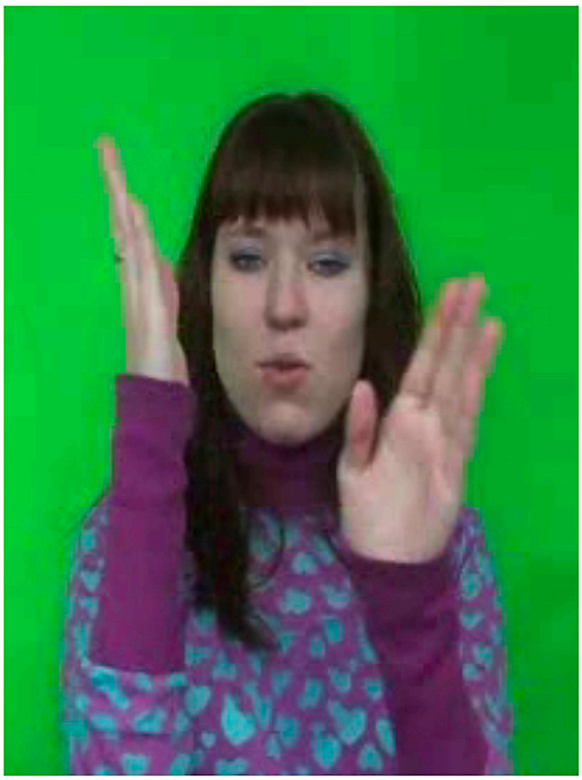


FIGURE 6 | RSL sign weather. Reproduced with permission from Svetlana Burkova (Novosibirsk State Technical University), available at the online corpus of Russian Sign Language, http://rsl.nstu.ru/.

signs of different types. Our data on the co-occurrence of mouthings with partially-lexicalized signs come from the 'Spot-the-difference' corpus, described in Section "Research Questions," above. This corpus provided 598 instances of SASSes to the sample set. It is important to understand, however, that, with respect to sign type, SASSes do not represent a homogeneous group in RSL. Rather, they can occupy different positions on the "lexical continuum". In employing the notion of this continuum, we follow usage-based approaches to sign language linguistics, according to which signs (or parts of signs) can be at various degrees of entrenchment into a speaker's linguistic knowledge (Lepic, 2019). We see fully-lexicalized and partially-lexicalized signs as extremes of the lexical continuum and we acknowledge the existence of signs that represent intermediate cases.

Irrespective of their position on the continuum, the manual components of SASSes iconically depict the visual characteristics of objects. The difference between more- versus less-lexicalized SASSes lies in the nature of the meaning they express. While the meaning of prototypical partially-lexicalized SASSes is compositionally formed out of the meanings of their sub-sign elements, more-lexicalized SASSes have non-compositional semantics. **Figure 7** represents a typical partially-lexicalized SASS.

This sign appears in Example (12) and describes a tall conical vase. The meaning of this sign is formed by combining the meanings of its components: the closed handshapes at the beginning of sign production indicate a narrow hole on top of the vase, the open handshapes at the end of the sign show its wide bottom; the downward movement of the hands signals the vertical orientation of the object; the size of the movement indicates that the vase is tall; and the trajectory depicts the straight smooth shape of the vase's sides.

(12) [RSL]
V-A-S-E TWO **SASS:tall-vertical-conical**
SECOND SASS:triangular
'There are two vases, a conical vase and a triangular vase.'
(SASScorpus-s3-f2.eaf)

Figure 8, below, gives an example of a SASS that is located closer to the fully-lexicalized end of the continuum. This sign appears in (13) and denotes a chest of drawers. In the same way as in the previous example, the manual components of the sign describe various aspects of its visual characteristics, i.e. the flat hands denote the wide surfaces, the angular trajectory shows the shape of the object etc. However, the sign does not denote just any three-dimensional cubical object, but specifically a chest of drawers. This meaning cannot be arrived at from the elements of the sign, it is a non-compositional part of the semantics.

(13) [RSL]
TABLE NEAR LEFT **SASS:chest.of.drawers**
D-R-E-S-S-E-R
'There is a chest of drawers to the left of the table'
(SASScorpus-s1-f1.eaf)

We used the presence of non-compositional semantics as the main criterion for determining the status of the sign, i.e., whether it is more- or less-lexicalized. The two groups were unequal in size, with the former comprising 197 elements and the latter – 401 elements. Each sign was marked according to the type of mouth articulation that accompanied the manual part. The three options were: mouthing, mouth gesture and no mouth activity. The bar chart below shows the distribution of these options in the two groups of signs.

Figure 9 illustrates that the three types of non-manual activity are not evenly distributed across the two groups. While the absence of mouth action has a similar percentage in less-lexicalized versus more-lexicalized SASSes, the same cannot be said about mouthing and mouth gestures. Less-lexicalized SASSes exhibit a strong tendency to co-occur with mouth gestures. More-lexicalized SASSes do not show this tendency. Instead, they exhibit a predominance of mouthings. This observation is confirmed by a logistic regression model: the predicted probability of observing mouthing was 0.48 for more-lexicalized SASSes and only 0.05 for less-lexicalized SASSes (logit difference -2.76, $SE = 0.26$, $z = -10.5$, $p < 0.0001$).

Our data contain examples where the same manual sign was accompanied by a mouthing in one instance and by a mouth gesture in another. In the first case, it acts as a noun that denotes a concrete object and, in the second case, as an adjective that



FIGURE 7 | SASS:tall-vertical-conical (about a vase).

describes visual characteristics. For example, if two hands in the small-C shape are moving in opposite directions and are accompanied by a mouthing of *doska* 'plank,' then the sign represents the noun PLANK, which is located closer to the fully-lexicalized end of the continuum. If the same manual sign is accompanied by the mouth gesture /u/, then it represents a SASS with the meaning 'long, thin, narrow' and is located closer to the partially-lexicalized end of the continuum.

We interpret the function of mouthings in these examples as a newly discovered type of sign disambiguation. Prototypical examples of lexical disambiguation include a fully-lexicalized sign that can be accompanied by different mouthings, depending on the intended meaning (Boyes-Braem, 2001). In our case, the same manual sign can be accompanied either by a mouthing or by a mouth gesture and, consequently, receives either a fully-lexicalized or a partially-lexicalized interpretation. Moreover, the statistically confirmed tendency of mouthings to co-occur more often with more-lexicalized SASSes than with less-lexicalized ones allows us to hypothesize that mouthings represent one of the general phonological mechanisms for distinguishing between the two sign types.[11] Other mechanisms, discussed in Kyuseva (2019), include the presence versus absence of movement and the syllabic structure.

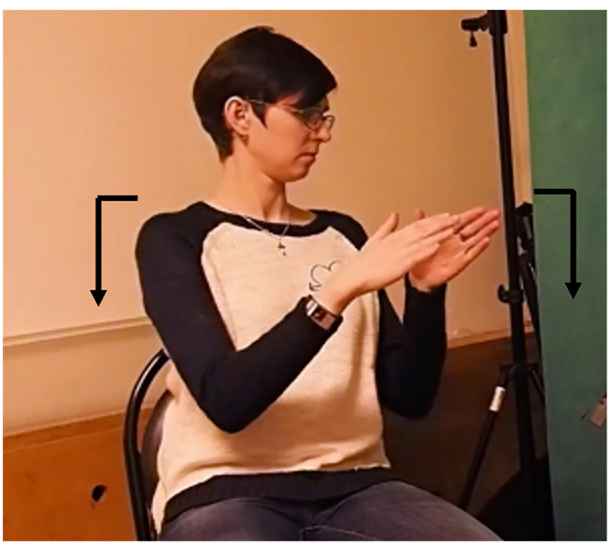


FIGURE 8 | Lexicalized SASS: chest of drawers.

Summary

This section described the functions that mouthings in RSL perform in a sentence. We attested the following functions: (1) lexical disambiguation, (2) prosodic binding, (3) a mechanism that helps to distinguish between nominal and verbal signs, and (4) disambiguation between different sign types. The first three functions have been established for such languages as Auslan (Johnston and Schembri, 2007), Israeli Sign Language (Sandler, 1999), NGT (Crasborn et al., 2008), and several others. The last function has not previously been discussed in the literature.

NEW INSIGHTS INTO THE ORIGIN OF MOUTHINGS

This section is concerned with the most frequent type of mouthing found in the RSL corpus, namely reduced mouthing. We answer here our third question as to how and why the reduction of mouthings occurs in RSL. The findings of this research have led us to re-think and re-hypothesize the source of the mouthing phenomenon.

[11]It is important to keep in mind, however, that more-lexicalized SASSes act as nouns in a sentence, whereas less-lexicalized SASSes prototypically act as predicate adjectives. Therefore, one could argue that mouthing here has an already established role as a mechanism that helps to distinguish between nominal and predicate signs. In order to instead confirm our competing hypothesis that mouthing in these examples differentiates between fully- and partially-lexicalized signs, additional data from sign language classifier constructions are needed. In the case of classifier constructions, the change of the status from less- to more-lexicalized does not lead to a change of the sign's part of speech. Therefore, a more frequent co-occurrence of mouthings with fully-lexicalized classifier constructions would serve as evidence in favor of our hypothesis.

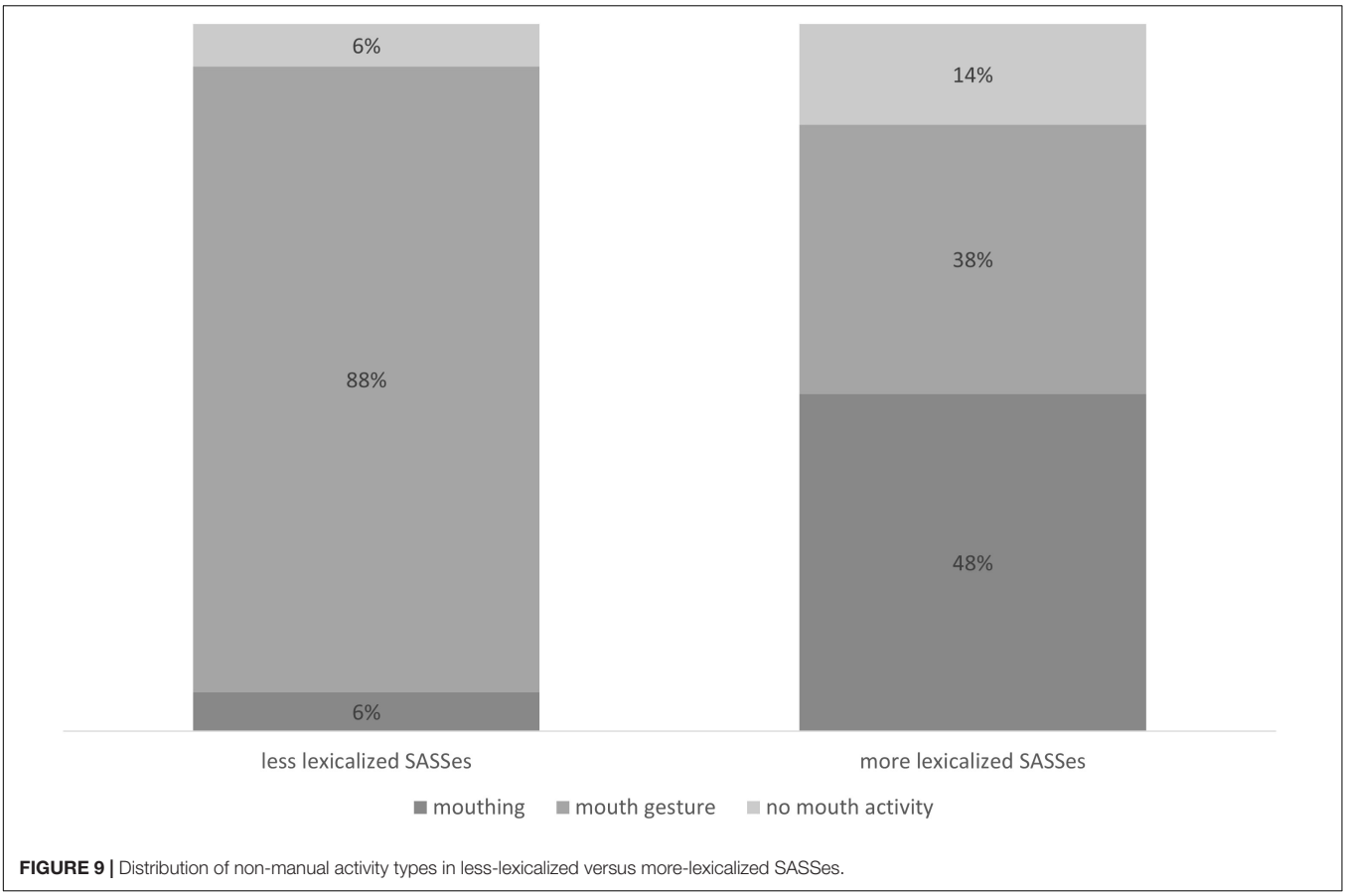


FIGURE 9 | Distribution of non-manual activity types in less-lexicalized versus more-lexicalized SASSes.

Linguists have never been in any doubt as to the origin of mouthings. They have always been understood as a spoken-language-based contact phenomenon (Boyes-Braem, 2001; Crasborn et al., 2008; Johnston et al., 2016). Thus, Bank et al. (2011, p. 250) believe that casual spoken Dutch is an important source of NGT mouthings. Nadolske and Rosenstock (2008) described ASL mouthings as being "derived from" or "influenced by spoken English," and Mesch and Schönström (2021) consider STS mouthings to be "borrowed from the spoken Swedish language." A recent study has defined mouthings as a "vocal production always borrowed from the surrounding spoken language, subvocalized or almost inaudible, and usually an approximation of the spoken word" (Bogliotti and Isel, 2021, p. 2).

In contrast, we propose in this section, based on the RSL data, that mouthing is not only a spoken-, but also a written-language-based contact phenomenon. Our suggestion is that the written modality may be a primary source for the occurrence of mouthings in RSL and possibly also in some other sign languages. Our study of the reduction patterns of mouthings in RSL (see section "Study of Reduced Mouthings"), as well as our analysis of the visual phonetic characteristics of vowel quality in RSL mouthings (see section "How Mouthings Differ From Spoken Russian Pronunciation"), have led us to conclude that mouthings in RSL are primarily based not on contact with the spoken modality (Russian speech), but rather on contact with the written modality (Russian orthography). In the following, we present the arguments supporting our claim.

Study of Reduced Mouthings

Reduced mouthings appear to be used quite differently in various sign languages, over various sign types and by various signers. In Auslan, for example, reduced mouthings are quite rare, according to Johnston et al. (2016, p. 21). In RSL, they are overwhelmingly frequent, based on our corpus data: 75% of all mouthings in the RSL corpus occur in their reduced form.

In contrast to DGS, where reduced mouthings occur more often with verbs than with nouns (Ebbinghaus and Heßmann, 1995), in our RSL data, 55% of all reduced mouthings occurred with nouns and only 34% with verbs. Our detailed analysis of 2000 randomly sampled RSL signs in the corpus was unable to confirm a tendency similar to the finding of Ebbinghaus and Heßmann (1995).

Two views exist in the literature as to why only parts of the spoken word are mouthed in sign language. The first hypothesis states that reduced mouthing conforms to the rhythm of the (mono)syllabic form of the manual sign (Sandler and Lillo-Martin, 2006, p. 105). The second hypothesis states that it is the stressed part of the spoken-language word that is usually mouthed, which indicates that signers are familiar with the rhythmic structure of spoken words (Bank, 2014, pp. 40–42). In the NGT corpus data, Bank (2014, p. 40) observed that the

reduction of mouthings only affected unstressed syllables such that the stressed syllable of the corresponding spoken Dutch word always remained visible. Similarly, the findings from the Auslan and DGS data showed that reduction in mouthings typically happened in the form of deleting word-final consonants and syllables with a schwa, which are usually unstressed in Germanic languages (Ebbinghaus and Heßmann, 1995; Johnston et al., 2016). The two hypotheses are, of course, not mutually exclusive: a mouthing can conform to the rhythm of the often monosyllabic form of its corresponding manual sign and, at the same time, be reduced to the stressed syllable of a surrounding spoken language word.

Our corpus observations reveal that mouthings in RSL do not necessarily occur in conformity with either of these hypotheses. Consider, for example, the RSL sign HELP. This sign is usually disyllabic (e.g. the number of sequential movements in its form is two in 73% of cases within the RSL corpus) and, in our data, this sign is never accompanied by a mouthing containing the stressed syllable of the spoken Russian word. It is rather accompanied by the first, unstressed syllable of the Russian word *pom*(*ogat'*) 'to help' or by the first two unstressed syllables *pomo*(*gat'*) (**Table 2**).

To follow up on this observation, we tested the two stated hypotheses. We use novel data by looking at reduced mouthings in RSL and ask which of the two hypotheses holds true. We thereby posed the following questions concerning the structure and contents of RSL mouthings:

(1) Do reduced mouthings conform to the rhythm of the (mono)syllabic form of the sign in RSL?

(2) Do reduced mouthings contain the stressed syllable of the equivalent spoken Russian word?

We analyzed 30 signs[12] in the RSL corpus, as listed in **Table 2**. The Russian translations of all these signs contain at least three syllables in their citation forms. Overall, we investigated 1400 tokens in detail with regard to the number of their sign movements and the form of the mouth actions they co-occur with in the corpus. The majority of these sign tokens (941) were accompanied by mouthings.

In testing the first hypothesis, we investigated whether the syllabic structure of a manual sign influenced the reduction pattern of an accompanying mouthing. According to the hypothesis, monosyllabic signs are usually accompanied by monosyllabic mouthings, and disyllabic signs should co-occur with disyllabic mouthings. Following Brentari (2019), we define sign language syllables in terms of the number of sequential movements in a sign's form. Reduplication of a sign's form thus generates another syllable. The difficulty in testing this hypothesis consists in obtaining an adequate number of disyllabic signs in the data. As is well known, sign languages exhibit a tendency toward a monosyllabic sign structure. In ASL, more than 80% of forms are monosyllabic, and only 17% are disyllabic (cf. Stokoe et al., 1965; Brentari, 1998). There has been no similar investigation of syllabic structure in RSL, but we were able to confirm the monosyllabic tendency through our corpus-based observations. Out of the 30 selected RSL signs (see **Table 2**), we interpret only eight signs as being disyllabic, as they were produced with a double movement in more than 50% of the cases in our corpus data. The majority of the signs in our sample set are monosyllabic (21). In **Table 2**, below, the monosyllabic signs (in the third column) are marked by a light grey color and the disyllabic signs (in the fourth column) by a dark grey color. One sign (CHEER, $n = 24$) may be considered mono- and disyllabic because it occurred monosyllabically in 46% of cases and disyllabically in 42% of cases within the corpus.

A glance at **Table 2** reveals that not all 21 monosyllabic signs were accompanied by a monosyllabic mouthing in all cases. Some monosyllabic signs do not co-occur with monosyllabic mouthings in the majority of their cases (e.g. more than 50% of all cases). Consider, as an example, the RSL sign INTERESTING. It is a monosyllabic sign (in more than 50% of all tokens) that was accompanied by a monosyllabic mouthing in only 39% of all cases, and by a disyllabic mouthing in 33% and a trisyllabic mouthing in 28% of cases. While monosyllabic signs did tend to be accompanied by a monosyllabic mouthing, disyllabic signs did not occur with a disyllabic mouthing in the majority of cases. Consider the disyllabic RSL sign NOVOSIBIRSK. It was accompanied by a monosyllabic mouthing of *nov* in 63% of all cases. Similarly, the disyllabic RSL sign MONKEY (see **Figure 10**) co-occurred with a monosyllabic mouthing of *ob* in 80% of all cases in the corpus.

Considering the data in **Table 2**, we can formulate the following hypothesis to test if there is a correlation between the syllable structure of signs (e.g. their number of movements) and the form of accompanying reduced mouthings (e.g. the number of their visible syllables).

H1: If a manual sign is disyllabic, its accompanying mouthing is also disyllabic.
If a manual sign is monosyllabic, its accompanying mouthing is also monosyllabic.

For this analysis, we calculated the percentage of all sign tokens in which only one syllable was mouthed (mouthed_1) and that of tokens in which more than one syllable was mouthed (including the few cases of full mouthing) (mouthed_2+). In order to quantitatively assess whether the proportion of mouthed syllables (i.e. one vs. two or more) allows us to draw any conclusions about the syllabic structure of the sign (namely the number of its constitutive movements), we used linear mixed models (performed with Anova) in the R software package (R Core Team, 2016). This entailed fitting two simple linear regression models, which tested, for each mouthing, whether the number of mouthed syllables was a predictor of the syllabic structure of its co-occurring manual sign. In both cases, the two predictors (mouthed_1 and mouthed_2+; see **Supplementary Table 1**) were not significant, i.e. the proportion of one vs. two or more mouthed syllables was not a significant predictor of the number of movements constituting the manual sign. Thus, we could not confirm a link between the syllabic structure

[12]These 30 RSL signs were the most frequent ones among RSL signs with at least a three-syllable citation form in spoken Russian.

TABLE 2 | Thirty RSL signs showing their syllabic structure and the form of the co-occurring mouthings.

RSL gloss (number of tokens)	Russian citation form	Monosyllabic sign (single movement)	Disyllabic sign (double movement)	Full mouthing	1st part of the word [1st syllable or 1st letter(s)]	1st-2nd syllable	2nd syllable	2nd-3rd syllable	3rd syllable	1st-3rd syllable
GRANDMOTHER (*n* = 41)	*ба*бушка *babuška*	63%	28%	10%	59%	13%	0%	0%	0%	0%
SPEAK (*n* = 21)	*говорить* *govorit'*	57%	30%	5%	48%	28%	14%	0%	5%	0%
GIRL (*n* = 64)	*де*вушка *devuška*	61%	36%	0%	74%	23%	3%	0%	0%	0%
WOOD (*n* = 19)	*де*рево *derevo*	71%	29%	0%	60%	40%	0%	0%	0%	0%
INTERESTING (*n* = 38)	*интересный* *interesnyj*	76%	24%	0%	39%	33%	0%	0%	0%	28%
COMPUTER (*n* = 22)	*комьютер* *komp'juter*	43%	57%	0%	72%	28%	0%	0%	0%	0%
BEAUTIFUL (*n* = 19)	*краси*вый *krasivyj*	95%	5%	0%	50%	28%	5%	11%	6%	0%
STORE (*n* = 22)	*магазин* *magazin*	77%	18%	0%	73%	27%	0%	0%	0%	0%
SMALL (*n* = 63)	*ма*ленький *malen'kij*	95%	5%	0%	85%	5%	10%	0%	0%	0%
MAN (*n* = 46)	*мужчи*на *muždina*	57%	37%	0%	92%	4%	0%	4%	0%	0%
FOR-EXAMPLE (*n* = 93)	*напри*мер *naprimer*	33%	65%	0%	78%	5%	11%	4%	2%	0%
NOVOSIBIRSK (*n* = 22)	*Новоси*бирск *Novosibirsk*	23%	77%	0%	63%	17%	12%	0%	0%	0%
NORMAL (*n* = 22)	*нор*мальный *normal'nyj*	59%	23%	0%	59%	41%	0%	0%	0%	0%
MONKEY (*n* = 21)	*обезь*яна *obez'jana*	33%	67%	0%	80%	20%	0%	0%	0%	0%
RETURN (*n* = 39)	*об*ратно *obratno*	82%	18%	0%	64%	31%	5%	0%	0%	0%
COMMUNICATE (*n* = 25)	*об*щаться *obščat'sja*	44%	39%	14%	76%	10%	0%	0%	0%	0%
CLASSMATE (*n* = 12)	*одно*классник *odnoklassnik*	75%	25%	0%	100%	0%	0%	0%	0%	0%
TENT (*n* = 24)	*па*латка *palatka*	100%	0%	0%	67%	33%	0%	0%	0%	0%
HELP (*n* = 33)	*помо*гать *pomogat'*	21%	73%	0%	64%	36%	0%	0%	0%	0%
CORRECT (*n* = 23)	*пра*вильный *pravil'nyj*	100%	0%	0%	100%	0%	0%	0%	0%	0%
WORK (*n* = 41)	*ра*ботать *rabotat'*	42%	51%	0%	77%	15%	0%	0%	0%	0%
CHEER (*n* = 24)	*ра*доваться *radovat'sja*	46%	42%	0%	40%	27%	7%	0%	13%	13%
CHILD (*n* = 30)	*ребё*нок *rebënok*	53%	42%	0%	45%	40%	5%	10%	0%	0%
DOG (*n* = 48)	*со*бака *sobaka*	38%	58%	15%	38%	32%	15%	0%	0%	0%
CALM (*n* = 18)	*спо*койный *spokojnyj*	100%	0%	0%	88%	12%	0%	0%	0%	0%
TRY (*n* = 17)	*ста*раться *starat'sja*	76%	24%	6%	41%	29%	18%	0%	6%	0%
COLD (*n* = 17)	*хо*лодный *xolodnyj*	23%	53%	0%	100%	0%	0%	0%	0%	0%
GOOD (*n* = 42)	*хо*роший *xorošij*	86%	12%	9%	19%	24%	26%	11%	2%	0%
PERSON (*n* = 20)	*чело*век *čelovek*	100%	0%	41%	59%	0%	0%	0%	0%	0%
FEEL (*n* = 35)	*чувст*вовать *čuvstvovat'*	57%	43%	0%	94%	6%	0%	0%	0%	0%

Underlined syllables (marked red) in the second column are stressed in spoken Russian.



FIGURE 10 | RSL sign monkey. Reproduced with permission from Svetlana Burkova (Novosibirsk State Technical University), available at the online corpus of Russian Sign Language, http://rsl.nstu.ru/.

of a given sign and the number of syllables visible in co-occurring mouthings though our statistical analysis of the RSL corpus data at hand.

For the above statistical analysis, each of the 30 signs that we evaluated (see **Table 2**) had been interpreted beforehand as mono- or disyllabic on the basis of the sign's number of constitutive movements in the majority of its tokens. If, for example, a sign had more than 50% disyllabic tokens in the corpus, it was interpreted as a disyllabic sign in this analysis. It must be admitted, however, that some signs, such as WORK, CHEER or CHILD, appeared in the corpus as mono- or disyllabic in almost equal proportions. It is therefore of questionable validity to define them as being one or the other. With this drawback in mind, we supplement our statistical analysis by a detailed qualitative analysis of each token and find only a very weak relationship between a manual sign's syllable structure and the number of co-occurring mouthed syllables. As **Figure 11** shows, both mono- and disyllabic signs tended to pair with monosyllabic mouthings, namely in 84 and 73% of all cases, respectively. There was only a slightly heightened tendency for disyllabic mouthings to occur with disyllabic rather than monosyllabic signs. We measured the strength of the correlation between the variables by computing Cramér's *V* (see **Figure 11**). The resulting value of 0.12 indicates a small effect size and gives an idea of the strength of the association within a range from 0 to 1. We interpret this association as being too weak to confirm the syllabic structure hypothesis (H1) and conclude that RSL signs prevailingly co-occur with monosyllabic mouthings irrespective of their syllabic structure.

Having found no significant correlation between the syllabic structure of manual signs and the reduction patterns of mouthings, we now turn to the second hypothesis. It posits that the stressed part of the spoken-language word is the part that is usually mouthed in sign languages (Bank, 2014, pp. 40–42). Up to now, the reduction of mouthing has been studied only for sign languages that are surrounded by Germanic spoken languages such as English, German or Dutch. The word-stress patterns of these West-Germanic spoken languages are very similar to each other (Domahs et al., 2014). Research shows that the potential default stress positions in German, English, and Dutch are the first (Levelt et al., 1999; Schiller et al., 2006) or the penultimate syllable (Eisenberg, 1991; Wiese, 1996).

Russian Sign Language is a sign language surrounded by a spoken language with variable stress. The position of the main stress in spoken Russian is largely unpredictable from a synchronic perspective. It can fall on a syllable in any position, depending on the word in question: e.g. on the first syllable, as in *prínter*[13] 'printer,' on the second syllable, as in *proféssor* 'professor,' on the third syllable, as in *inženér* 'engineer' etc. The stress is, moreover, movable and distinctive in the sense that different morphological forms of a lexeme may exhibit different syllable structures, as in (14).

(14) *stól* 'table-NOM', *stolá* 'table-GEN' [Russian]

The position of stress in spoken Russian can also differentiate morphological forms, such as in *profféssora* 'professor-GEN.SG' vs. *professorá* 'professor-PL.NOM'. RSL therefore lends itself well to investigating the potential relationship between the position of stress in a spoken word and the reduction pattern of a corresponding mouthing. The data in **Table 2** suggest that reduced mouthings in RSL do not necessarily preserve the stressed syllable of the respective spoken Russian word. Our analysis of the 30 selected RSL signs (see **Table 2**) revealed that 17 signs occurred with mouthings containing only syllables that are not stressed in spoken Russian. Consider again the RSL sign MONKEY as an example (see **Figure 10**). The spoken Russian word for 'monkey' consists of four syllables and is always stressed on the third one (*o.bez'.já.na*). At the same time, more than 80% of this sign's tokens in the RSL corpus were accompanied by a monosyllabic mouthing of the corresponding spoken word's first syllable only, while the remaining 20% of sign tokens co-occurred with a mouthing of the respective word's first and second syllable. Thus, the sign MONKEY was never accompanied by mouthing of the spoken word's stressed syllable. Another pertinent example is the RSL sign STORE. The spoken Russian word 'store' consists of three syllables, and the stress falls on the third one (*ma.ga.zín*). The majority of this sign's tokens (73%) again appeared with a monosyllabic mouthing of the spoken word's first syllable *ma*. The remaining 27% of this sign's tokens co-occurred with a disyllabic mouthing of the first two unstressed syllables. This is the predominant pattern suggested by our data, as shown in **Table 2**. Eighteen out of 30 RSL signs were accompanied by first-syllable mouthings in more than 50% of all cases while that same first syllable is not stressed in the corresponding spoken Russian words. Only six RSL signs (MOTHER, GIRL, WOOD, SMALL, CORRECT, CHEER) were accompanied by a first-syllable mouthing where that first syllable *is* stressed in the spoken Russian word. This appears to be a coincidence. Four RSL signs (CHILD, DOG, TRY, GOOD) co-occurred with mouthings that did not exclusively contain a stressed syllable. Consider, for instance, the RSL sign CHILD. It corresponds in spoken Russian

[13]We follow the Russistic convention of marking stress with an acute. Syllables bearing the letter <ë> also carry the stress.

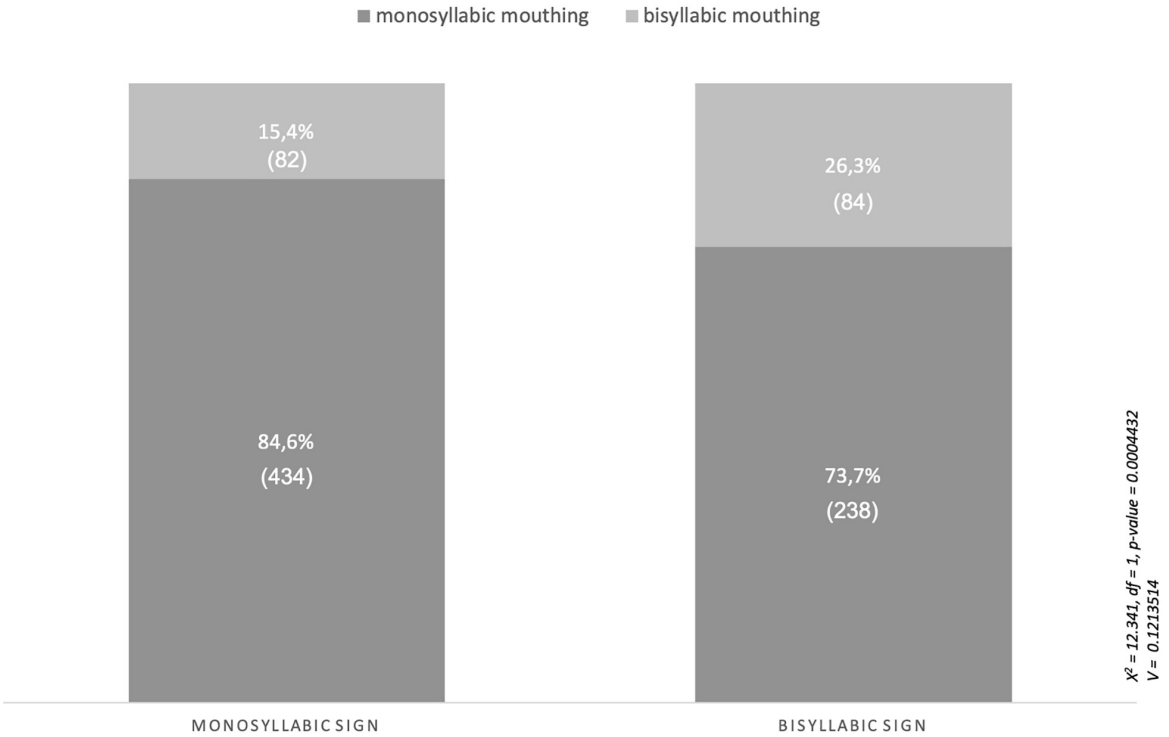


FIGURE 11 | The number of monosyllabic and disyllabic RSL signs corresponding to monosyllabic and disyllabic mouthings.

to a trisyllabic word, which is stressed on the second syllable (*re.bë.nok*). The mouthings that accompanied this sign in the corpus reproduced only the first syllable in 45% of all cases, the first and second syllable in 40% of cases, only the second syllable in 5% of cases and the second and third syllable in 10% of cases.

The results of our data observation suggest that first syllables tend to be mouthed in RSL irrespective of the stress pattern of the corresponding word in the spoken language. In all 30 RSL signs under investigation, unstressed syllables were mouthed more often than stressed ones. To verify our initial observation, we tested the following hypothesis for the same 30 selected RSL signs:

H1: If a syllable is stressed, it is mouthed in RSL.

We added two new variables, "same_syl" and "diff_syl," to the dataset (see **Supplementary Table 2**). The variable "same_syl" represented the percentage of cases where the same syllables visible in the RSL mouthing are stressed in spoken Russian. The variable "diff_syl" represents the percentage of cases where the syllables visible in the RSL mouthing are not stressed in spoken Russian. Because the data in these variables was not drawn from a normal distribution, we used the (Wilcoxon-) Mann–Whitney test. The *p*-value was below 0.05[14], which means that the difference observable between the two variables was not due to chance. The above hypothesis (H1) thus could not be confirmed. A given syllable does not have to be visible in a mouthing just because its counterpart is stressed in the corresponding spoken Russian word. The syllables visible in RSL mouthings are most often unstressed.

Our analysis of reduced mouthings in RSL could not confirm the existing hypotheses for why only certain parts of a corresponding spoken word are mouthed in sign language. With regard to the structure of reduced mouthings, our study shows that they do not conform to the rhythm of the syllabic form of the co-occurring sign. Both monosyllabic and disyllabic signs tend to be accompanied by monosyllabic mouthings of the first syllable of the respective spoken Russian word. This finding suggests that signers are not drawing upon knowledge of the rhythmic structure of Russian words. The data show that the word-initial segments are the ones being retained in RSL reduced mouthings. One possibility is that signers rely on the written form and thus proceed from a representation of the beginning of a written word (This idea will be reinforced by our second finding, in "How Mouthings Differ From Spoken Russian Pronunciation," below). We have furthermore shown that reduced mouthings do not mandatory reproduce the stressed part of the equivalent spoken language word, but rather tend to be constrained to the first syllable, irrespective of the stress pattern of the surrounding spoken language.

How Mouthings Differ From Spoken Russian Pronunciation

Our investigation of mouthings in RSL has, so far, revealed that they do not always follow the phonological patterns of the spoken language and therefore cannot be regarded simply as borrowings

[14] p = 5.021e-08.

of spoken language words or elements. In this section, we show that mouthings in RSL differ greatly from the observable pronunciation of spoken Russian words. This means that the lip movements of RSL mouthings differ from the lip movements of their spoken standard-Russian counterparts. As was already mentioned in "Study of Reduced Mouthings," reduced mouthings are not systematically reduced to the stressed syllables of the spoken words. They are typically reduced to the first syllable or even the first segment of the respective spoken word, regardless of its stress pattern. This section shows that mouthings in RSL pattern more closely after written Russian. Our findings reveal that RSL mouthings do not exhibit vowel reduction patterns, which are obligatory present in spoken standard Russian.

Conforming to the prominent phonological feature of vowel reduction, unstressed vowels in Russian are pronounced differently to the same vowel phonemes in stressed position (Yanushevskaya and Bunčić, 2015). The unstressed non-high vowels /a/, /o/ and /e/ are reduced to [ɪ] after soft onsets and to [a] elsewhere[15], as illustrated by the examples in (15).

(15) [Russian]

/a/ → [ɪ]	*пять pjáť*	[pʲatʲ] 'five' (Nom.)
	пяти́ pjatɪ́	[pʲiˈ ti] (Gen.)
/o/ → [ɪ]	*сёстры sëstry*	[ˈ sʲo. . .] 'sister' (Nom.Pl.)
	сестра́ sëstrá	[ˈ si. . .] (Nom.Sg.)
/o/ → [a]	*стол stól*	[stol] 'table' (Nom.Sg.)
	стола́ stolá	[staˈ la] (Gen.Sg.)
	дом dom	[dom] 'house'(Nom.Sg.)
	дома́ domá	[daˈ ma] (Nom.Pl.)
	во́дный vódnyj	[ˈ vodnɨj] 'water-' (Adj.)
	вода́	[vaˈ da] 'water' (Nom.Sg.)
	боль	[bol] 'pain' (Nom.Sg.)
	боли́т	[baˈ lit] 'hurts' (3p.Sg.)
	больни́ца bol'nɪca	[balʲ nica] 'hospital' (Nom.Sg.)

Because of the vowel reduction phenomenon, the orthographic representation and the pronunciation of vowels vary greatly from each other in Russian. Thus, although the words *vodnyj* and *voda* are both spelled with an *o*, the first syllable of the former is stressed and pronounced as [vo], while the first syllable of the latter is unstressed and thus pronounced as [va]. The difference between these vowels can easily be perceived upon the lips when pronounced: [a] is a central open unrounded vowel, [ɪ] is a front closed unrounded vowel, and [o] is a half-closed rounded vowel.

Research shows that lip rounding is the most easily visible labial feature. Both hearing and deaf people appear to be very good at visually perceiving such prominent features as the presence of lip rounding in vowels (Traunmüller and Öhrström, 2007). Assuming that signers are influenced only by visual information pertaining to lip movement in their production of mouthings, and given that they can easily detect the difference between the presence of lip rounding, as in [o], and the absence of lip rounding, as in [a], we can expect that the spoken Russian vowel reduction pattern would also be seen in mouthings. Thus, the sign VODA 'water' should be accompanied by mouthings with an unrounded vowel in the first syllable: namely [va] and not [vo], as is coded by orthographic *vo-*. Surprisingly, our corpus study shows a quite different pattern. RSL mouthings consistently fail to reproduce the vowel reduction patterns obligatory to the standard spoken Russian words that these mouthings are supposedly borrowings of. Thus, what we actually find is that the sign VODA 'water' is accompanied by a mouthing of [vo] in alignment with Russian orthography. It is a reduced mouthing with a rounded vowel, whereas the Russian pronunciation of the same word is [vaˈ da] (featuring an unrounded vowel in the first syllable due to vowel reduction). Similarly, we observed in RSL mouthings numerous prominent visual cues indicating lip rounding in cases where there is no lip rounding of the corresponding spoken Russian vowels. **Figure 12** presents images showing lip rounding in various RSL mouthings and a phonological transcription of the spoken Russian counterpart in contrast. The Russian pronunciations and the RSL mouthings evidently vary with regard to vowel reduction.

In all of the mouthings depicted in **Figure 12**, the lips were rounded. These examples are not exceptions. The RSL corpus exhibits numerous examples of mouthings that differ in this respect from standard Russian pronunciation. **Supplementary Figure 1** shows that the six randomly chosen RSL signs most often co-occurred with mouthings containing a rounded vowel, which means they are not subject to vowel reduction patterns. The most variation was found across signers in mouthings of 'water' (full: [voˈ da] ∼ reduced: [vaˈ da]), although the mouthings in the RSL corpus nevertheless overwhelmingly lacked vowel reduction (i.e. [voˈ da]). There are also numerous cases of full, i.e. unreduced, mouthings in the corpus that lack vowel reduction: e.g., *ogon'* [oˈ gonʲ] 'fire,' *odežda* [oˈdʲeʒda] 'clothes' or *xotjat* [xoˈ tʲat] 'want.3PL'[16]. This finding suggests that the articulatory shape of mouthings in RSL is not likely under the influence of visual information pertaining to lip movements for equivalent words in the spoken Russian language. We therefore suggest that signers of RSL are more heavily influenced in their mouthing

[15]It is worth stating for the benefit of critical readers familiar with Russian phonology that this is of course a simplified explanation of the phenomenon.

[16]This observation provides even more support for our thesis. Otherwise, one could entertain another possibility. Signers of RSL could have internalized the phonological rules of spoken Russian vowel reduction (given their heightened lip-reading ability) such that they would then apply them within their own reduced mouthings. So, for example, any monosyllabic mouthing (e.g. *sos(ed)* 'neighbor,' reduced to *sos*) with an underlying /o/ would necessarily be produced with a rounded [o] because monosyllabic prosodic units are always stressed in Russian (e.g. *stol* [stol] 'table'). To produce a form with [a] in such a case would be counter to the laws governing vowel reduction. This requires, however, that the visible segments would have been (re)processed by signers as a complete prosodic unit, in addition to their having internalized the rules of Russian vowel reduction. The fact that we find instances in which unreduced mouthings fail to exhibit vowel reduction patterns (e.g. a mouthing that resembles [oˈ gonʲ] rather than [aˈ gonʲ]) overrides both assumptions.



FIGURE 12 | RSL signs and mouthings with rounded vowels. Reproduced with permission from Svetlana Burkova (Novosibirsk State Technical University), available at the online corpus of Russian Sign Language, http://rsl.nstu.ru/.

patterns by Russian orthography than by the visual information from lip movements in spoken Russian.

Summary

This section presented our study of the most frequent type of mouthings in RSL, namely the reduced mouthing. We discussed the question of how and why mouthing reduction occurs in RSL and tested, based on our data, two hypotheses that have been postulated in the prior literature.

First, we found no statically significant correlation between the syllable structure of the manual sign (e.g., the number of its movements) and the form of the reduced mouthing (e.g., the number of its visible syllables), as has been hypothesized. Monosyllabic signs do not always occur with monosyllabic mouthings, and disyllabic signs are not even tendentially accompanied by disyllabic mouthings. Both mono- and disyllabic RSL signs tend to be accompanied by a monosyllabic mouthing. Reduced mouthings thus do not conform to the syllabic structure of the manual sign. Overall, our analysis suggests a tendency towards a monosyllabic mouthing. We did observe that disyllabic mouthings accompanied disyllabic signs more often than they did monosyllabic signs, but we found no strict relationship as would have confirmed the tested hypothesis.

Second, we scrutinized which of a spoken word's syllables it is that are mouthed by RSL signers. We thereby challenged the hypothesis that mouthing always includes a stressed syllable, to which our data do not lend any support. In RSL, reduced mouthings do not necessarily reproduce the stressed part of the equivalent spoken Russian word, but rather tend to be constrained to the first syllable or even the first element of the word in question. In most cases, it was the first syllable of the respective lexical item that was reproduced. Accordingly, a significant number of signs in the RSL corpus were accompanied by mouthings containing syllables that are unstressed in spoken Russian.

Our further observations revealed that RSL mouthings differ in their articulatory appearance from the pronunciation of the equivalent elements in spoken standard Russian. RSL mouthings lack phonetic reduction of vowels, i.e. systematic changes in the acoustic quality of vowels as a result of the position of stress. Phonetic vowel reduction is obligatory present in spoken Russian and is therefore one of the sources of distinction between the spoken and written Russian language.

These findings have led us to re-think the origin of mouthing and additionally posit the written modality as one of its possible sources. We conclude based on the analyses presented in "Study of Reduced Mouthings" and "How Mouthings Differ From Spoken Russian Pronunciation" that the source for mouthings in RSL and, possibly in other sign languages as well, is a combination of the surrounding spoken and written language. Mouthings should therefore be considered not only a spoken- but also a written-language-based contact phenomenon.

DISCUSSION

Our corpus-based study offers new insights into the use of mouthings in RSL, in particular yielding interesting discoveries in terms of frequency rates, functions, distribution and spreading patterns, as well as the source of this cross-modal contact phenomenon. Specifically, our findings for RSL reveal quantitative differences between sign languages in the use of mouthings, which have previously been reported to comprise the most frequent category of all mouth actions in various sign languages (i.e., NGT or Auslan). A markedly different pattern was observed for RSL in this study. We could thus answer our first research question with respect to the frequency of mouthings by observing that they are just as frequent in the RSL corpus as are mouth gestures, at a rate of 44%. This confirms the intuitions of the RSL signers who reported to us that they use fewer mouthings in their RSL signing than they do in other sign languages. Based on this finding and given the cross-linguistic comparability of our data (a large corpus, various text-types, similar annotations, analogous data analysis), we were able to conclude that sign languages differ in terms of the prevalence of mouthings. Our findings additionally suggest that sign languages also systematically differ with respect to the form of their mouthings. A recent STS corpus study showed that less than a quarter of all mouthings were reduced (20%). We have shown that mouthings in RSL appear mainly in their reduced form (75%). Thus, the use of mouthing types (full vs. reduced) differs cross-linguistically. The differences between the frequency of reduced forms of mouthing in RSL and STS might relate to the relative morphological complexity of spoken Russian in contrast to the relative poverty of inflectional morphology in spoken Swedish[17]. This idea should be investigated by future studies.

Our analysis of the distribution of mouthings in relation to grammatical class and sign type in many ways confirmed earlier findings reported for other sign languages. It was shown that mouthings in RSL most frequently accompany function words (auxiliaries, prepositions, conjunctions and *wh*-question words), numbers and nouns. Spatial verbs, discourse markers, interjections, negators and locatives most strongly disfavor mouthings and more readily co-occur with mouth gestures or with no mouth action at all.

Our findings lend support to those of Johnston et al. (2016) in that mouthings differ greatly over various sign types. Our data suggest that mouthing may be an obligatory formational component of fingerspelling, as fingerspelled elements in RSL were shown to co-occur with mouthings in 98% of all cases. This result is also in line with previous studies. We furthermore expanded our scope to include SASSes, which have not been analyzed in conjunction with mouthings in earlier research. By contrasting fingerspelled elements with SASSes, we showed that the use of mouthings in RSL can really only be properly considered in relation to various sign types. While fingerspellings almost always co-occur with mouthings, SASSes only rarely do so. This finding additionally underlines the strength of large corpus data for investigating mouthings.

[17] We thank one of our reviewers for this suggestion.

Beyond the frequency and distribution of mouthings, we explored their spreading patterns in RSL for the first time. The results presented here show similarities with other sign languages in the prevalence of progressive spreading. However, regressive spreading was shown to be possible in RSL when the mouthing spreads over a pointing sign. In addition to such standardly observable spreading from a (prototypically content-expressing) sign to one or more adjacent (prototypically functional) signs, we encountered spreading of free mouthings, as well as spreading that extend away from functional signs. These non-prototypical patterns are possible when a spreading connects two phrases, thus contributing to the coherence of the discourse.

Our second research question concerned the functions performed by mouthings. Based on our analysis, we were able to identify and describe a new function, namely disambiguation between different sign types. A mouthing performs this function when it co-occurs with a manual item that can otherwise be interpreted as either a fully-lexicalized or a partially-lexicalized sign, depending on its context. The co-occurrence of a mouthing together with the manual item functions as one of the indicators that it should be interpreted as a fully-lexicalized sign.

Pursuant to our third research question, we explored how and why mouthing reduction occurs in RSL. Our comprehensive analysis did not confirm the syllabic-structure hypothesis. Against anticipations, mouthings do not conform to the rhythm of the syllabic structure of accompanying manual RSL signs. We found that RSL signs prefer monosyllabic mouthings irrespective of their own syllabic structure.

The hypothesis that the stressed part of a spoken word is always reproduced in mouthings also could not be confirmed. Our data revealed that reduced mouthings in RSL do not systematically reproduce the stressed part of the equivalent spoken language word. We found instead that reduced mouthings mainly consist of the first syllable, irrespective of the stress pattern observable in spoken Russian. In addition, our study revealed that Russian pronunciation and RSL mouthings vary with respect to vowel reduction patterns and that, in this respect, mouthings pattern after Russian orthography more closely than the pronunciation of spoken Russian.

Given our results, and contrary to earlier assumptions that mouthings originate as borrowings of words from a surrounding spoken language through the observation of speakers' lip movements, we suggest that RSL signers are influenced in their mouthing production also by written language. We suspect that other sign languages may not be very different in this regard, but we must await further research on languages in which spelling and pronunciation do not correspond in a predictable way. Moreover, studies on the acquisition of mouthings[18] by preschool children prior to their exposure to the written language are also necessary in order to fully support our thesis. It is possible that children learn to mouth twice in their life, as has been suggested by Padden (2005) with respect to fingerspelling. First, a child may learn to use mouthing patterns as whole units, mimicking

[18] Studies on the acquisition of mouthings are virtually nonexistent (but see a recent study by Woll et al., 2019).

the lip movements of other signers or speakers. Later, when reading and writing become more prominent in everyday life, the child begins to understand mouthings as being made up of articulations that correspond to the letters of the alphabet. Accordingly, the child then learns mouthings a second time – this time in close connection to words in their written form.

Surely, some examples contradicting this claim can be found. Not all RSL mouthings lack the vowel reduction patterns of spoken Russian. Some high-frequency signs (e.g. WATER) do, at times, occur with vowel reduction features evident in the lip movements (see **Supplementary Figure 1**). This might vary from signer to signer based on the individual's proficiency in speechreading, their knowledge of the structure of linguistic sounds and how they are articulated in speech, their amount of exposure to, and the quality of, oral education and possibly other factors, which are yet to be investigated. Written language is an inevitable part of life for deaf people (at least in literate communities with access to formal education). Moreover, all signers display some degree of bilingualism, so we estimate that the impact of the orthographic representation of words is higher than that which occurs from observation of the lip movements performed in the speech of hearing people. In DGS, a similar mismatch between German pronunciation and DGS mouthings can be observed. Consider the examples of *Iphone* or *Dublin*. In the DGS Corpus, we can find the mouthings [ifon] and [dublin], which differ from the standard German pronunciations [ˈaɪˌfəʊn] and [ˈdʌblɪn]. Thus, with respect to the possibility that written language may serve as a source of the linguistic content drawn upon in mouthings, we propose that signers are guided in the articulation of their mouthings by both the orthographic form of a corresponding word and its pronunciation. Mouthings thereby reflect the constant situation of language contact between sign languages and their surrounding written and spoken languages, whereby the impact that a written language may have upon a sign language can evidently be stronger than previously assumed.

To conclude, the results of this quantitative corpus-based study contribute to our general understanding of mouthings and reveal that the multimodal practices of deaf signers are predicated upon a more complex interplay of signed, spoken, and written languages than has previously been thought.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/ **Supplementary Material**.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by German Science Foundation. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

AB: methodology, corpus investigation, writing of the sections "Frequency of Mouthings," "Distribution Over Grammatical Class and Sign Type," and "New Insights Into the Origin of Mouthings" and acquisition of funding. MK: methodology, elicitation analysis, and writing of the sections "Spreading Patterns" and "New insights into the functions of mouthings". AB and MK: conceptualization and writing the remaining sections. Both authors: conceptualization, analysis, writing and editing of this manuscript, read and agreed to the published version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.779958/full#supplementary-material

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The Contribution of Event-Related Potentials to the Understanding of Sign Language Processing and Production in the Brain: Experimental Evidence and Future Directions

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Functional neuroimaging allows investigation of the timing properties of the brain mechanisms underlying covert language processing. This paper presents a review of the use of the neuroimaging technique called Event-Related Potentials (ERPs) in sign language (SL) research. In the field of neurolinguistics, ERPs have been widely used in the study of spoken language, but their use in SL is still rare. Studying the neurocognitive aspects of SL could lead to a better understanding of the specific processing of SL in the brain. This review outlines the basic theoretical and methodological principles of ERPs. We focus on three groups of ERPs that are particularly relevant to SL processing and production: ERPs focusing on cognition, ERPs focusing on language, and ERPs focusing on movement aspects. We then summarize within each group some ERPs that we consider could be useful for studying the sequence of cognitive processes underlying SL processing and we discuss the current state of the use of ERPs within SL research. According to our analysis of the field, ERPs focusing on language aspects have been used more than ERPs focusing on cognitive and movement-related aspects to study SL. More variability in the type of SLs used is needed to expand the inferences made so far. For the development of the field, we recommend the more frequent use of videos and SL stimulation at a natural pace in order to understand how SL is processed in daily life. The use of a wider variety of ERPs in the study of SL is also recommended. We conclude that ERPs offer a useful tool to address unanswered questions in the field, especially those that call for measuring the building blocks of SL processing in real time. The study of SL cognitive processing in the brain is still in its infancy. One way of developing the field in the coming years would be the more frequent use of the ERP neuroimaging technique.

Keywords: event-related potentials, sign language, cognitive processing, covert language processing, cognitive neuroscience

INTRODUCTION

The cognitive processing of language (both spoken and signed) is suggested to be the outcome of a sequence of rapid cognitive processes executed over time (Jung-Beeman, 2005; Woll, 2010). This sequence of cognitive processes includes, but is not limited to, sensory, grammatical and semantic processing, and memory retrieval. When these processes are complete, the language item being processed is understood and integrated into the overall meaning in the ongoing discourse. Behavioral and cognitive tasks have given valuable information about this processing. However, usually, they provide only a measure of the overt cognitive outcome, without being able to differentiate the building blocks of language processing. Unfortunately, behavioral techniques alone are not yet good enough to detect the complex organization and coordination of linguistic operations at the cognitive level that support language performance.

The complex interconnection and sequencing of linguistic operations during language comprehension and production are performed very rapidly. One way of studying the timing properties of covert language processing is by focusing on their underlying brain mechanisms. This can be achieved with the use of functional neuroimaging techniques such as electroencephalography (EEG) and magnetoencephalography (MEG). EEG measures the electrical activity generated by the synapses (connections between neurons to transmit information). MEG, on the other hand, measures the magnetic fields generated by the electrical activity produced by the synapses. Thus, they are based on similar measures. Even though there are several differences between EEG and MEG (mainly their sensitivity to the orientation of the sources, for a review see Cohen and Halgren, 2003), regarding the temporal aspects of Event-Related Potentials (ERPs), EEG and MEG can be considered equivalent. In this review, we concentrated on EEG because it is considered a more affordable technology and is therefore more widely used than MEG. Because EEG and MEG are based on the electrical activity generated by the synapses, they are very sensitive to the extremely fast changes produced in this signal.

When a person is involved in a specific task (like language comprehension or production), the underlying electrical activity in the brain can be traced with very exact temporal resolution [in the order of milliseconds (ms)] with the use of EEG/MEG. One way of analyzing the ongoing EEG signals is in the time domain, using ERPs. From non-invasive electrodes attached to the scalp, the ongoing EEG electrical activity is pre-processed (including several procedures to reduce the electrical activity from other sources outside the brain) and averaged to extract the peaks, called ERPs [or Event-Related Fields (ERFs) in the case of MEG]. This review seeks to summarize a group of ERPs useful to research oriented to sign languages (SLs) as well as to provide some examples of studies that have been carried out using this neuroimaging technique.

It is believed that these different waves or peaks represent important stages in the sequential cognitive processing involved in the task. Physiologically, the different ERPs represent voltage changes from the summation of the post-synaptic potentials of a large number of neurons, activated (or inhibited) synchronously in response to a stimulus (Fabiani et al., 2007). The time of occurrence of the ERP (latency) gives essential information about the timing and complexity of the underlying cognitive process (measured in ms). Similarly, the size of ERPs (amplitude) is measured in microvolts (μV) which, it is believed, represent the number of neural resources devoted to processing that specific stimulus, or the cognitive process involved. Together, latency and amplitude give important information about how cognitive processing is performed by the brain. The main elements and processes involved in ERP recording are schematically illustrated in **Figure 1**.

Another advantage of using EEG/MEG techniques rather than behavioral tests in the study of the cognitive processing of language is that they limit the influence of the subject's state (or subjectivity), which is an essential aspect of conscious human responses. Because EEG/MEG are based on the brain's electrical activity, the participant cannot easily influence them intentionally (although some of the subject's higher-level cognitive stages can influence some ERPs). Since, then, the unwanted subjectivity usually included in behavioral studies can be overcome by the use of ERPs, they allow us to move toward a more objective measure of human behavior.

It is important to note that EEG has high temporal resolution but low spatial resolution. This happens mainly because of the physical properties of the electric signal. Electrical activity is sensitive to fast changes but can be distorted by, in the case of EEG, parts of the brain, bones, membrane or skin lying between the generators and the recording device (electrodes in the scalp). For this reason, the topographic distribution in the scalp (the location of the electrodes where the signal is recorded) is usually provided. Even though both the topography and the neural generators of an ERP can vary depending on the kind of stimulation and paradigm used, the topography of an ERP does not need to reflect the location of its brain generators. Reporting the information about the topographic distribution of ERPs provides useful information such as the number of underlying components, it helps in identifying ERPs, and it allows replicability of the results between laboratories. In this review, for each ERP we provide information about both the typical topographic distribution and the known neural generators. For the same reasons, in this review we purposely highlighted the use of EEG for research questions more related to temporal aspects of SL processing than to spatial or more localizationist questions.

Each ERP is elicited by a typical task or paradigm. For instance, several language-related ERPs in language comprehension are recorded by using a violation paradigm, as one possibility. In this kind of task, one element of the expression is violated depending on the kind of brain response (grammatical, semantic, etc.) that it is intended to measure. In addition, for recording cognitive-related ERPs, variations of the so-called oddball paradigm are among the tasks frequently used. The oddball paradigm involves the repetition of a frequent stimulus including an unexpected and infrequent stimulus that thus generates a cognitive mismatch response. These paradigms, and others, have been widely used in several

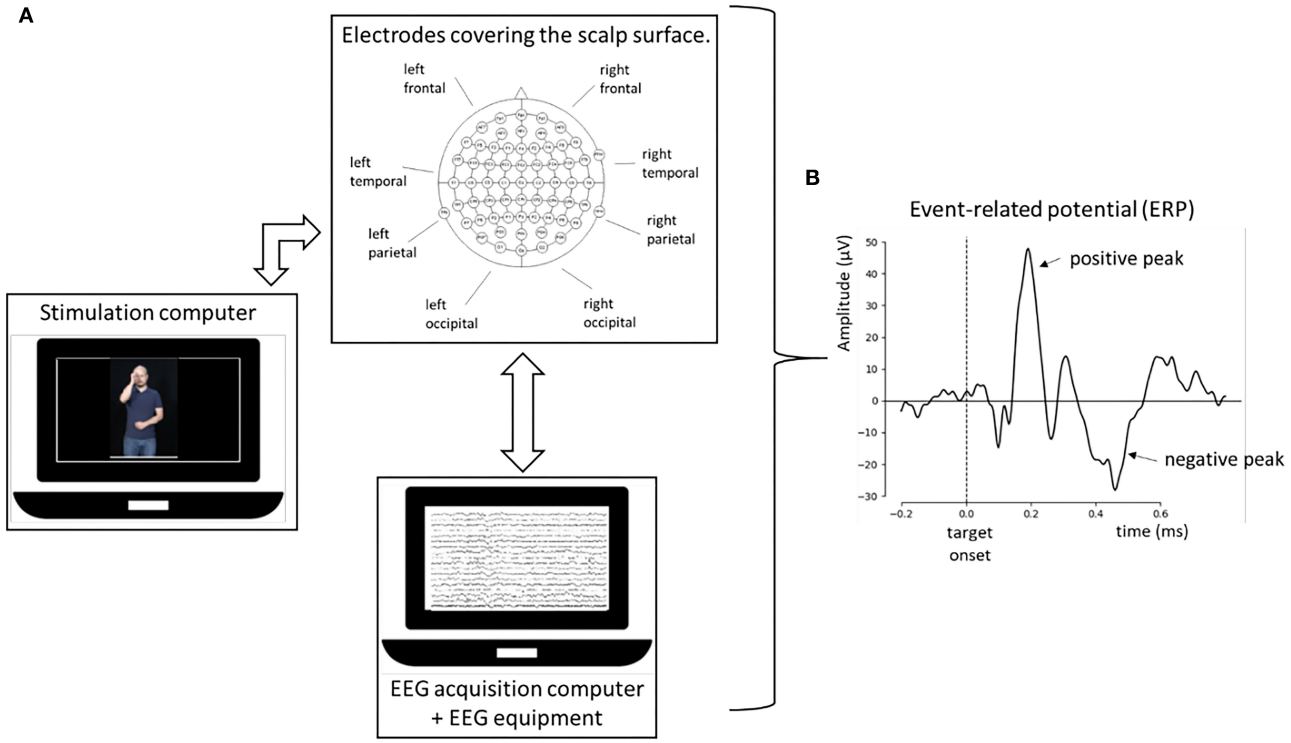


FIGURE 1 | Summary of the main elements and processes involved in the ERP recording. **(A)** Interconnection of the stimulation computer (which delivers the task to the participant), the set of electrodes covering the surface of the scalp (connected to the EEG equipment), and the EEG acquisition computer (connected to the EEG equipment). The main areas of the brain in the left and right hemispheres are also marked. **(B)** The signal coming from the three elements is averaged and the ERP is obtained as a function of the amplitude (y-axis and measured in μV) and time (x-axis and measured in ms). The vertical line represents the target stimulus onset. The positive and negative peaks or ERPs are marked according to the positive (upward) and negative (downward) position of the amplitude in the diagram.

neuroimaging studies on the cognitive processing of language. **Table 1** summarizes the main characteristics of the paradigms mentioned in this review.

Many studies have been conducted with ERPs as brain signatures of processing and production in spoken language (for a review see Beres, 2017). Sign language (SL) and spoken language (SpL) seem to share several general characteristics as regards processing (Neville et al., 1997; Deng et al., 2020; Emmorey et al., 2020). Despite their similarities, some differences between SL and SpL have also been reported (Gutiérrez et al., 2012; Thompson et al., 2020). In order to study specifically SL, we need to better understand how it is processed by the brain. The specific study of the brain bases of SL could help us to disentangle the basic core of language processing from the processes involved in the different modalities used (auditory, visual). Although there is now a growing number of studies focusing on the underlying brain mechanisms involved in SL, still our knowledge in this field is much more limited than that produced by the wide range of studies conducted in SpL. There is also a need for greater diversity in such studies, looking at different kinds of SLs, in order to differentiate what is inherent to SL in general from what could be arising in only one specific SL type.

Given the usefulness of ERPs within linguistics, this review aims to highlight and contribute to their expansion into the study of the cognitive processing of SL (including both comprehension and production) at the level of brain functioning. In particular, this review is intended for linguists and researchers working with SL who want to extend their research to include a cognitive neuroscience approach in a multidisciplinary manner. Based on the perspective that we chose, we will briefly overview some important components of ERPs (and, by implication, their magnetic counterparts as measured by MEG) related to cognition, language, and movement. In each case we will also offer some examples of how they have been used in recent as well as classic studies within the SL literature. To achieve that goal, we made a search in Google Scholar and three scientific databases (Scopus, EBSCOhost and ProQuest) with the string "sign language" AND "ERP." The search was performed between September 2020 and February 2021, so, only studies published before March 2021 have been included in this review. For each ERP relevant to SL, we chose two representative studies to serve as examples of their usefulness and application within the field so far. The criteria for inclusion of the studies to be presented here were that it was: (1) An original article, (2) using EEG, (3) with aims including SL processing or production in the brain (not enough to study reading in signers or just gestures), and (4) the methodology was well used and simple enough to be explained in a condensed form. (5) The study used and identified specific ERPs

TABLE 1 | Summary of the main characteristics of the paradigms (tasks used to record certain ERPs) mentioned in this review.

Paradigm	Structure	Target	Answer
Violation	Neutral stimuli + violated target [sentences or pairs of stimuli (e.g., figures, words, or combination of them)].	Onset of the neutral and violated stimuli in each sentence, pair, etc.	Usually not required.
Oddball	Frequent stimulus + infrequent (target) stimulus	Onset of infrequent stimulus presentation.	Sometimes is not required (passive oddball). When required (active oddball), participants should report (e.g., by pressing a button) when the target appears.
Picture naming	Picture presentation + time to produce an answer.	Onset of the picture presentation.	Required.
Lexical decision	Word or pseudoword presentation + time to produce an answer.	Onset of the word/pseudoword presentation.	Required.

(not just effects in defined time-windows), (6) the ERPs studied were within the group of ERPs selected to be introduced in this review, and (7) the study used mainly visual stimulation. Finally, we will discuss methodological and theoretical considerations, as well as suggestions for future directions.

COGNITION-RELATED ERPs

Based on the stimuli used, there are various kinds of ERPs. Cognitive-related ERPs are measured while the participants are solving cognitive tasks. When that is the case, the resultant ERP is a measure of the brain response involved in the processing of the relevant items (or stimuli) of the task. Because of this, cognition-related ERPs are considered mostly stimulus-locked ERPs. Some cognition-related ERPs are going to be further described (see **Figure 2A** for a schematic representation of the processing stages of cognition-related ERPs).

Mismatch Negativity

The Mismatch Negativity (MMN) (Näätänen et al., 1978) is a small negative-going deflection occurring between 150 and 250 ms after an unlikely deviation appears in a sequence of frequently repeating events. The MMN is elicited irrespective of whether the person is paying attention, and without conscious effort, and for that reason it is considered to be an automatic brain response (Näätänen, 2001). The paradigm employed to record it (called a passive oddball) simultaneously includes: (1) a sequence of standard stimuli interrupted by a rare deviant stimulus (to which no answer is required from the participant) and (2), an attention-demanding task to ensure that the MMN is not overlapped by conscious attentional brain activity. The MMN is extracted from the first part of the paradigm as the difference of deviant minus standard brain activity. Functionally, the MMN is considered to be a measure of a mechanism of deviant detection in the brain (Picton et al., 2000). Its brain generators seem to include different regions of the auditory cortex as well as the frontal lobes, with contributions from other brain structures such as the thalamus and hippocampus (Alho, 1995; Astikainen et al., 2000). For that reason, the MMN is usually recorded from electrodes located in frontocentral areas of the scalp.

The MMN was initially considered to be mainly an auditory-related component but some later studies revealed that it could also be obtained from other stimulation modalities such as visual (for a review see Pazo-Alvarez et al., 2003) or somatosensory (Kekoni et al., 1997). The focus here will be on the visual MMN (vMMN) as the one mostly used in SL studies. The vMMN can be used to study pre-attentional automatic sensory discrimination relying on visual information. The topographic distribution of the vMMN does not always match the one described for the auditory MMN. For the vMMN a broad topographical distribution has been reported including the visual cortex in occipital areas (Berti and Schröger, 2001; Czigler et al., 2002), posterior temporal areas (Woods et al., 1992), parietal regions (Cammann, 1990) and frontal regions (Czigler et al., 2002; Wei et al., 2002) regions. The topographic distribution around these areas could depend on the modality and the kind of stimulation used.

The vMMN was used in a study investigating the interplay between language and the perceptual visual system by studying the effect of SL on deaf people's perception of color categories (Xia et al., 2019). An oddball task was used to examine whether the previously known right visual field advantage in SpL also occurs in 14 native users of Chinese SL. Each trial presented two colored squares (green or blue) flanking a fixation point located in the center of the screen. Infrequently, two types of deviant stimuli (squares with a color variation in the same or a different color category) appeared either on the left or the right of the screen. Results showed that the amplitude of the vMMN evoked by the within-color category deviant was significantly smaller than the vMMN evoked by the between-color category deviant when displayed in either the right or the left visual field. These findings allowed the authors to claim that SL influences participants' color perception by using both brain hemispheres, which suggests a language-related effect on perception. The use of the vMMN also made it possible to allocate the time course of the effect in the early, specifically pre-attentive perceptual, processing stages.

Another recent study (Deng et al., 2020) used the vMMN to explore more closely the similarities or differences between languages that use different modalities (such as SpL and SL). Specifically, it examined whether automatic lexical access (previously reported for SpL in hearing speakers) also occurs in lexical sign processing by deaf signers. To answer this question, 22 deaf adult signers and 22 age-matched hearing non-signers were presented with a sequence of four static images representing Hong Kong SL lexical signs (2) and non-signs (2) using a classic oddball paradigm. The two signs represented the meaning of "nurse" and "beverage." The two non-signs were created as combinations of the signs. One non-sign was generated by combining the handshape of the lexical sign for BEVERAGE

and the location of the lexical sign for NURSE. The second non-sign was generated by combining the location of the lexical sign for BEVERAGE and the handshape of the lexical sign for NURSE. Two conditions were used, a lexical sign condition and a non-sign condition. Signs and non-signs were used in reverse order between conditions. In the lexical sign condition, the two non-signs were presented as standards, while the two signs were presented as deviants. In the non-sign condition, the two signs were presented as standards, while the two non-signs were presented as deviants. Unlike the hearing non-signers, deaf signers exhibited an enhanced vMMN to the lexical sign condition (but not to the non-sign condition) at around 230 ms in the parieto-occipital area. These findings were interpreted as indicating that deaf signers implicitly process lexical signs and that neural response differences between deaf signers and hearing non-signers occur at an early stage in sign processing. The authors concluded that the neural underpinnings of SpL and the underlying neural mechanisms for the lexical processing of sign languages are analogous.

As can be inferred from the studies mentioned above, the use of vMMN in the SL context seems to have increased in recent years. As vMMN has been reported to be sensitive to several kinds of violations [motion direction (Pazo-Alvarez et al., 2004), stimulus orientation (Astikainen et al., 2008), the omission of visual stimuli (Czigler et al., 2006), changes in facial expressions (Astikainen and Hietanen, 2009), changes in symmetry (Kecskés-Kovács et al., 2013b), presentation of left vs. right-hand stimuli (Stefanics and Czigler, 2012), or the gender of a face (Kecskés-Kovács et al., 2013a)], we consider that this ERP component still has many potential uses in the SL context. In particular, vMMN could be useful in broadening our understanding of the similarities and differences between signed and spoken modalities, still an issue with multiple open questions, especially from the point of view of brain functioning.

P300

Another ERP involved in the detection of changes in the environment is the P300, which differs from the previous one in that it gives a conscious and attention-driven perspective. The P300 (Sutton et al., 1965) is considered to be an attention marker (Polich and Comerchero, 2003). It is a positive wave with a maximum peak around 300 ms (250–500 ms) after the onset of the variation. It is usually recorded by using an active oddball paradigm in which an unexpected stimulus (target) occurs in a sequence of frequent and repetitive stimuli. The participant is required to respond as fast as possible when the target is detected. Functionally, besides its involvement in attentional processing, it is also considered to be a psychophysiological measure of cognitive function in decision-making processes. Topographically, its maximum peak is usually recorded over the centroparietal areas of the human scalp. The P300 is generated as a result of the interaction between several brain areas, such as the frontal and temporal/parietal networks, with some contributions from several subcortical structures (Ebmeier et al., 1995; Polich, 2003). As the P300 is generated by unlikely targets, the less probable the target, the larger the P300 amplitude (Donchin, 1981). The P300 latency seems to be negatively correlated with mental function, with shorter latencies associated with better cognitive performance (Howard and Polich, 1985; Emmerson et al., 1989).

A recent study (Navarrete et al., 2020) used the P300 to examine the impact of language on sensory visual processing. Based on previous studies suggesting associations between SpL and visual processing, the study explored whether there is an association between SL and the visual recognition of objects based on their orientation. For that purpose, a three-stimuli (drawings of objects) oddball task was presented to 10 deaf native adult signers of Italian SL and 10 hearing non-signer adults. The stimuli appeared in rapid succession, one at a time. The frequent stimuli (with 80% probability of appearance) and infrequent stimuli (with 15% probability of appearance) were the same pictures in different orientations. The target stimulus (with 5% probability of appearance) was another picture with a different orientation from those of the frequent and infrequent stimuli. Participants were asked to respond (by pressing the spacebar of the keyboard) as quickly as possible only when the target appeared on the screen. The analyses focused on the difference between frequent and infrequent trials. Results showed that the P300 elicited by the frequent and infrequent stimuli differed between groups. The P300 amplitude (in centroparietal electrodes) was bigger in signers than in non-signers. The authors conclude that their findings demonstrate that, as in the case of SpL, SL affects the processing of visual objects, thus supporting the idea of an interaction between the linguistic and visual systems, in which the information from both systems integrates with and affects the other (for more information see Ferreira and Tanenhaus, 2007).

Research has identified two subcomponents of the P300: the novelty P300, or P3a, and the classic P300 or P3b. The P3a (Squires et al., 1975) peaks earlier (250 – 280 ms) than the classic P300 and is a positive wave that is maximum over frontocentral electrodes. Functionally, the P3a seems to be associated with the processing of novelty and the orienting subcomponent of attention (related to involuntary shifts of attention to changes in the environment) (Polich, 2003) as well as frontal lobe function (Polich, 2007).

The P3a has been recently used in a study conducted by Ortega et al. (2020) who focused on SL as a second language in an investigation of bilingualism. They tested whether hearing non-signers rely on their gestural repertoire when they are exposed to SL for the first time. Brain electrical activity was recorded when 29 non-signing hearing adults viewed iconic signs that had high and low overlap with the forms of iconic gestures. For example, a sign with high overlap with gestures used in the study is the sign for "to descend" (executed as one hand descending diagonally from right to left) in the Sign Language of the Netherlands. An iconic gesture in Dutch culture to represent "to descend" would also be executed with one hand and a diagonal descending movement. A sign with low overlap with gestures used in this study is the sign for "butterfly" (executed with both hands joined at the base and the fingers opened and moving in and out) in the Sign Language of the Netherlands. An iconic gesture in Dutch culture to represent a butterfly is performed flapping the arms to personify the movement of the insect. Signs with

low overlap with gestures elicited a more enhanced positive amplitude in the P3a (with the typical anterior distribution on the scalp) compared to signs with high overlap. The signs with low overlap were interpreted as new to the participants, who therefore allocated more neural resources to processing them. On the other hand, signs with high overlap with gestures could be mapped onto existing gestural schemas. The authors concluded that non-signers generate expectations about the form of new iconic signs based on their implicit knowledge of gestures and not only from their linguistic experience.

Although the P300 is widely used in the field of cognitive neuroscience, its use in the SL research field is, according to our survey, still in its infancy. This ERP component could be particularly useful for isolating the cognitive processes involved in SL processing, such as attention focusing, novelty processing, and decision-making. A specific linguistic domain that could be investigated with P300 is iconicity (of different signs and their parts), for which the study by Ortega et al. (2020) provides an excellent basis. The involvement of cognitive processes could be studied in association with both the SL comprehension and production of children acquiring a SL, adult SL learners, and adult L1 signers.

LANGUAGE-RELATED ERPs

Various ERPs have been used to address more specific language-related questions. These ERPs have also used stimulus-locked tasks at different levels, such as vowels/consonants, syllables, words and sentences. In this review, we focus on the brain-based processing of sentence comprehension. Angela Friederici's model (Friederici, 2002) seeks to explain how language comprehension is performed in the brain. Basically, it assumes that sentence comprehension is performed as a succession of at least three main functionally distinct processing stages: an early parsing phase (indexed by the ELAN, see section Early Left Anterior Negativity), followed by processes including semantic information (indexed by the N400, see section N400) and morphosyntactic information (indexed by the LAN, see section Left Anterior Negativity), and a late phase of revision (indexed by the P600, see section P600), in which the semantic and syntactic information are integrated. In the model it is assumed that each stage produces and passes on information to the next stage about the kind of information that has been gathered.

It is worth noticing that some aspects of Friederici's model have been questioned. For instance, it is a syntax-first model stating that the building of syntactic structure precedes semantic processes and that these interact only during a later stage. While some studies have supported the assumption of a relative independence of the semantic and syntactic processing (Gunter et al., 1997; Osterhout and Nicol, 1999), others have found that, when they are combined, semantics and syntax at the brain level seem to interact. Specifically, Hagoort (2003) found that semantics and syntactic brain correlates not only interact, but also affect each other in different ways. Brain-based syntactic analysis seems to be unaffected by semantic integration while semantic integration seems to be harder in the presence of a syntactic problem. These findings are in line with more recent studies (Kemmerer et al., 2007; Kuperberg et al., 2007) describing P600 effects for semantic violations (see subsection P600).

The aforementioned violation paradigm, in which a word is violated (with reference to syntactical or semantical/world knowledge) in relation to the context (the sentence/text), is usually used to record ERPs related to each of the three phases of Friederici's model. It is important to note that there are other paradigms also used in language-related studies, such as "picture naming" (in the case of language production) or "lexical decision" (in the case of language comprehension), that we will not discuss here. The language-related ERPs that we will now go on to discuss can be identified as brain signatures for each of these phases of Friederici's model by the use of the violation paradigm (see **Figure 2B** for a schematic representation of the processing stages of language-related ERPs). The main methodological differences between the stimulus-locked and the response-locked ERPs are shown in **Figure 3**.

Syntax-Related ERPs

Early Left Anterior Negativity

The early left anterior negativity (ELAN)[1] (Friederici et al., 1993) is a negative-going wave peaking around 100 to 300 ms after a grammatical violation occurs. As its name indicates, the ELAN is recorded more usually by electrodes located over the left frontal areas of the scalp. This component is recorded in tasks including sentences where the lexico-grammatical category (cf. "word-class") of words is violated. Interestingly, the sentence does not need to be semantically understandable, thus suggesting that syntax and semantics might be processed independently in the early stages of brain processing. Thus, functionally, the ELAN is considered to reflect early automatic syntax processing in the brain and it is a specific ERP for the evaluation of word category. It has been recorded in both visual and auditory modalities. The ELAN brain generators seem to be located in the temporal as well as in fronto-lateral regions bilaterally, but with dominance in the left hemisphere (Friederici et al., 2000).

One example of the use of the ELAN within the SL context is provided by a study carried out by Capek et al. (2009). This study aimed to determine whether the brain processes indexed by language-related ERPs are specific to aural-oral language or if they underlie any natural language, like in the case of SL. Fifteen deaf native adult users of ASL were presented with sentences signed at a natural rate that were either correct or contained a syntactic error. The syntactic errors were two types of violation in verb modification: reversed verb modification and unspecified verb modification (referred to as verb agreement violations by the authors). In the reversed verb modification condition the verb was moved from the object to the subject, instead of in the opposite direction. In the unspecified verb modification condition the subject-like element and object-like element were set up in space, and instead of directing the verb to either of these

[1] In SL research, the abbreviation ELAN typically refers to a software used in video data annotation: the "Eudico Linguistic Annotator," developed in the Max Planck Institute in Nijmegen, The Netherlands. Obviously, the use of the abbreviation ELAN in this paper has nothing to do with the software.

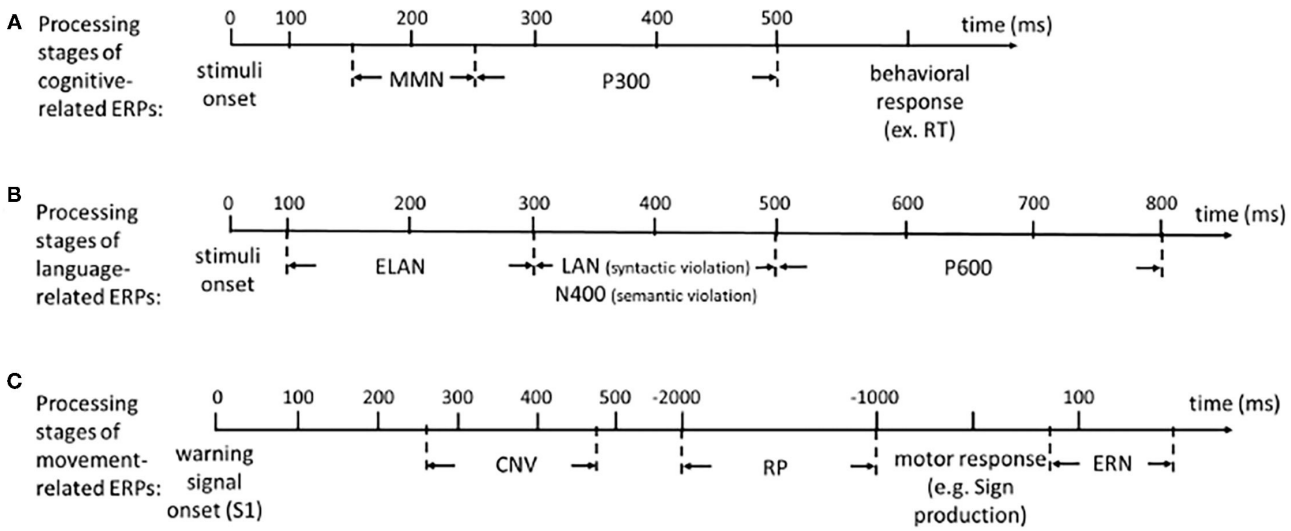


FIGURE 2 | Schematic representation of the processing stages for **(A)** cognition-related ERPs, **(B)** language-related ERPs, and **(C)** movement-related ERPs, over time.

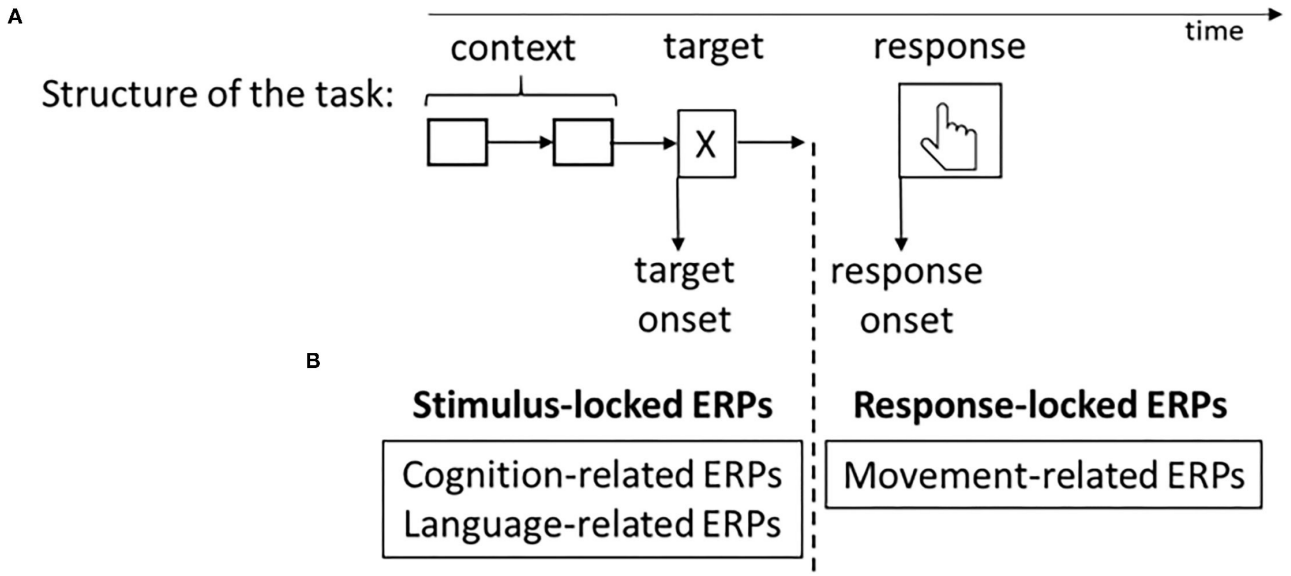


FIGURE 3 | (A) Schematic representation of the methodological difference between the stimulus-locked and the response-locked ERPs. **(B)** The types of ERP introduced in this review are classified as stimulus-locked or response-locked ERPs.

locations, the signer directed the verb to a different location in space that had not been previously established. The reversed verb modification condition elicited an ELAN and a later posterior positivity (P600, which will be explained below). The ELAN to the reversed verb modification showed the typical left frontal distribution on the scalp.

Apart from the rather limited use of the ELAN in the spoken/reading language context, according to our survey its use in the study of SL cognitive processing at the brain level is still minimal. This component could be particularly useful in the study of early syntax processing, such as the acceptability of different word-orders[2], which, to our knowledge, has not yet been addressed in neurolinguistic studies on SLs.

[2]Some research claims that the word order of SLs is fixed and stable. However, other research, using different data, claims that the word order exhibits variation. Our motive for suggesting SL word order as a possible target of an ELAN ERP study stems from this conflict. For an overview of studies on SL word order, see Napoli and Sutton-Spence (2014).

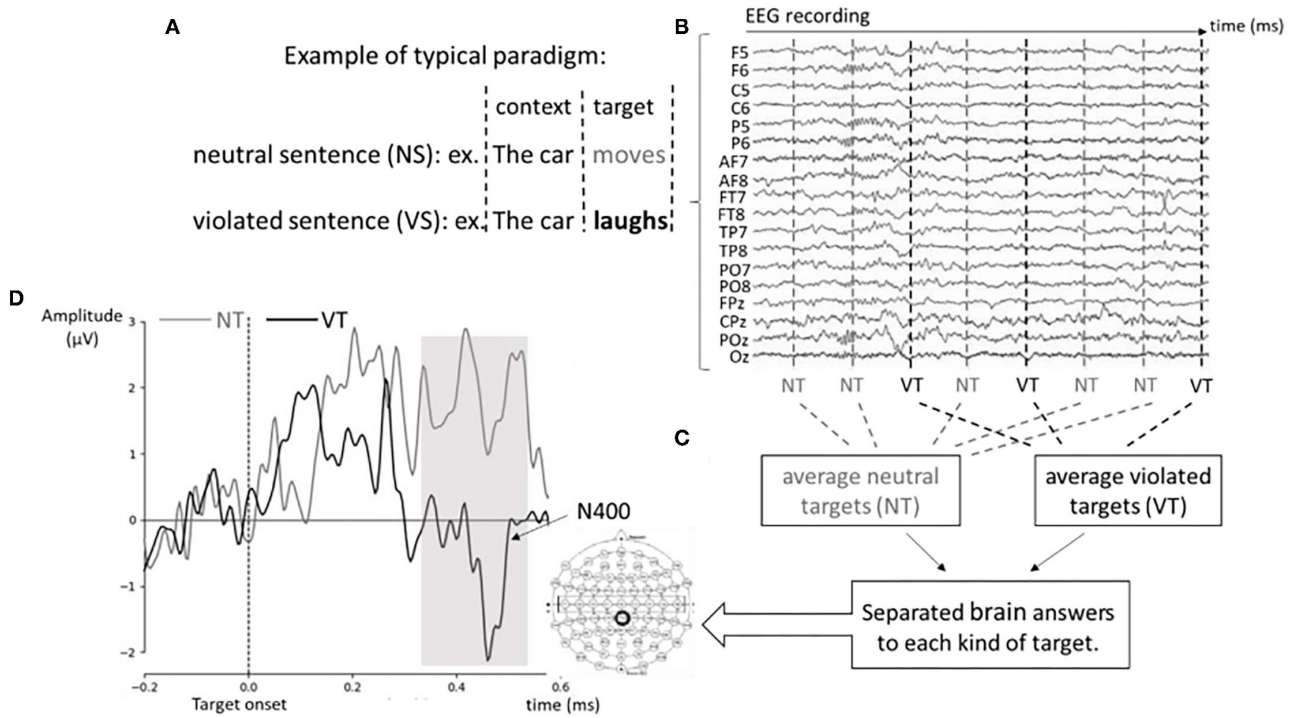


FIGURE 4 | Schematic representation of the recording and analysis processes involved in obtaining the N400 ERP + example of recording from a signer. **(A)** Example of a typical paradigm used to elicit the N400 ERP. In each kind of sentence (neutral or violated) the context and the target words are denoted. **(B)** Plot of raw EEG data as it is recorded over time from different electrodes. The vertical dashed lines represent the onset of each target (critical word) within the sentence. Vertical gray dashed lines show the onset of the target (semantically correct) word for the neutral sentences (NS). Vertical black dashed lines show the onset of the target (semantically violated) word in the violated sentences (VS). **(C)** Typical averaging of the EEG data after pre-processing (resampling, filtering, etc.) and removing artifacts (e.g., from eye movements, or motor movements). The brain signals corresponding to the onset of the target in each kind of sentence are averaged out to obtain separated brain responses for neutral and violated targets. **(D)** The resulting evoked potentials locked to the onset of neutral and semantically violated targets from an adult signer when processing actual sign stimulus material in videos. The gray line shows the brain response to the neutral targets, while the black line shows the brain response to the semantically violated targets. The area highlighted in gray denotes the typical time-window for the N400 ERP (between approximately 300–500 ms post target onset). The centro-parietal topography of the N400 ERP is also shown in the Figure.

Left Anterior Negativity

Another negativity related to other types of syntax violation is the left anterior negativity (LAN) (Friederici et al., 1996). It is a later ERP than the ELAN, usually recorded between 300 and 500 ms after the grammatical violation occurs in a sentence. It is usually elicited when a syntactically incorrect word is included in a sentence. The kind of task used to elicit the LAN led to the belief that it is related to morphosyntactic processing in the brain during sentence processing. It too is maximally recorded over electrodes located on the left frontal regions of the scalp, but it can also be recorded bilaterally (Hagoort et al., 2003). In Friederici's sentence processing model, the LAN represents the second phase in the processing of morphosyntactic information.

The LAN has been widely employed in language-related studies using spoken and written stimuli. In the last decade, it has started to be used also in the study of brain-based SL processing. For instance, in a study conducted by Hänel-Faulhaber et al. (2014), language-related ERPs were used to determine whether semantic and morphosyntactic aspects of German SL can be dissociated within the same individuals. Fifteen deaf adult native signers watched continuous videotaped German SL sentences (presented sign by sign at natural pace), which were either correct or morphosyntactically incorrect. The morphosyntactic error was performed by a modified verb (incorrect direction of movement) in middle position in the sentences. A LAN was elicited by the sentences with the syntactic violation (referred to as verb agreement violation by the authors) independently of the N400 effect (to be addressed further in the next section) also obtained for the semantic violations. The authors conclude that these results support the idea of a similar neural functional organization of SL and SpL, regardless of the difference in modalities used.

In the previously described study by Capek et al. (2009), the syntactic violation added by the unspecified verb modification elicited a LAN. This component showed a more rightward topographical distribution than the expected leftward maximum. The authors interpreted this hemispheric shift as an effect of the unique involvement of spatial processing in signed syntax, concluding that experience can shape the development of the neural systems that mediate language processing.

Despite the wide use of both ELAN and LAN in spoken language studies, their use in SL processing is still rare, at least

according to the survey conducted for this current paper. One reason for this could be the fact that there are still many open questions and even controversies about the syntax of SLs. For example, the distinction between morphology and syntax is not clear, as a single sign can also function as a well-formed grammatical sentence. Studying SL syntax with neurolinguistic methodologies would require that the basic syntactic framework was established. Borrowing conceptual starting points from the SpL research tradition would not serve all our needs. By focusing strictly on SL, ELAN and LAN could help in identifying the nature of the early cognitive mechanisms that underlie syntactic processing in SL. This procedure could help to detect the syntactic features that can be handled at a more basic cognitive level.

Semantic-Related ERP

N400

The most widely used ERP in the language context is the N400 (Kutas and Hillyard, 1980). The N400 is named for its polarity and expected latency (a negative-going deflection peaking around 400 ms after the stimulus onset). The task most typically used to record the N400 (among others using non-verbal stimuli such as figures and faces) involves a sentence (as a context) and a word that is syntactically correct but violates either semantic expectations or world knowledge. This ERP has been recorded in both visual and auditory modalities. Topographically, N400 usually shows a bigger amplitude in centro-parietal areas due to the way the signal is conducted from the sources to the electrodes on the scalp. The neural sources of the N400 include a wide network of brain areas, such as the anterior medial temporal lobe, middle and superior temporal areas, inferior temporal areas, and prefrontal areas (Kutas and Federmeier, 2011). Of these areas, the left hemisphere has been highlighted as an important neural source for the N400, with additional contributions from the right hemisphere (Van Petten and Luka, 2006; Tse et al., 2007). **Figure 4** shows the main recording conditions and processes of analysis used to obtain the N400 ERP. With the use of a violation paradigm (panel A), the electrical brain activity is recorded (panel B) over time (x-axis) from a group of electrodes (y-axis) distributed around the scalp. Different marks (triggers) are sent when each kind of target is presented (vertical lines). After averaging the brain response to each kind of target (panel C), the N400 is obtained as the amplitude difference between the brain responses to the neutral targets vs. the brain response to the violated targets (panel D).

As the N400 is elicited by semantic deviations in the context of a sentence (although it can also be recorded in word pairs), it is believed to reflect the brain's response to the processing of meaning (Kutas and Hillyard, 1980). Attentional involvement is not necessary to evoke an N400 since the participant is not required to give an answer. The amplitude of the response seems to be proportional to the degree of incongruity of the violation; thus, a more incongruent semantic mismatch would elicit a bigger N400 response than a less incongruent one. The increase in N400 amplitude is functionally interpreted as the processing cost of integrating the meaning of the word into the overall meaning of the sentence.

The N400 is by far the most widely used ERP both in spoken language and in the SL context. In one of the pioneering studies on SL processing with the use of ERPs, Neville et al. (1997) investigated the interplay between semantic processing and the age of acquisition of ASL, including open (noun, verb, and adjectives) and closed (pronouns, conjunctions, and auxiliaries) class elements. Four groups of people were included in the study: two groups of native SL users (one deaf and one hearing group, all with deaf parents), a group of hearing late learners (born to hearing parents, fluent in SL but having learned the language only after reaching 17 years old), and a group of hearing non-signers (with no knowledge of SL and born to hearing parents). The task included sentences in which each sign consisted of eight frames of a digitized film on a screen. Half of the final signs of the sentences were semantically correct given the preceding context and half were semantically anomalous. Each of the signs in the sentences except the first and last was classified as an open or closed-class element. The participants were asked to press one of two buttons to indicate whether or not the sentence made sense. The hearing non-signers were asked to guess whether or not each sentence made sense. Results revealed an N400 that was bigger for open class elements for all the groups. This was interpreted as indicating the existence of substantial similarities in the neural systems mediating the processing of language, independent of the modality through which the language is acquired. Interestingly, the group of hearing late learners showed an increased N400 response to the semantic anomalies, while no clear N400 for semantic violations could be identified in the group of hearing non-signers. The authors claim that these results could indicate that different developmental time courses mediate aspects of semantic processing.

Another study aimed to investigate the influence and time course of lexical access during sentence processing in ASL (Gutiérrez et al., 2012). In this study, the N400 was used to explore the electrophysiological correlates of the processing of handshape (semantic) and location (phonology) during the lexical access of signs. To answer their questions, the authors chose 17 deaf native signers, to whom sequences of pictures representing 100 ASL sentences were presented. The sentences contained 4 types of violation (in the middle of the sentence) regarding the baseline sentences (example: ME FRIEND WEDDING HERS ME BRIDESMAID ME WEAR MUST [target/violated sign: DRESS] EXCITED ME). The 4 types of violation in the sentences included (1) one sign that was semantically congruent in that it did not share location with the baseline (target sign in example sentence: SKIRT) (+S, –P); (2) one sign that was semantically congruent that also shared location with the baseline (target sign in example sentence: SHIRT) (+S, +P); (3) one sign that was semantically incongruent that shared location with the baseline sentence (target sign in example sentence: LUNGS) (–S, +P); and (4) one sign that was unrelated (target sign in example sentence: MIRROR) (–S, –P).

The results obtained by Gutiérrez et al. (2012) showed that the signs that had either only a semantic relationship (+S, –P) or only a phonological overlap (–S, +P) with the expected sign

elicited similar N400s, suggesting that semantics and phonology may interact at the level of lexical selection. Interestingly, the N400 elicited by the unrelated (–S, –P) and semantically and phonologically related (+S, +P) conditions exhibited a later onset (450 ms), which was considered to reflect a more difficult semantic integration. All unexpected conditions (+S, –P), (–S, +P), (–S, –P), (+S, +P) exhibited a centrally distributed N400 in the 450–600 ms window, also explained in terms of difficulty in semantic integration with the previous context. It is especially interesting that the N400 elicited by signs sharing only location with the expected sign (–S, +P) showed effects such as stronger and broader distribution, an earlier onset, and also a later offset (persisting into the 600–750 ms window) than the N400 elicited by the other experimental conditions. These results were interpreted as reflecting the special status of location and its potential contribution to semantic interpretation in SL processing, thus replicating at the brain level the results of (Klima and Bellugi, 1979). Based on all these results, the authors concluded that there is an intimate relationship between ASL form and ASL meaning that interacts during online language processing in ways that differ from what has been observed in SpL.

The N400 has been widely used to answer several questions regarding the processing of meaning in the brain in the SL context. It is important to note that there is some controversy over the functional meaning of the N400. Alternative interpretations, based on some interesting experimental findings, consider that the N400 could be reflecting the predictability of the word whose meaning was violated (Nieuwland et al., 2020) or aspects of semantic integration processes (Brown and Hagoort, 1993) rather than the semantic process itself. Experimental manipulation in the SL context could shed some light on this debate.

A Re-analysis or Integration-Related ERP P600

When a violation paradigm involving grammatical variation is used, the syntactic-related ELAN and LAN are usually followed by a later positivity called the P600, or Syntactic Positive Shift (SPS). This is an ERP elicited by syntactic anomalies of various types (e.g., Osterhout and Holcomb, 1992) and with a maximum peak around 600 ms after the change occurs (onset around 500 ms). It has been recorded in both auditory and visual modalities. Topographically, it is a very widely distributed component spreading over centro-parietal areas of the scalp. Its brain generators are believed to involve Wernicke's area (Service et al., 2007), located in the left temporal lobe. Functionally, it is hypothesized to index the integration of semantic and syntactic information at the neural level. Thus, the P600 seems to index the latest phase in Friederici's sentence processing model.

In the previously presented study by Capek et al. (2009), the biphasic brain response described above to syntactic disagreements formed by ELAN/LAN and P600 components was obtained. Both conditions, the reversed verb agreement and the unspecified verb agreement violations, elicited a P600 with the typical wide medial and centroparietal distribution in the brain. As both P600s showed the typical characteristics of the ERP described for spoken language, the authors claimed that the underlying cognitive operations that give rise to late syntactic processes might be relatively independent of the modality through which the language is perceived.

Also in the study by Hänel-Faulhaber et al. (2014), described above, in which either correct or syntactically modified videotaped German SL sentences were presented to deaf signers, the biphasic pattern of syntactic processing in the brain was present. The modified verbs (incorrect direction of movement) within a sentence elicited, in addition to the LAN, also a late positivity widely distributed in the brain that could be identified with the P600. This component also contributed to differentiating the neural processing of semantic and syntactic aspects as it has been found in oral languages.

Interestingly, several studies have shown the presence of P600 instead of N400 when semantic anomalies representing a violation of a grammatical-semantic constraint are used (e.g., rearranged thematic roles or inverse prenominal adjective order). These results (Kemmerer et al., 2007; Kuperberg et al., 2007) have led to closer examination of the functional significance of the P600 and the language system in general. Kolk and Chwilla (2007) put forward two possible explanations. The first one is consistent with the one presented in this review: that the functional meaning of P600 is related to the integration of semantic and syntactic information. This would support the notion of an interplay between semantics and syntax at the neural level. The second explanation involves the interaction of the language system with the cognitive system. It relates to the involvement of the executive functions in a process of sentence reprocessing promoting of discourse coherence. The executive functions are a group of cognitive processes that are vital for goal-directed behavior such as attention, inhibitory control and working memory (for a review see Diamond, 2013). Thus, the P600 could reflect a reprocessing of sentences to find out whether the cause of a particular inconsistency could be a processing error due to a misunderstanding. Conducting some experiments in which the semantic-syntactic aspects and/or executive cognition are manipulated in SL processing could shed some light on this question. In our opinion, the specificity of SL grammar (e.g., the ability to express information about grammatical relations by modifying the stem of lexemes), provides yet one more channel to explore the two possible explanations for the P600 as a response to semantic violations introduced earlier.

Unfortunately, apart from the studies mentioned above, the P600 has been used hardly at all in the study of the neural correlates of SL processing, according to our survey. This is probably because the nature of SL syntax is still being debated and is not yet fully understood. The combination of P600 with ELAN/LAN could offer a useful tool to distinguish between the early syntactic processing of some SL features and the integration of the syntactic processing into the sentence context, with very exact time tracing. This procedure could help to disentangle the syntactic features that might require a more complex cognitive processing from those that can be handled

at a more basic cognitive level. This ERP could even be useful in disentangling core syntax or syntactic phenomena from other types of grammatical (e.g., morphological) phenomena in SLs.

MOVEMENT-RELATED ERPs

Movement-related potentials are ERPs produced before or after a voluntary movement. Thus, they mainly index the neurocognitive processing related to movement preparation and generation. Because they are considered to reflect some aspects of anticipatory behavior when the motor system is involved, these ERPs are classified as response-locked components (see **Figure 3**). Because SLs are based on the movements (and stopping the movements of) the hands and other parts of the body, we consider that movement-related ERPs are useful research tools to study SL processing. We will now describe some particular movement-related ERPs (see **Figure 2C** for a schematic representation of the processing stages of movement-related ERPs).

Contingent Negative Variation

One of the ERP components related to preparing for action is the contingent negative variation (CNV). It is a well-known ERP and it is assumed to be a biomarker of expectancy of and preparation for movement in the brain (Walter et al., 1964). It is usually recorded while the participant is solving a task that includes a warning sign (the S1) and another signal (the S2, or imperative stimulus) that indicates a call for a certain kind of response, such as a motor response. The CNV is usually the most prominent component observed in the EEG between S1 and S2. It appears as a negative change of 15–20 μV from the baseline and continues until the S2 onset (Rugg and Coles, 1995). Its maximum peak occurs around 260–470 ms after S1 onset. The topography of the CNV varies with the complexity of the task used. For tasks using mainly motor conditions, the more negative values of the CNV are recorded in the central areas of the scalp (Cui et al., 2000; Brunia and van Boxtel, 2001). Other studies have shown that when the tasks used to elicit the CNV involve more cognitive preparatory processes, it shows a more frontal topographical distribution (Falkenstein et al., 2003). The brain generators of the CNV seem to include multiple areas, including the primary motor cortex, the supplementary motor area, the anterior cingulate cortex, the prefrontal cortex, and the premotor cortex (Hultin et al., 1996; Gómez et al., 2003). Higher motivation for the motor action, a higher requirement of attention, or an S1 that is more prominent or informative could all contribute to increasing the CNV amplitude.

In the language context, the CNV has usually been recorded in rhyme priming tasks. In this kind of task, two items (words, pictures, etc) are sequentially presented to subjects with a long enough interval to separate the neurophysiological and behavioral responses to the first stimulus (S1) and to the second member of the pair (S2, also called the target). Usually, a motor response is needed after the presentation of the S2. The task assumes that exposure to the first (prime) stimulus will influence (by facilitating or inhibiting) the processing of the following stimulus within the pair. The neurophysiological response to S1 usually produces a CNV. An N400 is usually elicited in the neurophysiological response to S2. The combination of CNV and N400 in response to S1 and S2 therefore gives detailed information about the time course of the neural processes involved.

In a study in which they aimed to determine the identity and time course of the neural systems supporting rhyme processing in deaf and hearing adults, MacSweeney et al. (2013) used a rhyme judgment task. In this task, 100 pairs of written rhyming words were presented to nine adult deaf native ASL signers, who showed rhyme judgment performance above chance, and 15 hearing adults. Between the first (S1) and the second (S2) words, a one-second interval made it possible to split the brain responses to the S1 and S2. Results regarding the CNV in response to S1 from the deaf subjects were similar (in polarity, distribution, and timing) to those from the hearing group although, behaviorally, the deaf participants' rhyming abilities were poorer. The authors conclude that the similarity of the CNV modulations between the deaf and hearing groups could indicate sensitivity to the phonological structure of speech in the deaf group, even in the absence of auditory input. They also considered that this result supports the suggestion that phonological processing of written words is to a large degree amodal or supramodal.

The same kind of task and ERP component was used in a similar study aiming to investigate the neural processes underlying both the rhyming and the location judgment abilities of skilled deaf signers as well as of non-signing hearing participants (Colin et al., 2013). Colin et al. (2013) presented 64 pairs of pictures sequentially to 10 deaf native signers and 10 non-signing hearing participants. In the oral language condition (so called by the authors, but not involving spoken language), deaf and hearing participants judged whether the written French name of each picture rhymed or not. In the SL condition, participants judged whether the signs from Belgian French SL corresponding to the two pictures were produced at the same or different locations. A CNV evoked by the first picture of each pair in the oral language condition was present for both groups with a left hemispheric dominance for frontal sites. To the authors, these results suggested that a first phonological encoding of linguistic material is shared by hearing participants (for rhyme) and deaf participants (for rhyme and sign location) hosted in the left hemisphere. The CNV evoked by the first picture of each pair in the SL condition was also present for both groups, but the typical left-hemispheric dominance at the frontal sites was only shown for the group of deaf participants. This result was interpreted as a consequence of early exposure to SL creating a linguistic sensitivity to specific phonological parameters (location). The CNV between both conditions showed the same time course and brain topography for deaf signers, thus confirming previous studies (MacSweeney et al., 2013) claiming that similar neural networks support phonological encoding across modalities.

It should be noted, however, that drawing correspondences between rhyme in SpL and the location of signs in SL is somewhat debatable. For example, the structural parts of signs such as handshape, location and movement may be meaningful, as the use of hand configuration and space in

SL may be predominantly motivated rather than arbitrary (e.g., Liddell, 2003; Cormier et al., 2015). It cannot be assumed that structural groupings such as rhymes in SpL and similar sign locations in SL are comparable phenomena, as they may involve different semiotics and patterns of organization.

Although the CNV has mostly been used in SL settings for the study of lexical/phonological processing in signers, it could also be useful for the study of production in SL settings. Since the CNV seems to index the neural processes that occur before movement, it could throw light on the neuroelectric activity related to the preparation of SL production. More specifically, the CNV could help to investigate the more fine-grained cognitive analysis that is performed before a guided movement is executed. As the CNV is usually affected by motivation, attention, and other states of the subject, then those variables could also be manipulated in SL production studies to explore their effects on the neurocognitive correlates of motor preparation before a sign is produced. To the best of our knowledge, no studies tackling this important topic have yet been conducted in the field.

Readiness Potential

Another ERP component indicating the preparation of the brain for an upcoming motor behavior is the Bereitschaftspotential (by its German name) or Readiness Potential (RP, also known as pre-motor potential) (Kornhuber and Deecke, 1965, 2016). It is a measure of brain activity at the cortical level before a voluntary movement is produced, and it is therefore usually recorded when the EEG response is locked to the onset of the movement itself. It is a negative deflection observed from about 1–2 s before the onset of a voluntary action. Topographically, the maximum amplitude of RP is recorded over the motor cortex (left and right precentral and centro-parietal areas of the scalp). The RP's neural generators seem to be located in the primary and supplementary motor areas (Deecke et al., 1982). Other movements, like those of the head, eyes or mouth can affect its recognition and amplitude. The onset of the motor movement needs to be clearly detected to reliably identify the onset of the RP. Thus, usually, the EEG signal is recorded in conjunction with other procedures like Electromyography (EMG) of muscle activity.

The RP has been recorded prior to the motor aspects of speech (Jansen et al., 2014; Wesselmeier and Müller, 2015). Unfortunately, we were unable to find any study conducted in the SL context using the RP. For that reason, here we will describe one study using the RP in the study of some kind of movement production.

In a study based on the assumption that the processing of action verbs and motor planning share common neural substrates, Boulenger et al. (2008) aimed to determine whether the processing of action-related language could interfere with motor action when they are performed concurrently. The authors investigated the impact of a subliminal action word on the neurophysiological correlates of motor preparation (using RP) and on the subsequent execution of an arm-reaching movement (using kinematic analyses). To force the subliminal processing of the words, the words were visually presented, before a signal to execute the arm movement, at a very fast rate, to avoid their being consciously detected and triggering mental motor imagery. Thus, 25 French native speakers were presented with three conditions, one using action words (action verbs), another using non-action words (concrete nouns), and a third, the control (a consonant string), before the signal to move. The results revealed that the slope of the RP that preceded the movement was less negative (indicating a bigger amplitude) following a verb than following a noun. This result suggested that subliminal perception of action verbs could interfere with the concurrent preparation and subsequent execution of a motor movement. The authors concluded that language-related activity in motor areas is indeed part of word processing and that motor areas contribute to the understanding of action words.

Even though the RP seems not to have been a method of choice within SL studies so far, we consider that it would be a useful tool in the study of preparation for action prior to SL production. Motor aspects of language production are usually more studied than the cognitive processes that need to be performed before the movement is initiated. Studying the latter could help us to understand what might be responsible when varying results are achieved in SL production studies. As it has been suggested that the RP reflects planning and anticipation for the forthcoming action (Travers et al., 2021), this ERP offers a good tool to investigate how these cognitive aspects might affect SL production. Methodologically, using SL instead of speech would make the recording of the RP easier, because SL involves a more prominent motor behavior than speech and is therefore easier to identify.

Error-Related Negativity

The error-related negativity (ERN) (Gehring et al., 1990; Falkenstein et al., 1991) or Ne (error negativity) is observed when participants make an incorrect response, even when they are not conscious of it, in simple-choice tasks. It is therefore considered a brain signature of error detection and compensation. The ERN is another component locked to the response, as with other movement-related ERPs. After an error occurs, the ERN appears as a negative-going deflection in the event-related brain potential around 100 ms after the error onset. Topographically, the ERN seems to have a scalp distribution maximal at central and frontal electrode sites (Gehring et al., 1993). It has been suggested that the neural generators of the ERN are located in the dorsal portion of the anterior cingulate cortex (Carter et al., 1998; Miltner et al., 2003) located in the frontal area (surrounding the frontal part of the corpus callosum). Interestingly, the ERN is less evident in correct responses.

In a study examining SL production, Riès et al. (2020) investigated whether the monitoring mechanism of SpL is also involved in SL production. Electrical brain activity was recorded when 20 deaf signers (ASL dominant) and 16 hearing signers (English dominant) were presented with written word-picture pairs (illustrating meaning). Three conditions were included in the task: an identical condition (word and picture coincided semantically), a semantically related condition (word and picture represented different but semantically related objects), and an unrelated condition (word and picture were not related semantically). The participants were instructed to name the

pictures as quickly and accurately as possible while ignoring the words. The EEG results revealed an ERN (negativity peaking within 15 ms after the signing onset) in the deaf signers. The ERN was larger in errors than in the correct responses with maximum amplitude over fronto-central scalp electrodes. No clear negativity was present in the hearing signers. Also, the slope of the ERN was correlated with ASL proficiency across signers. From these results, the authors concluded that a similar medial frontal mechanism is engaged in pre-output language monitoring in SL and SpL production.

We were unable to find any report of other research related to the study of SL using an ERN, suggesting a limited usage of this ERP to study SL processing. The ERN (as with the other movement-related ERPs introduced here) could be particularly useful in the study of the cognitive processes preceding SL production. As it is considered to reflect the activation of action monitoring processes in response to erroneous behaviors, its use could be very beneficial in the study of the compensatory processes that are likely to take place during SL production. This top-down cognitive compensatory process could be unequally affected by various factors, including SL proficiency level.

DISCUSSION AND FUTURE DIRECTIONS

ERPs are non-invasive objective correlates of brain activity locked into cognitive processes. They provide basic information about brain cortex activity with exact time-tracing of brain processing, and they can be successfully applied to the study of language processing and specifically to SL studies. As we have shown in the previous sections, ERPs have allowed researchers to significantly expand our knowledge of SL processing and production in the brain. Study of the neurocognitive bases of SL would give access to the undetected cognitive processes that underlie behavior and performance in real-life situations involving SL.

Some ERPs have been used more often than others in SL research, perhaps because of their individual characteristics and how easy they are to record. While language-related ERPs have been relatively popular, movement- and cognitive-related ERPs have been used less. One of the advantages of increasing the number of studies using ERPs in the field would be increased comparability between studies.

Interestingly, the classification of ERPs into stimulus-locked and response-locked components suggests that the two groups of ERPs seem to be used to a greater or lesser extent in the study of different aspects of SL. For instance, stimulus-locked ERPs have mostly been used for examining cognitive and language-related research questions, while response-locked ERPs have been typically used for the study of neural aspects of language (SpL and SL) production. Motor movements are often avoided during EEG and MEG measurements as they can contaminate the signal with unwanted activity from muscles, thus compromising the quality of the results. However, response-locked ERPs (where the brain activity is recorded before the motor movement takes place) offer a useful framework for studying motor-related electrical activity in the brain. When using this methodology, there is even an advantage for SL as compared to SpL. In speech, the articulators are located in the head, close to the brain, making it harder to separate the motor from the brain signals. SL, on the other hand, involves overt movements executed especially by the hands, so the motor response could be more easily detected.

There is still little variability as regards which SLs have been included in studies performed with the use of ERPs. Certain SLs, such as American, British or German SL seem to predominate. This limits the extension of the inferences made by these studies. More studies need to be conducted in other SLs in order to conclude whether the findings already reported for one specific SL are universal, and therefore, applicable to users of other SLs.

Much of the history of modern SL research has been influenced by the view that the structure of SL and the structure of SpL are largely comparable and that the linguistic units and concepts used in SpL research are also applicable in the study of SL. While in some respects this may be true, it should be noted that the different linguistic channels used by SpL and SL are a cause of significant differences between them. For example, signers are able to use two manual articulators (e.g., both hands, as well as the mouth and other parts of the body) (for more information see Puupponen, 2019), which allow meaningful utterances to be constructed in a very different way than those constructed by the speech organs. This may, in fact, also have an effect on the study of the processing of SLs. Problems may emerge when taking concepts from the study of SpL and applying them to the study of aspects of SL that are still the subject of academic debate and that are associated with theoretical claims that still lack empirical support. (Johnston, 2012) 163 points out that the "vast bulk of experiments in the language sciences are conducted using well-described, well-documented languages," but that "experimental studies of SL users have been conducted just as much to establish the facts of SLs as to test claims about language structure and use." Although cognitive neuroscience offers new possibilities for tackling relevant issues in the field of SL linguistics, one should exercise caution when considering which claims about SL structure and use are established well enough to be tested, and what we can actually say based on the results. In this respect, studies in closely related fields can shed some light on how SL is processed, and for that reason, they deserve to be included in joint approaches (like in studies comparing SL with gestures).

According to our survey of the field, different types of tasks are used to explore the covert mechanisms involved in several aspects of SL processing. This suggests that by manipulating some SL aspects, their brain neural correlates can be revealed when using neuroimaging techniques. By developing imaginative new tasks to study the linguistic and cognitive properties inherent in SL, several topics that remain understudied in the field could be addressed. For instance, so far, most SL-related ERP studies have avoided the use of videos, perhaps for methodological reasons (as well as limitations of the ERP technique). Because SL is based on movement in space, using video stimulation seems to us to be crucial. This problem could be solved by using clever task manipulations as well as by introducing some modifications into the processes of analysis. With this kind of manipulation, future SL-related ERP research could establish a bridge between laboratory science and the "real-world" settings in which SL

interaction occurs. That is, more videos and SL stimulation at a natural pace could be introduced more often to give us more reliable understanding of how SL is processed and produced in daily life. Following this line of thinking, Hosemann et al. (2013) performed an N400 study using videos of naturally signed German SL sentences. Among more specific findings related to their research questions, the authors showed an N400 onset before the critical sign onset (stroke, in terms of Kita et al., 1998). This result suggests that signers also make use of the properties of the transition (or preparation/recovery; see Kita et al., 1998) phase between signs. According to this result, SL comprehension does not seem to start with the beginning of the sign (stroke), but it relies also on valuable information coming from the transition (or preparation/recovery) between one sign (stroke) and the next one. Without using video-stimulation and the ERP technique, it would not be possible to identify this particular attribute of SL comprehension.

Even though ERPs offer multiple advantages, they also have several important limitations that should be considered carefully when applying this methodology to SL research. First, EEG has a low spatial resolution for localizing the neural generators of a particular effect. Although there are some methods (based on mathematical solutions to the inverse problem) for localizing the neural generators of ERPs based on EEG activity, it would be wiser, when answering research questions about localization, to use other techniques with higher spatial resolution, such as MEG or fMRI/MRI. Fortunately, several ERP components have been quite well-studied and their neural generators are well-known. Second, ERPs rely on averaging the stimulus- or response-locked EEG data, on the assumption that the only relevant activity is the one that is kept constant. This procedure might lead to the discarding of important information that is not regular across trials. One way of dealing with this limitation is by analyzing the EEG signal in terms of brain oscillations. Another consideration worth mentioning related to the averaging of EEG activity is that to reliably identify some ERPs, a large number of trials are needed, which will mean extending the measuring times. This requirement could also affect the measurement of rapidly habituating cognitive and neural processes. In that case, the use of trial-by-trial analyses should be considered. As has been mentioned above, it is still difficult to separate brain signals from motion artifacts. This can be considered another limitation of the EEG in general because minimal movements are required from the participants to record reliable data.

In conclusion, ERPs can be considered a very useful tool for understanding different aspects of SL processing that remain uncertain or elusive with the use of other techniques. ERPs could particularly help researchers interested in SL to target, for example, the underlying mechanisms of SL comprehension and production that occur in real time. ERPs' high temporal resolution would allow researchers to determine the sequence of cognitive processes underlying SL processing under a wide variety of task conditions. We believe that they will be used much more widely in SL research in the future.

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DH, AP, and TJ: conception and design of the work, drafting of the article, and critical revision of the article. All authors contributed to the article and approved the submitted version.

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Historical Linguistics of Sign Languages: Progress and Problems

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In contrast to scholars and signers in the nineteenth century, William Stokoe conceived of American Sign Language (ASL) as a unique linguistic tradition with roots in nineteenth-century *langue des signes française*, a conception that is apparent in his earliest scholarship on ASL. Stokoe thus contributed to the theoretical foundations upon which the field of sign language historical linguistics would later develop. This review focuses on the development of sign language historical linguistics since Stokoe, including the field's significant progress and the theoretical and methodological problems that it still faces. The review examines the field's development through the lens of two related problems pertaining to how we understand sign language relationships and to our understanding of cognacy, as the term pertains to signs. It is suggested that the theoretical notions underlying these terms do not straightforwardly map onto the historical development of many sign languages. Recent approaches in sign language historical linguistics are highlighted and future directions for research are suggested to address the problems discussed in this review.

Keywords: historical linguistics, language change, sign language, language relationships, language families

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INTRODUCTION

Today, signers and scholars alike commonly view each sign language as representing a distinct linguistic tradition. We consider *American* Sign Language to be distinct from *British* Sign Language in part because distinct linguistic conventions have respectively evolved within the American and British signing communities. We also recognize the recent genesis of new traditions, such as the emergence of Nicaraguan Sign Language beginning in the 1970s (Polich, 2005) and of Israeli Sign Language beginning in the 1930s (Meir and Sandler, 2008). According to this contemporary view, a view that developed in significant part due to the ideas of William Stokoe, sign languages have histories.

However, a different view of sign languages, a universalist view, was common in the eighteenth and nineteenth centuries, the period during which many contemporary sign languages emerged in connection with schools for the deaf. Earlier scholars and signers thought of signed language as a universal human language, "the native language of man" (Peet, 1853). For this reason, signed language was commonly called "the language of signs," without social or geographic modifiers (Baynton, 1996). Insofar as differences were recognized in the signing of geographically distinct communities, the differences were likened to dialectal variation in one common language (Peet, 1853; Baynton, 2002). Thus, Laurent Clerc of France, shortly after arriving in the U.S. in 1816 and upon meeting Alice Cogswell, who would become his first student at the American School for the Deaf, was not surprised to find that he could easily communicate with her in sign: "so true it is, as I have often mentioned before, that the language of signs is universal and as simple as nature" (Clerc, 1852, p. 107).

As a universal language, signed language was not thought to have a historical dimension in the same way that spoken languages were thought to have. Around the mid-nineteenth century, August Schleicher and others had begun to trace the ramification of eight spoken language families from Indo-European (e.g., Schleicher, 1853). In roughly the same period, Thomas H. Gallaudet (1847, p. 56) theorized that the "natural language of signs" had its origins in deaf children's "natural, spontaneous facility." Gallaudet and his contemporaries held that the similarity of signs among deaf students in schools across Europe and the U.S., and even among Native American signers, had a simple explanation: "[these signs] originate from elements of this sign-language which nature furnishes to man wherever he is found" (Gallaudet, 1847, p. 59). On this view, as the universal, natural expression of all humans, both deaf and hearing, signed language transcended history. When nineteenth-century scholars of signed language, most of whom were professional educators, wrote about history, they most often had in mind the history of pedagogical approaches—with particular focus on manualist vs. oralist methods in deaf education—but not the history of the sign languages that had developed in signing communities (Baynton, 1996; Edwards, 2012).

How has the contemporary view of sign languages as distinct traditions, each with its own unique history, come to differ so markedly from the earlier universalist view? Stokoe's work represents one critical inflection point in the intellectual history of the study of signed language and in the development of the historical linguistics of sign languages. For Stokoe (1960, p. 5) "the natural language of signs" was a "false entity." In contrast to the views of his universalist predecessors, Stokoe (1960, p. 3) held that a "natural" sign language was "a language system of visual symbols" embedded in a language community, such as "the sign language of the American deaf." Although historical linguistics was not the primary focus of Stokoe's scholarship, he conceived of ASL as a unique linguistic tradition with roots in nineteenth-century *langue des signes française* (LSF), a conception that is apparent in his earliest scholarship on ASL (Stokoe, 1960; Stokoe et al., 1965). Thus, Stokoe contributed to the theoretical foundation upon which linguists would study not only the history of ASL but also the histories of many other sign languages. Only when sign languages came to be seen as the linguistic traditions of distinct signing communities could broader questions be foregrounded about their histories; and only then could a discipline develop that would focus on the historical linguistics of sign languages.

Sign Language Historical Linguistics Since Stokoe

Historical linguistics is broadly interested in understanding language change, including how languages change as they diversify from a common ancestral language and how languages change as the speakers and signers of distinct languages come into contact with one another. One principal aspect of the endeavor to understand language change has been the study of language relationships, an area that encompasses the reconstruction of protolanguages, the classification of languages in families, and the subgrouping of more closely-related languages within those families. Following Stokoe, the study of language relationships among sign languages has arguably been the primary area of focus for sign language historical linguists. When sign languages were seen to represent distinct linguistic traditions, the question naturally arose as to how those distinct traditions have developed in relation to one another.

From the 1960s onward, sign scholars have made important advances in our understanding of the histories of many sign languages and of language change in the gestural-visual modality; many of these advances are highlighted in Section Early progress in sign language historical linguistics. Notwithstanding these considerable achievements, I will argue that there remain fundamental theoretical and methodological problems that hinder further progress in sign language historical linguistics. Sign scholars have adopted notions from traditional historical linguistics, such as the language family and cognacy, to theorize the relationships of sign languages and the historical relations of their constituent signs and features. Scholars have also adapted historical comparative methods from that discipline, such as lexicostatistics, to study sign language relationships. The appropriateness of these theories and methods to the historical study of sign languages has, in my view, received insufficient attention to date.

Here I examine the development of sign language historical linguistics since Stokoe through the lens of two related problems pertaining to how we understand sign language relationships and to our understanding of cognacy, as that notion is used to describe the historical relations of signs. I will argue that the relevant theories and methods from historical linguistics do not straightforwardly map onto the historical development of many sign languages. I show how, in light of the problems highlighted here, sign scholars have developed alternative approaches to study the histories of sign languages. While these innovative approaches have provided insights into the histories of many sign languages, I will show that, in some cases, they have also masked important characteristics of sign language change.

In Section Relationships among spoken languages and among signed languages, I examine the first problem, which concerns our theorization of sign language relationships. Do sign languages that are said to be historically related indeed share the same type of relationship that characterizes the spoken languages in a language family (Zeshan, 2006, 2013; Campbell, 2018; Reagan, 2021)? I will show that assumptions underlying theories about spoken language relationships, specifically those pertaining to the intergenerational transmission of language, do not hold for the diversification of sign languages in many sign language families.

The second problem (Section The identification of cognates) concerns our understanding of the cognacy relation among signs. This problem has both a theoretical and a methodological dimension. The theoretical dimension of this problem is related to the first problem mentioned above—the cognacy relation in traditional historical linguistics obtains only among lexical items and linguistic features that have been inherited *via* a specific process of diversification (e.g., Thomason and Kaufman, 1988; Ringe et al., 2002). Where this process has not characterized the

diversification of sign languages, the cognacy relation may not be appropriate to describe the historical relations of signs. The methodological problem concerns our ability to identify patterns that uniquely differentiate inherited signs from those that have entered a language *via* processes other than inheritance, such as borrowing. I will show that sign scholars have not yet developed rigorous methods for identifying inherited signs. I argue that, lacking such methods, it is more appropriate to understand the relations of signs among sign languages that are thought to be related as an etymological relation, rather than a cognacy relation.

EARLY PROGRESS IN SIGN LANGUAGE HISTORICAL LINGUISTICS

Stokoe's work on ASL played a pivotal role in the recognition that sign languages indeed have a historical dimension, but progress in understanding the particular histories of these languages, their relationships, and the processes driving historical change in them has been the work of other scholars. These scholars have benefited from the methodological and theoretical developments of the past two centuries in historical linguistics. Early in the development of sign language historical linguistics, lexicostatistics and glottochronology, quantitative approaches that had been developed to study the histories of spoken languages (e.g., Swadesh, 1955; Gudschinsky, 1956), were adapted to the study of sign language data, as was Swadesh's list of basic vocabulary (Woodward, 1978). In interpreting the results of these methods, scholars adopted from historical linguistics the same metaphors to describe language relationships, such as the language family, that had developed in that discipline (see Reagan, 2021 for a recent discussion). They also adopted much of the same terminology that had developed to describe the historical relations of words, such as the relations of cognacy and borrowing, and applied these same notions to the historical relations of signs (Woodward, 1978, 1991). The emergence of many sign languages was theorized in terms that had developed for the analysis of spoken languages. For example, the emergence of ASL was characterized by some scholars as a creolization process with parallels to the emergence of spoken language creoles (Fischer, 1978; Woodward, 1978; Meier, 1984; but see Lupton and Salmons, 1996).

As with the study of language relationships, the study of change in sign languages was influenced by the theories and methods of traditional historical linguistics. Frishberg's (1975) seminal study of historical change in ASL drew connections between the processes driving change in that language and processes such as assimilation and lexicalization in diachronic change in spoken languages. Frishberg argued that other changes, such as the centralization of signs articulated below the neck and the lateralization of signs articulated at the face, reflected tendencies toward articulatory and perceptual ease. Both of these mechanisms of change have parallels in theories of spoken language change (Ohala, 1981, 1993). Battison et al. (1975) adopted the type of variationist approach that had been introduced by Weinreich et al. (1968) to argue that thumb extension in a class of ASL signs—specifically, signs with an extended index finger—represented a historical change in progress in the American deaf community.

By adapting the methods and theories of historical linguistics to the study of sign languages, early scholars made important advances in our understanding of sign language relationships. Woodward (1978) showed that historical relationships among sign languages can be reflected in contemporary linguistic data. Based on quantitative measures of shared cognates, he estimated that ASL and LSF—two languages that were thought to be related on extralinguistic grounds—share 61% of their basic vocabularies. He also studied the intergenerational transmission of ASL signs in the American deaf community, finding that greater than 99% of the signs seen in videos of ASL signers from the early twentieth century have reflexes in contemporary ASL. Thus, Woodward's early work suggested that a historical signal can be identified and measured both in the diversification of sign languages and in the intergenerational transmission of a sign language.

Other studies suggested that related and unrelated sign languages could be reliably differentiated by using the historical comparative methods that had been adapted to study sign languages. In their comparison of British, Australian, and New Zealand Sign Languages, three languages that were hypothesized to be related, McKee and Kennedy (2000) found that between 79 and 87% of these languages' basic vocabularies were cognate—though their operationalization of the term "cognate," and perhaps also their theory underlying that notion, differed from Woodward's (see Woodward, 2011 for a discussion). In contrast, when these languages were compared with ASL, which was hypothesized to be unrelated to any of the other languages, only between 26 and 32% of their basic vocabularies were found to be, in their terms, cognate. Similarly, in a study of the sources of vocabulary in *Lengua de Señas Mexicana* (LSM), Guerra Currie et al. (2002) found a relatively high percentage of phonologically-similar vocabulary (38%) when comparing that language with LSF, a language that was hypothesized to be related. In contrast, when comparing LSM with *Lengua de Signos Española* and with *Nihon Syuwa* (Japanese Sign Language)—two languages thought to be unrelated to LSM—the percentages of phonologically-similar vocabulary were lower (33 and 23%, respectively).[1]

As in the two studies just mentioned, the methods first used by Woodward to study the relationship of ASL and LSF have been applied to study sign language relationships in other parts of the world. Woodward himself conducted several historical comparative studies of sign languages in Costa Rica, South Asia, Thailand, and Vietnam (Woodward, 1991, 1993, 1996, 2000, 2011). In each of those studies, Woodward used lexicostatistical methods together with quantitative thresholds that were based on expected levels of shared cognates to decide whether the sign varieties that he studied were dialects of the same language. Sign varieties that were inferred to be distinct languages were classified into families. In more recent work, Clark (2017) used a similar approach to study sign varieties in Peru, finding that

[1]Guerra Currie et al. (2002, p. 225) hypothesized that cultural ties between Spanish-speaking Mexico and Spain might "manifest themselves" in linguistic similarities among LSM and *Lengua de Signos Española*.

there are two distinct sign languages in use in that country and that a third variety is a hybridized variety with elements of the two distinct languages. Other scholars have adapted Woodward's methods to argue for the historical relationships, inter alia, of sign languages in Eastern Europe, such as *Russkii Zhestovyi Yazyk* and *Ukrayinska Zhestova Mova* (Russian and Ukrainian Sign Languages; Bickford, 2005), of *Nihon Syuwa* and *Táiwān Shǒuyǔ* (Japanese and Taiwan Sign Languages; Sasaki, 2007), and of sign languages in the Middle East, such as *Lughat il-Ishaarah il-Urduniah* and *Lughat al-Ishārāt al-Filisṭīniyyah* (Jordanian and Palestinian Sign Languages; Al-Fityani and Padden, 2010).

In addition to the advances in our understanding of the historical relationships among sign languages and in the methods for studying those relationships, sign scholars have also made progress in understanding language change in the gestural-visual modality. Radutzky's (1989) study of historical change in *Lingua dei Segni Italiana* (LIS) investigated the categories of change that had been identified in Frishberg (1975). She found that many of the same diachronic changes that Frishberg had described for ASL, such as changes in the shape of the nondominant hand and in the lateralization of signs articulated at the face, had also occurred in LIS. She also found that one diachronic change in LIS paralleled the type of change in thumb extension that had been identified by Battison et al. (1975) as an ongoing change in the American deaf community. As with Frishberg's account of diachronic changes in ASL, Radutzky identified articulatory and perceptual ease as important drivers of change in LIS.

Like Frishberg, Supalla and Clark (2015) investigated historical sources—particularly, video recordings of ASL signers in the early twentieth century—to understand the origins of lexical signs and grammatical constructions in ASL. Their analysis of video recordings in addition to more static sources, such as historical dictionaries (see Frishberg's analysis of Long, 1918), allowed them to observe historical signs in a range of phrase- and discourse-level contexts. They observed that many signs in contemporary ASL have developed from historical compounds and collocations, which have undergone diachronic processes of reduction and semantic shift. They argued that many changes affecting forms in the ASL of the early twentieth century had been driven by grammaticalization processes (see Hopper and Traugott, 1993).

Just as Battison et al. (1975) used a variationist approach to study changes in handshapes, later scholars took a similar approach to investigate changes in the locations of signs. Lucas et al. (2001) examined a class of signs in ASL that is defined phonetically by articulation at the forehead or temple in citation form. They found a positive correlation between the height of signers' articulations and their ages: older signers produced more tokens at higher locations on the head, while middle-aged and younger signers produced more tokens with lower articulations. The authors tentatively concluded that the differences in location in this class of signs represented a change in progress in the American deaf community. In a study examining a similar class of signs in Australian and New Zealand Sign Languages, Schembri et al. (2009) also found that sign articulations were positively correlated with signers' ages. In both studies, the authors hypothesized that the mechanism driving the diachronic changes was articulatory ease, since higher articulations presumably require more effort compared to lower articulations (Mauk, 2003; Napoli et al., 2014).

In sum, the preceding brief survey of sign language historical linguistics has highlighted two critical areas of progress since Stokoe. First, scholars have developed methods that can identify historical signal in contemporary sign data; that historical signal is sufficiently robust to differentiate sign languages that are thought to be related on extralinguistic grounds from those that are thought to be unrelated. Second, real time and apparent time studies of change in sign languages have identified diachronic changes that have occurred in more than one sign language. These discoveries suggest that the field might eventually identify a comprehensive set of common diachronic changes that occur in languages in the gestural-visual modality. The changes that have already been identified have been argued to be driven by mechanisms, such as ease of articulation and perception, that have also driven many changes in spoken languages.

RELATIONSHIPS AMONG SPOKEN LANGUAGES AND AMONG SIGNED LANGUAGES

What does it mean to say that languages are *related*? The word *related* has multiple senses; one of these senses means "connected or having relation to something else" (Oxford English Dictionary, 2021b). Thus, one answer to the initial question could be that two languages are related—that is, connected—if they share words or linguistic features. This view of language relationships would be unconcerned with how shared words and features have entered languages; instead, the main consideration on this view would be how closely connected, or perhaps how similar, the two languages are at a particular point in time, given some metric of connection. Hence two previously unrelated languages could become related, if, for example, the speakers of these languages begin to borrow words from one another; conversely, two related languages could become unrelated, if speakers would cease to use the words or features they once had in common. Because the connections among languages and their similarity may change over time, so too, on this view, might language relationships change.

The term *related* in traditional historical linguistics differs from the view just described. When deciding whether two languages are related, historical linguists are not concerned with their similarity or with connections among their speakers *per se*, but rather with the processes that have resulted in these languages' shared words and features. Language relationships in historical linguistics are theorized in a way that parallels the evolutionary relationships of organisms (Atkinson and Gray, 2005). For example, birds and bats share many morphological similarities; yet from an evolutionary perspective, bats are more closely related to humans than they are to birds because bats and humans share a more recent common ancestor (Morrison et al., 2015).

In historical linguistics, common ancestry has been fundamental to the meaning of language relationships. Just

as offspring inherit DNA from an ancestor, a younger generation of speakers is thought to acquire, or inherit, a language system from an older generation, including that language's words and features. For example, the Proto-West-Germanic verb **laidijan* "lead" (Ringe and Taylor, 2014) is thought to have been inherited by successive generations of children along a chain of language transmission events down to the present day. As Proto-West-Germanic diversified, **laidijan* came to be inherited in distinct speech communities, in which the word subsequently underwent distinct sound changes, resulting in, for example, Old English (*lædan*), Old Dutch (*leiden*), and Old High German (*leiten*) (Ringe and Taylor, 2014). Although the contemporary reflexes of these words—namely, English *lead*, Dutch *leiden*, and German *leiten*—differ in their phonological forms, they have all been inherited along chains of language transmission events that trace back to a common ancestor, namely, Proto-West-Germanic.

In contrast to the process of inheritance, consider the process of borrowing, which represents a different pathway by which words and linguistic features may enter a language. During the 1940s, adult speakers of American English, initially soldiers, evidently borrowed the word 'honcho', meaning leader or person in charge, from Japanese *hancho* [*han* "corps, squad" and *cho* "head, chief"; (Online Etymological Dictionary, 2021; Oxford English Dictionary, 2021a)]. Although in this case a word with etymological origins in Japanese entered into American English, and although American English and Japanese have become, in a sense, more closely connected after this borrowing event, historical linguists would not say that the two languages are related because of the borrowing event. The American English word *honcho* and the Japanese word *hancho* were not intergenerationally inherited from a common ancestral language as constituents of that language system.

Genetic Language Relationships

Characteristics of the language transmission process itself play a fundamental role in how language relationships are understood in historical linguistics.[2] These characteristics are not fixed; instead, language transmission is sensitive to social and cultural variation. The network of social connections through which language transmission occurs can differ. For example, language can be transmitted from parent to child, from nonparental adult to child, and among peers; and many children are exposed to multiple languages along these various pathways (Cavalli-Sforza and Feldman, 1981; Mufwene, 2008). The typical settings within which language is transmitted can also differ. For example, in some speech communities, language may be primarily transmitted to children in the home, at least early on. Sign languages too may be primarily transmitted to children in the home in some village signing communities (Zeshan and de Vos, 2012), in multi-generational family signing communities (Dikyuva, 2012), in relatively small networks of families with deaf members (Hou, 2016), and, in general, in any setting in which older generations sign with younger generations (Newport and Meier, 1985; van den Bogaerde and Baker, 2016; German, 2021). But, in some signing communities, an important setting for language transmission to children has been the deaf school and dormitory (Singleton and Meier, 2021).

Language transmission can also occur at differing ages and hence at differing stages of cognitive development. Power and Meier (2021) report that there were few young children at the American School for the Deaf in Hartford during the school's first 50 years because its minimum age for admission was 8 years old or higher. Less than 1% of 1,700 students were under age 8 at enrollment during that period, and the average age at enrollment was 14.4 years old ($SD = 5.2$ years). The school's admission policy likely caused many deaf children, particularly those without access to visual language at home, to experience language deprivation in childhood, an experience which can have negative consequences for language acquisition. The age at which an individual acquires a sign language has been shown to affect language processing (Morford, 2003), second language acquisition (Mayberry et al., 2002), as well as the acquisition of verbs and basic word order in ASL (Newport, 1988; Cheng and Mayberry, 2020). When late learners transmit language to a subsequent generation, the language system itself may have varying levels of complexity and consistency (Senghas and Coppola, 2001; Singleton and Newport, 2004). In sum, it seems that many aspects of the language transmission scenario can vary—including characteristics of the transmitter, transmission pathway, language, setting, and acquirer.

Among the overall set of potential language transmission scenarios, one scenario has been termed *normal*, or typical, because it arguably occurs under typical social conditions.[3] According to Thomason and Kaufman (1988, p. 9–10), normal transmission occurs "from parent generation to child generation and/or *via* peer group from immediately older to immediately younger, with relatively small degrees of change over the short run, given a reasonably stable sociolinguistic context." When successive generations inherit a language *via* this type of transmission, the process results in a chain of languages, each one having been derived from the immediately preceding language. Ringe et al. (2002, p. 63) refer to this process as *linguistic descent*, which they define in the following way: "A language (or dialect) Y at a given time is said to be descended from language (or dialect) X of an earlier time if and only if X developed into Y by an unbroken sequence of instances of native-language acquisition by children." The process parallels asexual biological reproduction in that each derived language is thought to have just one antecedent language.

The notions of normal transmission and linguistic descent have been critical to the understanding of language relationships in historical linguistics. Languages are related and belong to the

[2]Labov (2007) uses the term "transmission" in a restricted sense to mean the intergenerational transmission of language and its acquisition by children; see Section Linguistic descent and its consequences for theories of sign language relationships. Here I use the term in its more general sense.

[3]With hindsight, the modifier "normal" may have been ill-considered; see Thomason (2002, p. 102), who admits that the opposite notion of abnormality of transmission is "arguably pejorative." More to the point, to my knowledge, there have been no careful empirical studies on the basis of which historical linguists might determine which are the normal, or perhaps the most common, pathways of transmission within the world's language communities.

same language family if they are derived *via* linguistic descent from a common ancestral language (Thomason and Kaufman, 1988; Thomason, 2002; but see DeGraff, 2001; Mufwene, 2003 for critiques). In the terminology of many historical linguists, languages that are related in the way just described are said to share a specifically *genetic* relationship.

Nongenetic Language Relationships?

How do we characterize the relationships of languages that are not derived from a common ancestral language *via* linguistic descent? Historical linguists consider many languages, such as English and Japanese, to be unrelated because no plausible common ancestral language has yet been reconstructed for them; and perhaps none can be, if no such ancestral language existed. English and Japanese have genetic relationships to other languages—just not to each other. Language isolates, such as Basque and Ainu, are also thought to lack genetic relationships to any existing or extant languages (Campbell, 2013). However, language isolates may once have had genetic relationships to some language or group of languages that are now extinct. And, importantly, an isolate is presumably linked *via* linguistic descent to antecedent stages in its own historical development.

What happens if the chain of linguistic descent is broken in a language's historical development—as the development of a creole language has been thought to entail? What if the intergenerational transmission of language differs from the type of transmission described above? How do we characterize the relationships of languages that have not developed *via* linguistic descent? According to Thomason and Kaufman (1988, p. 10), if the chain of linguistic descent is broken at any point, the relationship between languages on either side of the break is not genetic: "the label 'genetic relationship' does not properly apply when transmission is imperfect." In addition, as we have seen, in linguistic descent exactly one ancestral language develops into a derived language. Thus, any language that is descended from more than one ancestral language—as creole languages and many sign languages are thought to be—has no genetic relationships to any antecedent language or to any other languages that have descended from those antecedents. These languages with multiple sources "[have] followed a nongenetic pathway of development" (Thomason and Kaufman, 1988, p. 8).

Scholars of creole languages have debated how to characterize the relationships of a creole to its lexifier and its substrates (DeGraff, 2001; Thomason, 2002; Mufwene, 2003). How does a creole's history connect with the histories of the languages that have, at least in part, formed the basis of its lexicon and grammar? If linguistic descent is taken to be definitional in the theory of language relationships, a creole has no genetic relationship to its antecedents because its linguistic system has multiple sources. For example, Thomason and Kaufman (1988, p. 11) contend that mixed languages "by definition...are unrelated genetically to the source(s) of any of their multiple components"; and, similarly, that "a claim of genetic relationship entails systematic correspondences in all parts of the language because this is what results from normal transmission: what is transmitted is an entire language." Thus, on this view, any language with heterogeneous sources has no genetic relationships to its antecedents or to the contemporary languages that have descended from those antecedents. While these relationships are not considered genetic, the theory does not make clear how to positively define the relationship; witness the unwieldy term "genetic nonrelatedness" in Thomason (2002, p. 105).

The Diversification of Sign Languages *via* Processes Other Than Linguistic Descent

Sign languages have been grouped into language families based on a variety of types of evidence, including extra-linguistic evidence, such as historical connections among deaf educators and educational institutions, linguistic evidence, and a combination of both types of evidence (see Fischer, 2015; Reagan, 2021 for recent discussions). For example, contemporary ASL and LSF are typically classified together with other sign languages that have some historical connection to the variety or varieties of LSF used in eighteenth- and nineteenth-century schools for the deaf in France, including European sign languages such as *Nederlandse Gebarentaal*, *Teanga Chomharthaíochta na hÉireann*, and *Lingua dei Segni Italiana* (Sign Language of the Netherlands, Irish Sign Language, and Italian Sign Language) and sign languages of Latin America such as *Lengua de Señas Mexicana* and *Língua Brasileira de Sinais* (Anderson, 1979; Quer et al., 2010; Abner et al., 2020; Power et al., 2020). Other proposed sign language families include, inter alia, the family of British, Australian, and New Zealand Sign Languages (McKee and Kennedy, 2000), the family including *svenskt teckenspråk* and *Língua gestual portuguesa* (Swedish and Portuguese Sign Languages; Bergman and Engberg-Pedersen, 2010), and the family including *Nihon Syuwa*, *Táiwān Shǒuyǔ*, and *Hanguk Sueo* (Japanese, Taiwan, and Korean Sign Languages; Sasaki, 2007).

However, many languages in the sign language families that have been proposed to date evidently are not derived *via* linguistic descent from a common ancestral language because, (i) as with creole languages, many sign languages are thought to have multiple sources; and (ii) the diversification of these languages implicated a break in their intergenerational transmission. First, some scholars have characterized the emergence of ASL as the creolization of LSF with the indigenous sign varieties of nineteenth-century American deaf signers (Woodward, 1978; Groce, 1985). Fischer (1978, p. 329) hypothesized that ASL has been "recreolized" by deaf children in each generation since the early nineteenth century (see also Meier, 1984) because most deaf children do not acquire ASL from birth—roughly 90% do not (Mitchell and Karchmer, 2004). Guerra Currie (1999) speculates that *Lengua de Señas Mexicana* may have emerged in a similar way—that is, the indigenous sign varieties of Mexican deaf signers may have creolized with LSF in the emergence of *Lengua de Señas Mexicana*. The emigration to Israel of Jewish deaf people from a variety of countries in the first half of the twentieth century is thought to have played an important role in the diversification of that language from *Deutsche Gebärdensprache* (German Sign Language) and other sources (Meir and Sandler, 2008). Insofar as the emergence of these and other sign languages have implicated multiple sources, they may not be genetically related to each other

in the way that the languages in a spoken language family have been thought to be.

Second, many of the historical relationships among sign languages that are thought to have resulted from connections among deaf institutions and the travels of deaf educators have not been characterized by linguistic descent. For example, the historical relationship between ASL and LSF is understood to be based in large part on the transmission of LSF by Laurent Clerc, a deaf educator who moved from Paris to the U.S. in 1816 in order to teach at the American School for the Deaf in Hartford (Edwards, 2012). Clerc himself had acquired LSF at the age of 12, when he moved to Paris from La Balme to attend the Paris National Institute (Lane, 1984). Arguably, Clerc's acquisition of LSF does not straightforwardly map onto the type of intergenerational transmission said to define genetic spoken language relationships because he did not acquire that language as a child. Additionally, as we have seen, some 99% of Clerc's students in Hartford during the school's first 50 years were above the age of 8 at the time of their enrollment; and the average student enrolled in adolescence (Power and Meier, 2021). Thus, both Clerc's acquisition of LSF and his transmission of that language to his American students arguably were not characteristic of linguistic descent, in the sense under discussion here. Instead, the diversification of ASL from a nineteenth-century variety of LSF evidently entailed a break in the intergenerational transmission of that language.

As with the early development of ASL, the diversification of many other sign languages may not have occurred *via* linguistic descent. For example, another French deaf educator, Édouard Huet, who had apparently acquired LSF at age 12, established schools for the deaf in Brazil (est. 1857) and Mexico (est. 1867; Guerra Currie, 1999). The sign languages that later developed in those countries—namely, *Língua Brasileira de Sinais* and *Lengua de Señas Mexicana*—have been thought to be historically related to LSF (Quinto-Pozos, 2008). However, while Huet may have driven the establishment of the schools in Brazil and Mexico, Ramsey and Quinto-Pozos (2010, p. 49–50) speculate that, in Brazil, Huet's LSF-origin signs may have "mixed with the varieties of signing that Brazilian Deaf students brought to the school"; and, regarding Mexico, the authors report that "neither sign-medium instruction nor Deaf teachers played a major role in the school" following its establishment.

A deaf Norwegian, Andreas Christian Møller, began attending the school for the deaf in Copenhagen at age 16; he later returned to Norway and established the first school for the deaf in that country in Trondheim (Greftegreff et al., 2015). *Norsk tegnspråk* and *Dansk tegnsprog* (Norwegian and Danish Sign Languages) have been thought to be historically related (Schröder, 1993). In sum, the diversification of *Língua Brasileira de* Sinais and *Lengua de Señas Mexicana* from a nineteenth-century variety of LSF and of *Norsk tegnspråk* from a nineteenth-century variety of *Dansk tegnsprog* evidently occurred *via* transmission from late learners of those languages.

While Huet and Møller were themselves deaf, the diversification of many other sign languages has occurred in part *via* hearing educators, who were not likely native users of those languages. For example, a hearing priest, Father Tomaso Silvestri, received training in sign language and in pedagogical methods at the Paris National Institute before founding the first public school for the deaf in Italy in 1784 (Quer et al., 2010). A hearing educator of the deaf from Sweden, Per Aron Borg, helped to establish a school for the deaf in Portugal (est. 1823–1828), in which he introduced aspects of *svenskt teckenspråk* to his Portuguese deaf students (Bergman and Engberg-Pedersen, 2010). A hearing teacher, Dorcas Mitchell, introduced a variety of British Sign Language to deaf students in New Zealand in 1868 (Schembri et al., 2010).[4] Hearing Irish nuns, after learning a variety of LSF during a visit to a school in Normandy, introduced that variety in a school for female deaf students in Dublin; later, the nuns shared their variety with hearing teachers at another school for male deaf students in Dublin (LeMaster and Dwyer, 1991). A variety of BSL was introduced by a hearing teacher and her two deaf children, who had moved from England to establish the first school for the deaf in Uganda (Lule and Wallin, 2010; Lutallo-Kiingi and De Clerck, 2015). The origins of *Ishorai Tojiki* (Tajik Sign Language) have been linked to the introduction of a second language variety of *Russkii Zhestovyi Yazyk* (Russian Sign Language) by a group of hearing educators in the former Soviet Union, who established a school for the deaf in Tajikistan around the 1940s (Power, 2020). In each of these cases, and in many other cases around the world like them, sign languages have been classified in the same language family, even though their diversification has not occurred *via* successive instances of the native acquisition of language by children—that is, not *via* linguistic descent.

Not all sign languages have diversified in close connection with educational institutions in the ways just described. For example, the diversification of Australian Sign Language may have initially occurred *via* the migration of at least one signer of British Sign Language, John Carmichael, who had attended the school for the deaf in Edinburgh (Schembri et al., 2010). Other British Sign Language users immigrated to Australia soon after, such as Carmichael's schoolmate, Thomas Pattison, who would later establish the first school for the deaf in Australia in 1860 (Schembri et al., 2010). Carmichael had five children, at least one of whom, Edward Feeney Carmichael, was deaf (Eaton, 2015). Thus, following their presumptive native acquisition of British Sign Language from their father, Carmichael's hearing children and his deaf son may have played a role in the diversification of Australian Sign Language from the British Sign Language of the nineteenth century *via* linguistic descent. However, Carmichael himself apparently began attending the Edinburgh school at age 9 (Eaton, 2015); similarly, Pattison may have begun his studies there at around age 8 (Cooper, 2014). Prior to their attendance at the Edinburgh school, it is unclear whether either of these

[4] Schembri et al. (2010) point out that, perhaps unexpectedly, British Sign Language (BSL) has exerted only limited influence on many sign languages in countries that once formed part of the former British empire, such as India, Pakistan, and South Africa. For example, the authors report that there are relatively few signs in Indian Sign Language that may have origins in BSL—although the two-handed (BSL-origin) manual alphabet does appear to be in use among at least some Indian signers. In South Africa, they report that some schools—though certainly not all—may have used BSL as a medium of instruction (see Aarons and Akach, 1998 for a history of schools for the deaf in South Africa).

individuals had had any exposure to British Sign Language. When viewed through the lens of the theory of genetic language relationships, these signers' relatively late acquisition of British Sign Language may have resulted in a break in the type of chain of child language acquisition events that has been thought to characterize linguistic descent (Ringe et al., 2002; see Section *Genetic* language relationships).

In sum, the relationships of sign languages in many sign language families arguably differ from the types of relationships that are thought to characterize spoken language families because, in many cases, the diversification of languages in these sign families has not occurred *via* linguistic descent. The diversification of many sign languages from antecedent sign languages—such as the diversification of ASL from LSF—may more closely resemble the process described by Mufwene (2009) as "indigenization." In the context of the diversification of world Englishes from varieties of British English, Mufwene (2009, p. 353) defines linguistic indigenization as a "process whereby a language is adapted to the communicative habits and needs of its (new) speakers in a novel ecology." In the case of the diversification of ASL from LSF in the early nineteenth century, the novel ecology into which LSF was introduced—initially, New England—certainly differed in numerous ways from the ecology within which LSF had developed to that point. In its adaptation to the American linguistic ecology, with its complex array of novel demographic, social, cultural, and linguistic features, LSF likely changed in profound and complex ways.

Linguistic Descent and Its Consequences for Theories of Sign Language Relationships

As we have seen, historical connections among sign languages can be reflected in their contemporary forms; for example, sign languages in the French family share similar vocabulary (Woodward, 1978; Guerra Currie et al., 2002), similar structural features (Abner et al., 2020), and similar fingerspelling alphabets (Power et al., 2020). If we accept a historical explanation for many of these similarities, what is the theoretical significance of whether these shared signs and features have been inherited *via* linguistic descent or *via* some theoretically nongenetic pathway?

Linguistic descent crucially implicates the native acquisition of language by children. Labov (2007) argues that differences in the ways that children vs. adults acquire language underlie differences between internal language change and change due to contact. Linguistic descent produces gradual changes ("incrementation") in a language from generation to generation: "the continuity of dialects and languages across time is the result of the ability of children to replicate faithfully the form of the older generation's language, in all of its structural detail" (Labov, 2007, p. 346). In contrast, "adults do not learn and reproduce linguistic forms, rules, and constraints with the accuracy and speed that children display" (Labov, 2007, p. 349). Thus, if the chain of child language acquisition events is broken, relatively abrupt, chaotic changes may be introduced in the historical development of a language. The diversification of many sign languages has arguably been characterized by abrupt changes of this type. Following diversification, however, the transmission of language in a signing community—for example, of ASL in the American deaf community after the introduction of LSF in the early nineteenth century—could be characterized by linguistic descent.

That the diversification of many sign languages has arguably been characterized by abrupt changes introduces a second set of problems. In traditional historical linguistics, methods for identifying inherited words—that is, cognates—among related languages rely on the type of gradual and regular changes that Labov has argued are characteristic of linguistic descent. If, for example, the diversification of sign languages in the French family has implicated abrupt changes, and not gradual, regular changes, then it may not be possible to use the methods of traditional historical linguistics to identify historically-related signs among languages in a sign language family. Before considering this second set of problems for sign language historical linguistics, I first raise a number of critiques of the theory of genetic language relationships.

Critiques of the Theory of Genetic Language Relationships

To this point, I have attempted to bring into stark relief one aspect of the problem situation confronting sign language historical linguistics. The theoretical dimension of this problem relates to the key roles played by the notions of normal transmission and of linguistic descent in the theory of genetic language relationships. My aim has been to emphasize that these notions should not be uncritically adopted in theorizations of the historical development of sign languages and of their relationships to each other. In this section, I turn the focus onto the theory of genetic language relationships by raising two critiques; see Mufwene (2003, 2008) and DeGraff (2001) for additional critiques from the field of creole studies.

The first critique arises through a comparison of the theory of genetic language relationships with the putatively parallel theory in evolutionary biology. Although these theories share many similarities, the underlying processes of linguistic and biological evolution nevertheless fundamentally differ (Atkinson and Gray, 2005). Hence it may be misleading to use terminology such as genetic and nongenetic in theories of language relationships. In the theory of genetic language relationships, as we have seen, some pathways of development are considered nongenetic; however, there are no nongenetic pathways of development in evolutionary biology. Every life form has inherited genetic material from at least one antecedent, and hence every species—arguably, the notion that most closely parallels the notion of a language in the current discussion (Mufwene, 2008)—has developed *via* fundamentally genetic pathways. Relatedly, all species are represented on the one evolutionary tree of life; hence all species have genetic relationships (Maddison et al., 2007). Thus, if the theory of genetic language relationships adopts terminology such as genetic from evolutionary biology, why does the theory allow for some languages to lack relationships?

Furthermore, because creoles, mixed languages, and many sign languages are thought to have multiple antecedents, their

development, according to the theory of genetic language relationships, has been nongenetic (Thomason and Kaufman, 1988; Ringe et al., 2002). That is, linguistic descent implicates asexual reproduction, in a sense; whereas the parallel to sexual reproduction, or perhaps to hybridization, in language formation is considered a nongenetic pathway of development. In contrast to this aspect of the theory of genetic language relationships, both sexual reproduction and hybridization in biology are fundamentally genetic processes. In sum, if intergenerational language transmission and language relationships are theorized in such starkly different ways compared with biological evolution and evolutionary relationships among species, then perhaps terms such as genetic and nongenetic are not appropriate in theories of language relationships.

There is at least one apparent limitation to the theory of genetic language relationships that pertains to this first critique. If some languages have developed along nongenetic pathways, then how does one describe the historical relations of vocabulary and linguistic features that apparently have shared common pathways of historical development? For example, Fischer (1996) has argued that the sign in ASL representing the number three has its origins in nineteenth-century LSF. But, if ASL has not developed from the LSF of the nineteenth century *via* linguistic descent—or indeed from any other language by that process—how do we describe the historical relation obtaining between the contemporary signs in ASL and LSF for the number three? See Section The identification of cognates for a discussion of this problem as it relates to the term cognate.

In one sense, the theory of genetic language relationships divides languages into two classes: one class of languages has genetic relationships because these languages have developed *via* linguistic descent; whereas languages in the other class have no genetic relationships due to characteristics of their intergenerational transmission. The traditional methods in historical linguistics for studying language relationships only properly apply to the former group of languages. For instance, scholars applying the Comparative Method presume that the languages being compared are related (Nichols, 1996; Hale, 2015). How does one study relationships among languages that have developed, according to the theory, along nongenetic pathways?

The second critique pertains to the notion of normal transmission and the emphasis in that notion on the native acquisition of language by children. Because most deaf children are born into hearing, non-signing families (roughly 90%, Mitchell and Karchmer, 2004), these children often experience delays in their exposure to visually-accessible language. Hence the typical situation for language transmission, when considering many signing communities, is not the type of parent-to-child, intergenerational transmission that is assumed to be normal in the notion of normal transmission described above. Costello et al. (2008) note that, in smaller signing communities, such as the community in Basque Country, there may be extremely few deaf signers who could be considered native signers, given the notion of native that is assumed in speech communities. These authors suggest that the number of signers who have acquired their community's language from birth may depend on factors such as the community's marriage patterns and the prevalence of genetic deafness in the community. Because these factors likely vary across language communities, the patterns of typical language transmission in these communities may vary as well.

Cheng et al. (2021) suggest that the terms "native speaker" and "native signer" have sometimes been used by scholars in ways that conflate differing aspects of language acquisition, proficiency, and identity. In light of differences in the demographics of many signing vs. speech communities and, relatedly, in light of differences in the typical pathways of language transmission in these communities, the authors recommend that scholars carefully disentangle the various assumptions that constitute the category of native speaker or native signer. Arguably, a more nuanced theorization of linguistic experience and language transmission would allow historical linguists to more fully capture the natural complexity in how languages change and in how they are related to one another. In sum, we might expect of a theory of language relationships that it engages with the complex patterns of intergenerational language transmission and of language diversification that actually occur in the world.

THE IDENTIFICATION OF COGNATES

At the beginning of Section Relationships among spoken languages and among signed languages, I contrasted the inheritance of **laidijan* "lead" from Proto-West-Germanic in contemporary English, Dutch, and German with the borrowing of *honcho* from Japanese by American English speakers. Because English *lead*, Dutch *leiden*, and German *leiten* have been inherited *via* linguistic descent from Proto-West-Germanic, the contemporary words are said to be cognates. Trask (2000, p. 62) defines the term cognate as "one of two or more words or morphemes which are directly descended from a single ancestral form in the single common ancestor of the languages in which the words or morphemes are found, with no borrowing." Because cognates are inherited *via* linguistic descent, by comparing them across related languages linguists may discover information about the internal structure of a language family—that is, the sequence of language diversification events in that language family. In contrast, borrowings do not provide the same type of historical information—certainly, not at the point of the borrowing event—because they were not inherited *via* linguistic descent as constituents of a common ancestral language.

In traditional historical linguistics, the Comparative Method has been the principal methodology used to identify cognates among related languages. Even in more recent quantitative approaches in historical linguistics, the data have typically comprised cognates that had been previously identified using the Comparative Method (e.g., Gray and Atkinson, 2003; Kolipakam et al., 2018). The Comparative Method depends on the assumption that sound change can be regular (Rankin, 2003; Hale, 2015). The methodology seeks to identify regular sound correspondences across semantically similar words; see Campbell (2013) for a comprehensive discussion of the methodology. In the example above, the correspondence in the second consonants

across English (-d), Dutch (-d-), and German (-t-) regularly recurs in many other words in those languages (e.g., in English *ride*, Dutch *reijden*, and German *reiten*). The most parsimonious explanation for this regular correspondence is the genetic hypothesis (Hockett, 1965)—that is, that the contemporary words have been inherited from a common ancestral language.

We do not yet know if sign change can be regular in the way that sound change in spoken languages has been argued to be (Labov, 2020). None of the diachronic changes identified among sign languages have yet been shown to occur uniformly, given a defined phonetic context (Power et al., 2019); nor have regularly recurring correspondences of the type described above been identified across sign languages that are thought to be related. In the previous section, I highlighted a potential explanation for this apparent lack of regular correspondences: namely, the diversification of many sign languages in sign language families may not have been characterized by linguistic descent. Hence we would not expect to find regular correspondences across these sign languages because regular correspondences result from the type of gradual change that is characteristic of linguistic descent.

If sign change cannot be regular, or if the historical development of many sign languages has not resulted in regular correspondences across languages that are thought to be related, then it is not possible to use the Comparative Method to identify cognate signs. Because the Comparative Method in traditional historical linguistics is so tightly intertwined with the identification of cognates through regular correspondences, it is unclear how cognates ought to be identified among sign languages that do not exhibit such correspondences—or, indeed, whether signs that are apparently historically-related, given some alternative method to identify such signs, should be considered cognates.

One further feature of all known sign languages that complicates the identification of cognates is the apparently greater prevalence of iconic and indexical representations in the lexicons of signed vs. spoken languages (Perniss et al., 2010). As a matter of course, historical linguists of spoken languages avoid iconic, or onomatopoetic, vocabulary in their historical comparisons because phonological similarities, and even apparent correspondences, among such vocabulary may not reflect shared history (Campbell, 2013; but see Joseph, 1987). The avoidance of iconic vocabulary in historical comparisons of spoken languages developed from the work of early theorists, such as Meillet (1925/1967, p. 14), who stressed that our ability to make historical inferences based on language depends on the conventional, but not "natural," connection between form and meaning: "If the meaning to be expressed by language were linked by a natural connection, loose or strict, to the sounds which indicate it, that is, if by its own value, apart from tradition, the linguistic sign evoked an idea in any way… all linguistic history would be impossible." As we have seen, however, sign scholars such as Woodward have developed methods that apparently identify historical signal in comparisons of sign language vocabulary—despite the high prevalence of iconic representations. Nevertheless, in agreement with Meillet, the historical signal that the methods of sign language historical linguistics apparently identify is, in a sense, fuzzy. That is, when comparing a set of putatively cognate signs across sign languages, no currently-available methodology rigorously differentiates signs that are similar due to iconicity from those that have been inherited from a common ancestral language.

In the next section, I describe how, absent regular correspondences, sign scholars have adapted their theories and methods to confront the problem of identifying historically-related signs.

Theoretical Adaptation of the Cognate

The inability to identify regular correspondences using the Comparative Method has, in my view, significantly shaped the field of sign language historical linguistics. Sign scholars have developed alternative theories and inferential frameworks for understanding the historical relations of sign vocabulary and, relatedly, the historical relationships of the languages themselves. These alternative approaches fundamentally differ from the Comparative Method because they do not rigorously identify vocabulary that has been inherited from a common ancestor or differentiate that vocabulary from borrowings. Here I briefly highlight two approaches in which the notion of cognacy has been expanded to encompass both inherited vocabulary and borrowings. In the next section, I describe two classes of methods that sign scholars have developed as alternatives to the Comparative Method.

The first approach was developed by James Woodward, who has argued for an adaptation of lexicostatistical methods that allows sign scholars to classify sign languages into families without identifying specifically inherited vocabulary.

> "A particular advantage to lexicostatistics that is not shared by the comparative method is that lexicostatistics does not assume that languages in the same language family necessarily came from one common ancestor—merely that something has influenced these languages so that they have become similar to each other. This something could be a common ancestor, or it could be extensive borrowing, hybridization, and/or creolization" (Woodward, 2011, p. 41).

In Woodward's approach, the sign language family differs from the spoken language family because it is based on *influence* rather than inheritance. Influence is conceived as a broad category encompassing both inherited and borrowed features. In addition, lexicostatistics is seen by Woodward to be tightly intertwined with the aims of sign language historical linguistics in general, taking the place of the Comparative Method in traditional historical linguistics.

A second alternative approach is found in Supalla and Clark's (2015) notion of "sign language archaeology" (see also Shaw and Delaporte, 2014). Their archaeological, or perhaps philological, approach deals mainly with historical texts, videos, and descriptions of sign meanings and their origins. As with Woodward's approach, these authors take an expansive view of cognacy: "[t]o determine a cognate relationship, researchers make an informed decision with the help of either folk etymology or additional scientific excavation for evidence of historical relatedness between the current LSF form and the

modern ASL form" (Supalla and Clark 2015, p. 90). The archaeological approach to identifying cognates does not seek to differentiate vocabulary in ASL that has been inherited *via* linguistic descent from vocabulary that has entered the language *via* other processes.

Supalla and Clark (2015, p. 190) also point out that folk etymologies about the origins of signs—and hence their potential cognacy relations to other signs—"arise when there is a gap in knowledge about the true history of a word"; typically, these etymologies "are not substantiated by history or fact." Over time, according to these authors, folk etymologies may come to constitute shared cultural knowledge that is "transmitted across generations as part of sign language culture." Thus, folk etymologies may simultaneously represent important cultural knowledge that nevertheless may not provide an accurate description of the historical development of a sign.

In Section Early progress in sign language historical linguistics, I highlighted several of the important contributions that sign scholars, including the scholars discussed above, have made to our understanding of the histories of many sign languages and of language change in the gestural-visual modality. Many of these contributions have been due to these scholars' innovative approaches in the face of the theoretical and methodological problems that I have described here. However, these innovations have also created new issues. The theoretical adaptation of the term cognate has avoided the methodological problem raised above because, in this adapted view of the cognate, inherited signs are not differentiated from borrowings. However, while sign scholars have often used the term cognate to describe historically-related signs (but see Guerra Currie et al., 2002), it is important to recognize that this notion in sign language historical linguistics differs from the notion of the cognate in traditional historical linguistics. Consequently, sign language relationships that are based on this expanded notion of the cognate theoretically differ from relationships among spoken languages, which are strictly based on inheritance.

Methodological Adaptations for Identifying Historically-Related Signs

Sign scholars have developed two main approaches for making inferences about the historical relations of signs. In contrast to the aims of the Comparative Method, these approaches have been concerned with identifying historically-related vocabulary—potentially including both inherited and borrowed signs. The first approach adjusts the parameters of the Comparative Method such that correspondences are not required to regularly recur; this approach also incorporates an implicit model of how signs may historically change. The second approach uses measures of phonetic similarity to make inferences about the historical relations of signs; this approach does not include a model of historical change. The strength of the first approach is that it incorporates a theory of diachronic sign change in the historical inference procedure. The second approach includes a clearer inferential procedure, which, to some extent, mitigates the potential for systematic bias present in the first approach.

Woodward's Approach to Identifying Cognates Without Regular Correspondences

In perhaps the earliest work applying methods from historical linguistics to study the histories of sign languages, Woodward (1978) adapted lexicostatistical and glottochronological methods in a lexical comparison of ASL and LSF. He used Swadesh's 200-word list of basic vocabulary as the basis for comparing the two languages; he also used Gudschinsky's (1956) methodology for making cognate inferences.

The appeal of Gudschinsky's methodology may have come from its use of the notion of *probable cognacy*, which in effect loosened the requirement of the Comparative Method that correspondences regularly recur. For example, her "criterion c" allows sounds that differ across potential cognates to be analyzed as "agreeing" (i.e., corresponding) if the sounds' environments might plausibly have conditioned their difference—even if, crucially, the correspondence does not regularly recur in other words (Gudschinsky, 1956, p. 184). The methodology is less rigorous compared to a procedure that requires correspondences to regularly recur in other vocabulary, given the same conditions. Like Starostin's (2013) "preliminary lexicostatistics," Gudschinsky's methodology could function as an initial heuristic by which potentially informative correspondences can be identified in comparative data. However, as a stand-alone procedure for inferring cognates, the methodology opens the door to a multitude of *ad hoc* explanations about conditioning environments; that is, it is not possible to independently test a hypothesis about a conditioning environment if it is relevant for only one set of sounds.

In adapting Gudschinsky's methodology to the historical study of sign languages, Woodward retained the notion of probable cognacy and its omission of the requirement for correspondences to regularly recur.

> "Linguists working on lexicostatistics of sign languages should classify two forms as cognates using the same standards employed by linguists working on spoken languages, that is, only if the application of plausible rules can derive form A from form B, form B from form A, or both form A and form B from some other form that once existed or continues to exist in related languages. Such phonological rules can be rules of assimilation, dissimilation, deletion, epenthesis, coalescence, metathesis, maximal differentiation, centralization, and/or some other phonological process in sign languages recognized by modern linguistics" (Woodward, 2011, p. 41).

In traditional historical linguistics, the process outlined in Woodward's first two scenarios above—that is, the derivation of one contemporary sign from another contemporary sign—would be better described as borrowing from a related language because, by definition, cognate forms cannot be derived from sister languages. Rather, cognate forms in sister languages are derived from a form in a common ancestral language *via* linguistic descent, which is the situation described in Woodward's third scenario above.

If the cognate inference procedure allows for *ad hoc* accounts of conditioning environments, such as those allowed in

Woodward's cognate inference procedure, there may be greater potential for the introduction of systematic bias—particularly when comparing sign languages that we believe to be related on extra-linguistic grounds. For example, because we know that Laurent Clerc was a signer of LSF, we may be more likely to formulate *ad hoc* explanations for differences across contemporary signs in ASL and LSF.

Despite the issue outlined above, one advantage to Woodward's approach is that it incorporates a model of historical sign change in the cognate inference procedure. As our understanding of language change among sign languages improves, our model of historical sign change could allow us to more accurately reconstruct the potential pathways along which signs may have historically developed.

Inferences Based on Measures of Phonetic Similarity

The second main approach to making inferences about the historical relations of signs bases these inferences on measures of phonetic similarity. In a lexical comparison of American, Australian, British, and New Zealand Sign Languages, McKee and Kennedy (2000) introduced an algorithmic methodology for inferring cognates. In their approach, the sign parameters of handshape, movement, location, and orientation were pairwise compared, with three mutually exclusive possible results: "identical," in which all four parameters match; "related," in which at least one of the parameters matches and at least one differs; and "different," in which all of the parameters differ. Sign pairs in the identical and related categories were inferred to be cognates. Inferences about the historical relationships among the four languages in the study were based on the distribution of sign pairs across the three categories—identical, related, and different.

Because of its algorithmic nature, McKee and Kennedy's (2000) procedure for inferring cognates might potentially be viewed as more objective than Woodward's. Their approach also excludes one possibility for the introduction of systematic bias in historical comparisons of sign languages because their algorithm does not allow for *ad hoc* accounts of conditioning environments when parameter values differ (see the discussion of Woodward's approach in the previous section). However, McKee and Kennedy's approach places strict constraints on language change that may not have strong empirical or theoretical grounding. All four parameter values in a sign can change, including handshape (Battison et al., 1975), number of hands and movement (Frishberg, 1975), orientation (Wilcox and Wilcox, 1995), and location (Lucas et al., 2001; Schembri et al., 2009). But, for sign pairs to be inferred as cognates in McKee and Kennedy's approach, signs must have only minimally changed over time or they must have changed in exactly the same ways because all parameter values in a pairwise comparison must match for signs to be considered "identical," and at least one parameter value must match for signs to be categorized as "related."

As with Woodward's approach, McKee and Kennedy's methodology does not attempt to differentiate inherited vocabulary from borrowed vocabulary. Instead, it solely bases historical inferences on measures of phonetic similarity. That similarity could be due to inheritance, if two sign languages have inherited similar forms from a common ancestral language and those forms have not yet substantially changed. However, that similarity could also be due to borrowing or chance similarity. The inability of this methodology to differentiate vocabulary based on the differing processes by which that vocabulary has entered a language is a weakness that is inherent in any approach that bases historical inferences on phonetic similarity.

Recent Approaches to Historical Inferences

Relatively few sign language historical linguists in the twenty-first century have taken qualitative approaches in their historical comparisons. Supalla and Clark (2015; see Section Theoretical adaptation of the cognate) and Shaw and Delaporte's (2014) studies of the histories of signs in ASL are two notable exceptions to this observation. Many more historical comparative studies of sign languages have taken quantitative approaches, following Woodward and McKee and Kennedy (e.g., Parkhurst and Parkhurst, 2003; Sasaki, 2007). In sign language historical linguistics, this focus on quantitative approaches may ultimately stem from discussions within the field about the appropriateness of lexicostatistics for studying the histories of sign languages (Woodward, 2011). However, in historical linguistics more broadly there also has been a surge in the use of quantitative approaches over the past two decades. In that time, historical linguists have come to recognize how computational phylogenetic approaches and methods that developed in the fields of biology and systematics may help them to investigate questions about the historical evolution of languages and language families (Gray and Atkinson, 2003; Atkinson and Gray, 2005; Bouckaert et al., 2012; Kolipakam et al., 2018). Here I briefly highlight three recent studies that have used quantitative and computational phylogenetic approaches to compare signs and other linguistic features.

In a recent large-scale comparison of 23 sign languages, Yu et al. (2018) annotated signs based on Brentari's (1998) model of the sign and then computationally pairwise compared these annotations. Their comparison produced a distance matrix, which was used as the input for a hierarchical cluster analysis. Many of the clusters produced by their approach were expected based on our understanding of the extra-linguistic history of connections among signing communities. For example, LSF and *Língua Brasileira de Sinais* are closely grouped, as are *svenskt teckenspråk* and *Língua gestual portuguesa*. However, other clusters were unexpected: ASL was more closely grouped with Polski Język Migowy, Eesti viipekeel, and Latviešu zīmju valoda (Polish, Estonian, and Latvian Sign Languages) than with LSF; and Türk işaret Dili (Turkish Sign Language) was closely grouped with Íslenskt táknmál and Lingua dei Segni Italiana (Icelandic and Italian Sign Languages). Despite these unexpected results, Yu et al.'s study represented an innovative approach to studying the histories of sign languages; it is also one of the few available large-scale comparisons of sign languages. In a follow-up study, Abner et al. (2020) used a similar computational approach to study the distribution of phonological features across the languages in their sample and to make inferences about the historical development of sign language families based on the distribution of those features.

Power et al. (2020) designed a database of 76 manual alphabets, including those of contemporary sign languages and of historical manual alphabets dating to the sixteenth century. They compared handshapes in these manual alphabets by making qualitative judgements about the similarity of their forms. The manual alphabets were then pairwise compared and a series of computational phylogenetic network methods were applied to understand the complex patterns of similarity among these manual alphabets. Because the sample of manual alphabets included 36 historical examples, the authors were able to compare subsets of manual alphabets at various historical periods and to make inferences about their evolution over time. By assuming that the historical connections among manual alphabets paralleled historical connections among sign languages more broadly, the authors used their results to understand the world-wide dispersal of European sign languages.

In sum, recent work in sign language historical linguistics has followed broader trends in historical linguistics by applying computational and phylogenetic methods. Whereas previous quantitative comparisons mainly focused on sign vocabulary, the recent approaches highlighted here have studied other aspects of sign languages—such as their phonological features and manual alphabets—to better understand the histories of these languages. Thus, these recent approaches can also be viewed as alternative approaches to the Comparative Method. Like the previous approaches discussed in the preceding two sections, more recent approaches do not rigorously differentiate between inherited and borrowed signs or linguistic features.

Etymological Relations

I have argued that one of the main problems that has shaped the theories and methods of sign language historical linguistics has been the inability to identify regular correspondences among apparently cognate signs. In this section, I briefly recapitulate that argument before discussing the notion of the etymological relation.

As I discussed in Section Relationships among spoken languages and among signed languages, the process of linguistic descent—that is, the native acquisition of language by children over multiple, successive generations—has been argued to be a driver of the type of incremental change that can result in regular correspondences (Labov, 2007). Because many sign languages that are thought to be related have not diversified *via* linguistic descent, we might not expect to find regular correspondences among the apparently cognate signs of these languages. If we cannot identify regular correspondences, we cannot use the Comparative Method to identify cognates or to rigorously differentiate inherited vocabulary from vocabulary that has entered a language due to other processes, such as borrowing. Given this problem situation, the term cognate is not, in my view, an appropriate characterization of the historical relations of many signs—perhaps even of similar signs in the languages of many sign language families. What is an appropriate characterization of the historical relations of these signs?

In his comparison of theoretical terminology in historical linguistics and evolutionary biology, List (2016) showed that some of this terminology does not map in similar ways onto abstract historical relations. For example, a fundamental notion in biological evolution is homology (attributed to Owen, 1843). According to List (2016, p. 120), "[h]omology is a very general historical relation between evolving objects. It does not specify the process from which the relation originated." Homology is a superordinate concept describing "a relationship of common descent" (Koonin, 2005, p. 311), with three subtypes "based on the processes underlying the homology"—namely processes of speciation, gene duplication, and horizontal transmission (List, 2016, p. 120).

Homology is distinct from similarities arising through analogy—that is, the evolution of functionally-similar traits that have no specifically historical relation. One example of a process giving rise to analogy was the independent parallel evolution of wings in bats and birds, which did not arise from common historical pathways of descent; rather, wings independently evolved in birds and bats for functional reasons (Morrison et al., 2015). There are clear parallels in traditional historical linguistics to the distinction between homology and analogy. Greenberg's (1957) four causes of similarity differentiate between two causes that are thought to be historical—namely inheritance and borrowing—and two others that are considered nonhistorical—chance and sound symbolism. According to List (2016), however, there is no broadly accepted theoretical notion in historical linguistics that corresponds to the notion of homology. Theories in historical linguistics are certainly concerned with processes of language diversification *via* linguistic descent; they are also concerned with borrowing. But, historical linguists do not commonly make reference to an overarching term to describe both inherited and borrowed features.

In parallel to the concept of homology, List (2016) proposed the term *etymological relation* to encompass the historical relations of cognacy and borrowing (see also "sign language etymology," Supalla and Clark, 2015). List's invocation of etymology seems appropriate as a parallel to homology because the concept has a long history in linguistics with precisely this meaning. Mailhammer (2015, p. 424) defined an etymology as "a historical account of the origin and the subsequent historical development of a linguistic item." He distinguished between "internal" and "external," or "contact," etymologies. An internal etymology is one that describes the history of an inherited linguistic feature, whereas a contact etymology implicates borrowing events, or horizontal transmission. Mailhammer (2015, p. 432–433) pointed out that "the etymology of a linguistic item can comprise one or more cases of horizontal transmission" and that "a contact etymology necessarily combines internal and external etymologies, vertical and horizontal transmission." Thus, in parallel to homologous biological traits, the linguist may speak of etymologically-related words, the histories of which connect at a shared common etymon.

List's notion of the etymological relation accurately captures the type of historical relation that the less precise notion of influence is intended to invoke in the theory of sign language relationships described in Section Theoretical adaptation of the cognate. Characterizing the historical relations of many signs as etymological directly acknowledges the methodological problems facing sign language historical linguistics—in particular the

current inability to identify cognates using the Comparative Method. In contrast to previous theories about sign language relationships, the notion of etymology maintains important theoretical distinctions between vertical and horizontal pathways of descent in the histories of signs and linguistic features. A contact etymology, per Mailhammer, is flexible enough to incorporate instances of both vertical and horizontal transmission in the history of a sign, without committing historical linguists of sign languages to any conclusions about the genetic language relationships of the sign languages being compared.

CONCLUSION

The two subfields of historical linguistics—namely, those focusing on spoken and signed languages—have rarely engaged one another, despite the relevance of both subfields to an overarching theory of language change. Why have they so rarely engaged with each other? As we have seen, the field of sign language historical linguistics since the 1970s has adopted many of the theories and methods that developed in traditional historical linguistics, including notions such as the language family and cognacy, as well as methods such as lexicostatistics. More recently, too, sign scholars have applied computational and phylogenetic methods in their historical comparisons of sign languages, thereby following broader trends in the approaches used in historical linguistics. Thus, in one sense, sign language historical linguists have indeed engaged with the theories and methods of spoken language historical linguistics.

However, I have argued that theoretical notions like the genetic language relationship, the language family based on genetic relationships, and cognacy do not straightforwardly map onto the processes of historical development that have characterized the diversification of many sign languages. In addition, the innovative methods that sign language historical linguists have developed as alternatives to the Comparative Method have both fostered progress in our understanding of the histories of sign languages and, perhaps, hindered cross-disciplinary engagement because these methods fundamentally differ from those used in traditional historical linguistics. Greater clarity about the strengths and weaknesses of our methods as well as their aims may foster greater collaboration in the future.

Much progress has been made in sign language historical linguistics since Stokoe, but, as I have argued here, fundamental theoretical and methodological problems remain. In my view, one of the main thrusts in future research in this area should be a concerted effort to identify regular correspondences among apparently related sign languages and across historical stages of the same sign language. To date, there have been few systematic attempts to do so (Power et al., 2019, 2021). Relatedly, there have been few systematic studies of diachronic change between different stages in the historical development of sign languages. For example, more than 40 years have passed since Frishberg's (1975) groundbreaking study of diachronic change in ASL, and few scholars have attempted to refine or to add to Frishberg's insights (see Shaw and Delaporte, 2014; Supalla and Clark, 2015). Another promising area for future research is the use of simulation studies to model the effects of differing processes of language transmission on language change (Gong et al., 2010; Gong and Shuai, 2016; Mudd et al., 2020) and to understand how iconicity may shape language change (Greenhill et al., 2009; Currie et al., 2010).

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Perspectives: On the Historicalness of Sign Languages

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This paper aims to provide a reflection on an assumption sometimes present in linguistic research: the supposed youth of sign languages (SLs). In this research (the importance of which we do not question), SLs are considered to date back to the mid-eighteenth century, or even the mid-twentieth century. As historians, we wish to question this hypothesis. To this end, we will question the scientific consequences of a reversal of this hypothesis. The historical method used forbids presenting a hypothesis as a postulate until it has been validated by sources, whose authenticity can be granted. In order to illustrate this, we will take the example of the French sign language: from a historical point of view, sources attest that its roots go back at least to the early Middle Ages. It would therefore be an old language, at least as old as French. From this case, we would like to propose a new hypothesis: that the sign languages of the world are not young. And we would like linguists to consider the possibility for the SL they are studying to be an old language. Would this new paradigm change previous conclusions? To what extent would this allow for a renewal, for example opening the way to another perspective on the genesis of these languages?

Keywords: French sign language, LSF, history, deaf history, linguistics

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INTRODUCTION

"Why do you say that sign languages (SLs) are "young"?" was the question we asked a few years ago to a well-known sign language linguist, after his presentation at a seminar in our laboratory[1]. We were interested in his talk, but as historians we were surprised to learn that there are linguists who could consider sign languages they are studying to be young languages (e.g., Meier, 2002, 2004 ed., p. 6), dating back at best to the eighteenth century (Fischer, 2015, p. 445), or even only to the twentieth century (Sandler et al., 2005, p. 2,261). He himself had been surprised that this surprised us, and with great intellectual honesty he had admitted that it was an unproven hypothesis. We therefore wanted to take advantage of the Perspective article format for this special issue to put this question on the table. Let us make it clear right away that we are not linguists. We are historians, specializing in deaf history and we wish to propose a historical reflection to our linguist colleagues

[1]This text was translated into English with the help of Madeleine Papiernik.

working in the field of sign languages. We think that our disciplines can be complementary, each one keeping its specificities. This also implies that our article should not be read and evaluated as a linguistic article. We do not use the linguistic method, but the historical method. We do not make a typology of the sign languages of the Middle Ages and today. We do not make a diachronic study of the variations of sign languages. We only wish to stimulate reflection from a new angle on the subject of the historicalness of sign languages. In order to provoke this reflection, we present our point of view, that of historians, which is not the same as that of linguists, whether they think that sign languages are young or not. Indeed there are linguists that suggest that sign languages are not young languages (Cuxac and Antinoro Pizzuto, 2010; Garcia, 2010; Wilcox and Occhino, 2016). Our objective is only to propose a debate on this question, because it is not yet the case, and to bring a complementary point of view to this debate, without claiming in any way to settle the question.

THE ORIGINS OF LSF FROM A HISTORIANS POINT OF VIEW

A Voluntarily Historian Article

Before anything else, we think it is important to specify the most fundamental aspect of the historical method. In history, any assumption must be supported by primary (not secondary) sources that can be verified by any reader. Furthermore, as historians, we understand sign language through its primary speakers: deaf people. The history of sign language cannot be dissociated from the history of deaf people, which is itself interwoven with the history of the society in which they live (Encrevé, 2012). Deaf people of the urban centers were integrated into the society. We consider this element when we notice that the sign language has elements of influence of the French language and culture (in its most visual aspects). As far as the transmission of sign language is concerned, we also take into account this social dimension in its entirety. For example, concerning the contacts between deaf people, thanks to the testimony of Pierre Desloges (in the twentieth century), we know that deaf people are far from all being isolated. Moreover, we also have older examples of deaf travelers such as a certain Jacobus de Venitis who is said to have traveled from Venice, Italy, to the city of L'Aquila, in central Italy, in the fourteenth century AD (Pellegrini, 2009).

French Deaf People and Their Sign Language in History

The question of the ancientness of languages is a question that has been present for a long time in the research of the origins of languages. However, these reflections were only posed by deaf people themselves concerning sign languages belatedly, at the end of the nineteenth century. At that time, these languages were made more visible by the expansion of schools and by the menace of institutional oralism that weighed on them. The unfavorable context of the beginning of the twentieth century put into perspective the similarities and differences between the SL, especially at the level of grammar. For example, the deaf writer Henri Gaillard wrote in 1893 about the differences between French and American SL:

> *"The signs of the American Deaf-Mutes do not differ from the signs of the French Deaf-Mutes because they were imported from France by Gallaudet and the French Deaf-Mute Laurent Clerc. There are only a few new signs, of conventional value, having much more to do with the words of the English language than with the ideas themselves, ideas which are mostly abstract and which it would be difficult to express by the natural or figurative gestures which are the same among all peoples.* (Gaillard et al., 1894: 30.)

Gaillard thus pointed out, 80 years after Laurent Clerc's arrival in the United States, a beginning of divergence between French Sign Language (LSF) and ASL at the level of vocabulary, but not only:

> *"It seems that the Deaf-Mutes of the United States have more signs than we do, almost for every word. So their gesticulation is hurried. Sometimes it is too hasty, when it becomes obscure to those who are not accustomed to follow them. When a Deaf-Mute is what we call a mimic speaker, he amplifies his gestures and becomes clear to everyone. On the contrary, the signs of French Deaf-Mutes are sparse and broad, expressing at once an idea with all its undertones and corollaries."* (Gaillard et al., 1894: 30.)

This analysis, of what can be considered as a precursor, shows that the divergence between the two languages on both sides of the Atlantic has been rather rapid, even though they have a common origin. So, what can we think if we project ourselves over even longer periods of time? We already have confirmation that LSF existed before the Abbé de l'Épée with a testimony of Pierre Desloges (Desloges, 1779, see above). And even further back, the philosopher Michel de Montaigne, in (1580 [2019]), wrote:

> *"Our mutes argue, argue and tell stories by signs. I have seen some so agile and trained in this, that in truth they lacked nothing in the perfection of knowing how to make themselves understood."* (Montaigne, 1580 [2019]).

But all this is not sufficient to show how sign languages could be ancient languages, especially French SL (Cantin, 2016, 2021; Cantin et al., 2019). We will not be able to demonstrate it in such a short article. Again, this is not our purpose here. We simply wish to stimulate a debate and encourage historical research on the origins of sign languages. To this end, we propose to present two examples of vocabulary of LSF that allow us to point to more ancient origins.

Pierre Desloges' Book

Pierre Desloges is the oldest known published deaf author. We have not found any other older deaf testimonies. His testimony about the anteriority of the contacts between deaf people and monks allows us to consider an ancient introduction of monastic signs in the deaf sign language:

> *"There are those deaf and mutes from birth, workers in Paris, who can neither read nor write and who have never attended the lessons of Mr. Abbé de l'Épée, who have been found so well instructed in their religion by signs alone, that they have been judged worthy of*

being admitted to the sacraments of the Church, even to those of the Eucharist and of marriage." (Desloges, 1779: 14.)

This quote is also interesting because it shows us that deaf people are far from being isolated, especially in Paris:

"This is true to those who are deprived of the society of other deaf and mutes, or who are abandoned in hospitals, or isolated in the corner of a province. This proves at the same time, without reply, that it is not from people who hear and speak that we commonly learn sign language. But it is quite different with deaf and mute people who live in society in a big city, in Paris for example, which can rightly be called the abridged version of the wonders of the universe. In such a theater, our ideas develop and expand, by the opportunities we have of constantly seeing and observing new and interesting objects." (Desloges, 1779: 13.)

The first example we want to present is based on his description of the sign concerning the nobility. This description shows that it was based on the visual description with the sash of the nobles:

"We have two different signs to designate nobility, that is, we distinguish it into two classes, the high and the low. To announce the high nobility, we put the flat of the left hand on the right shoulder and we draw it to the left hip: then on the spot we spread the fingers of the hand and put it on the heart. We designate the lower nobility, tracing with the tip of the finger a small band and a cross on the buttonhole of the habit. To make known the person of one of these classes, we use signs taken from his job, his coat of arms, his livery, etc. Or finally the most natural sign that characterizes him." (Desloges, 1779: 45–46.)

The current sign [ROI] (king), in the current LSF does not represent the sash, but the crown. This discrepancy would date from the beginning of the twentieth century, at a time when the monarchy was becoming a very abstract representation for the French population. However, in a dictionary of 1873 (Clamaron, 2006 [1873]), the sign [ROI] is represented with a sash. This is similar to the description of Pierre Desloges a century earlier for the nobility. On the other hand, we have, at the level of the current LSF, equivalent signs concerning the queen and the prince/the princess (**Figure 1**).

The second example we want to present is not issued from Desloges' book (it is more ancient): the sign [AIMER] (love). In the medieval iconography that we found, we notice that the representation of love is often made with the gesture of giving his heart or a crown of flowers to the lover[2]. In this example, the correlation between medieval gesture and current French sign is visible. It shows an evolution between the medieval representation of love, an abstract concept, not based on the fact of really giving one's heart in the literal sense, and the current French sign which has preserved it[3] (**Figure 2**).

There is another element to consider when thinking about the development of early LSF. It is the fact that, during the 16th−18th centuries, Paris was the most populous and dynamic city on the European continent, before being overtaken by London in the nineteenth century. As Desloges explained, encounters between deaf people are fundamental in the transmission of signs. This may explain why Desloges considered Paris to be an "*abridged version of the wonders of the universe*" (Desloges, 1779, p. 13).

To us, these elements plead in favor of the possible ancientness of LSF, and thus of the importance of pursuing historical research on the roots of LSF beyond the eighteenth century, including the impact of the visual representations of past societies on sign language of today.

DISCUSSION - QUESTIONS

With these examples, we wish to show that from a historical perspective, LSF can be considered ancient, even very ancient, in the same way as French (Cantin et al., 2019). We cannot extrapolate this hypothesis to all sign languages, of course. However, we believe that this viewpoint could be considered and thus studied for other sign languages as well. For a non-linguist deaf or hearing reader "young" can be perceived as "developing," and therefore "unfinished" (if one can qualify a living language as finished), even "incomplete" (cf. Cuxac and Antinoro Pizzuto, 2010; Garcia, 2010). Linguists themselves have mixed views on the question of the ancientness of sign languages. Some assume that the sign language they study is young. Others hypothesize that sign languages have a semiogenesis (common to all sign languages). And others have already made research on historical change in sign languages, including French Sign Language, that directly addresses the question of the supposed youth of sign languages (Janzen and Shaffer, 2002; Wilcox, 2004). We do not pretend to settle this question. We just wish to draw attention to the consequences of these points of view on the conclusions of linguistic research. In concrete terms, we propose at least not to stop at the creation of schools for the deaf to date the origin of sign languages. Thus, for example, British Sign Language (BSL) could have origins that go back beyond the first British schools founded in the middle of the eighteenth century, before that of the Abbé de l'Épée. Similarly, the origins of ASL could go back to those of BSL before Abbé de l'Épée, knowing that the famous Signs of Martha's Vineyard are older than American Sign Language (ASL) proper, and merged into it, and could go back to the first English settlers of the sixteenth century. This is a whole area of unexplored historical research that we feel it is essential to explore. Why do we think this is essential? Because it seems to us that, certain conclusions of linguistic research could be modified. In this respect, we submit for discussion two questions often addressed in linguistics and which seem to us essential: that of transmission and that of lexical units.

The first question therefore concerns the place of the lines of transmission in the evaluation of the age of a sign language. Given that sign languages are not transmitted mainly within the biological family if the latter is hearing, it seems to us that it is difficult to reason with the criterion of direct family transmission between deaf people to confirm or deny a filiation

[2]See here: https://etusourdes.hypotheses.org/44 (21/10/2021).
[3]See also Bulwer (1648).

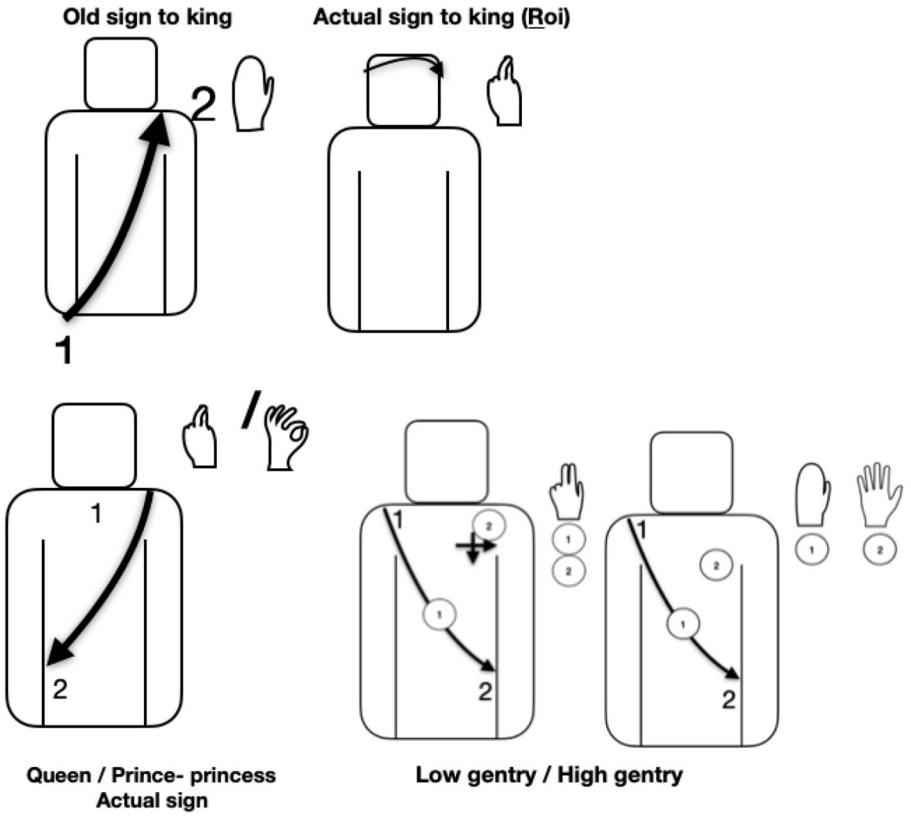


FIGURE 1 | On the signs of French Gentry in eighteenth century. This sign of king, actually forgotten, was discovered in a French sign language dictionary of 1873. This joins the originel Desloges' description of sign on the signs to designate the gentry scarf. The sash is the typical representation of the gentry in the eighteenth century (see the example of the picture of Louis de Bourbon-Conde (Link: https://upload.wikimedia.org/Wikipedia/commons/d/db/Louis_Joseph_de_Bourbon_Prince_of_Conde.jpg). Every member of the gentry, women and men, have a scarf and a cross on the heart. That is why Desloges describes the signs of the nobility in two different signs, one for the high gentry (linked with the King, or in the monarchy government,) and the low gentry, more local and less powers He described it in his book *Observations d'un sourd et muet*, published in 1779. These examples of the signes are the best to understand the place of the deafs In the society in seventeenth and eighteenth centuries. These signs show us their representation of this society by the visual representations.

between sign languages in the same country. Because it is a criterion very specific to vocal languages. Since they have been studied, sign languages have forced researchers to rethink their criteria of analysis. Thus, we propose to researchers to study the possibility of a transmission also via hearing members of deaf families or via hearing friends of deaf people. Let's take a totally fictitious example: let's imagine a hearing daughter of deaf parents (having acquired their sign language in a school for the deaf) who marries a hearing man whose distant cousin is an isolated deaf person (with no known deaf family) not attending school. When this hearing woman meets this deaf man, it is reasonable to presume that she will naturally use her parents' sign language to communicate with him. This man's emerging sign language and this woman's institutionalized sign language will then be able to blend, in a potentially regular face-to-face communication that is constantly adjusting. Thus, there will not have been a direct transmission from deaf to deaf but from signer to signer. Would this man's sign language therefore be qualified as "young" because he has no deaf ancestor or deaf acquaintances? If he adopts for himself elements of the sign language of this woman's parents, would it be necessary to decide on a minimum percentage (and according to what criteria?) of resumption of signs strictly common between the institutionalized sign language coming from this woman in order to be able to attest to a transmission and thus that this man's sign language is related to the other one and that it can thus be qualified as old? To summarize this example: at what point is it considered that a variant, even that of an isolated deaf person, can be attached to institutionalized sign language? Can the institutionalized sign language alone serve as a standard, or even as a super-standard, in defining variations? Finally, what role is given to the signers in the broad sense (hearing and deaf) in the transmission?

The second question is the place of lexical units in the evaluation of the age of sign languages. If we take the example above, what about the highly iconic constructions described in the semiological approach (see Garcia and Sallandre, 2020)? Are they more, less, or equally relevant in the evaluation?

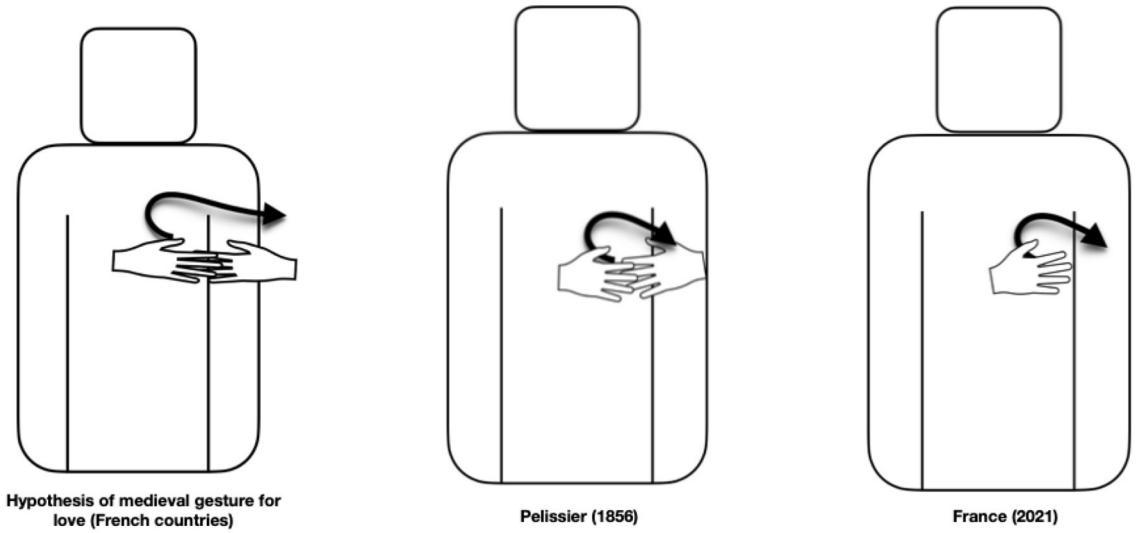


FIGURE 2 | The origins of the sign Love in LSF. This sign is specific to France and its cultural influence on French Sign Language and differs from the American Sign Language (ASL) sign for "Love." It's represents the gesture of the heart (or flowers) giving to somebody. This is a French cultural representation. So, in the first schema. we see two hands to move. This is the hypothesis representation of a medieval sign of love from. an 1100's pictural representation of love (Link here for example of representation: https://journals.openecition.org/cem/17049) in the second, this is the 1856 sign from Pelissier dictionary. And the third, the modern sign in France. We see the cultural link since the Middle Ages period and his cultural and visual representations. The explanations of Desloges in his book give us a better understand of the French sign language origins.

Why should we use only lexical units to determine whether a current sign language has its roots in an older sign language? Does historical change operate faster in sign languages than in spoken languages, contributing to error in judging their age (Wilcox and Wilcox, 2009[4])? Some researchers consider that sign languages are as old as the deaf (Cuxac and Sallandre, 2007; Garcia and Sallandre, 2020). Even though linguists may not disagree that sign languages have been around as long as deaf people, we think it is possible that this also applies to individual named sign languages. At least, we would like to see this studied.

CONCLUSION: ON THE ROOTS OF SIGN LANGUAGES

To conclude, we think that the "roots" of sign languages should not be considered as "taproots" (as those of a dandelion, for example). Taproots, with a main root (which would be the national sign languages, officially recognized—or in the process of being recognized—and described in majority), that sinks vertically into the ground around which are grafted secondary, lateral and less thick roots (which would be the emergent or micro-community sign languages, see Martinod et al., 2020). We see the roots of SLs rather as "fibrous roots" (as those of grass, for example), i.e., a series of roots separated from each other but all of the same size and constituting a bundle that together give rise to a plant. Moreover, we know that trees and plants in general are interconnected, including of different origins: they exchange nutrients with each other via fungi that act as "bridges." These fungi leave few traces, but precisely these roots connect each other deeply in the past. This image gives a glimpse of the multiplicity of potentialities and ways of reflection opened by this research.

[4]See also Keith Martin Cagle "Exploring the Ancestral Roots of American Sign Language: Lexical Borrowing from Cistercian Sign Language and French Sign Language", PhD thesis in Language, Literacy, and Sociocultural Studies, University of New Mexico, 2010.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Identifying the Correlations Between the Semantics and the Phonology of American Sign Language and British Sign Language: A Vector Space Approach

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Over the history of research on sign languages, much scholarship has highlighted the pervasive presence of signs whose forms relate to their meaning in a non-arbitrary way. The presence of these forms suggests that sign language vocabularies are shaped, at least in part, by a pressure toward maintaining a link between form and meaning in wordforms. We use a vector space approach to test the ways this pressure might shape sign language vocabularies, examining how non-arbitrary forms are distributed within the lexicons of two unrelated sign languages. Vector space models situate the representations of words in a multi-dimensional space where the distance between words indexes their relatedness in meaning. Using phonological information from the vocabularies of American Sign Language (ASL) and British Sign Language (BSL), we tested whether increased similarity between the semantic representations of signs corresponds to increased phonological similarity. The results of the computational analysis showed a significant positive relationship between phonological form and semantic meaning for both sign languages, which was strongest when the sign language lexicons were organized into clusters of semantically related signs. The analysis also revealed variation in the strength of patterns across the form-meaning relationships seen between phonological parameters within each sign language, as well as between the two languages. This shows that while the connection between form and meaning is not entirely language specific, there are cross-linguistic differences in how these mappings are realized for signs in each language, suggesting that arbitrariness as well as cognitive or cultural influences may play a role in how these patterns are realized. The results of this analysis not only contribute to our understanding of the distribution of non-arbitrariness in sign language lexicons, but also demonstrate a new way that computational modeling can be harnessed in lexicon-wide investigations of sign languages.

Keywords: sign language, ASL, BSL, iconicity, semantic modeling, vector space, computational methods

1. INTRODUCTION

While wordforms are mapped to referents in a variety of ways, there is a growing body of evidence from spoken and signed languages demonstrating consistent trends in how the form of words can relate to their meaning. Some of these relationships are arbitrary, where the form of a lexical item has no connection to its referent other than through social convention, and some of these are non-arbitrary, where the meaning or function of an item can be predicted through some aspect of its form. For example, the meaning of a word like "tree" is not motivated by the letters or sounds making up its label. There is nothing about the sounds /t/ and /ɹ/ and /i/ that necessarily evoke "tree-ness," and so the relationship between form and meaning in this case is considered arbitrary. In contrast, there are forms like "boom" and "roar," which have a clear resemblance to their referent in their phonological form that can be said to exemplify a non-arbitrary relationship between form and meaning. Scholarship across languages and modalities has begun to test how these motivated relationships are distributed in the lexicon, and show patterns wherein there is a pervasive presence of words, across languages and modalities, whose meaning and whose phonological form are linked (Blasi et al., 2016; Dautriche et al., 2017b; Perlman et al., 2018). Here, building on this work, we use computational modeling to examine how these non-arbitrary form-meaning relationships are organized within the lexicons of two unrelated sign languages in order to better understand how a pressure toward non-arbitrary relationships between form and meaning might shape sign language lexicons.

Languages can exhibit multiple types of non-arbitrariness in their vocabularies, and do so in distinct ways across modalities. One form of non-arbitrariness expressed in language is **systematicity**,[1] whereby patterns in how words are realized within a language correspond to word usage, and therefore meaning, in a statistical way (Dingemanse et al., 2015). Systematic cues in spoken languages, including vowel height, duration, stress, voicing, phonotactics, etc., have been found to correlate to syntactic, as well as semantic information (Kelly, 1992; Monaghan et al., 2007; Reilly et al., 2012). For example, in English disyllabics, stress often distinguishes verbs from nouns (ˈ**re**cord vs. reˈ**cord**, ˈ**per**mit vs perˈ**mit**). Systematicity is not limited to prosodic information, and can be found embedded in the form of the words themselves. In Semitic languages such as Arabic or Hebrew, many verbs and nouns are formed from a consonantal root, or a sequence of consonants that combine with vowels and non-root consonants to form semantically related terms. For example, in Arabic, the triconsonantal root "k - t- b" (ك ت ب) relates to the meaning "writing." Words derived from this root are associated with writing along varying degrees of abstraction, such as كاتب *kāṭib* (writer), كتاب *kitāb* (book), مكتب *maktab* (office/desk), مكتبة *maktaba* (library), and many others (McCarthy, 1981). Systematic non-arbitrariness is also exemplified in phonesthemes (Firth, 1930), a type of non-morphemic sound-meaning pairing. We see this in the English onset *gl-* which often occurs with words relating to light, such as *glitter, glimmer, gleam, glisten, glow* (Bergen, 2004).

Systematic non-arbitrariness occurs in sign languages as well, as is the case in sign families. Sign families refer to "groups of signs each with a formational similarity and a corresponding meaning similarity" (Frishberg and Gough, 2000). In ASL, the signs MOCK, IRONIC, and STUCK-UP form such a family, each articulated with the 1-I or "horns" handshape (the index and pinkie finger extended). All three signs have some implied negative meaning and conform to a pattern in ASL in which signs produced with the 1-I handshape often have such connotations; however, this correspondence is likely to be language-specific as it is not derived from any transparent visual resemblance[2].

A second form of non-arbitrariness is **iconicity**[3]. Iconicity here refers to a motivated relationship between form and meaning by way of perceptuomotor resemblance-based analogies (Frishberg, 1975; Dingemanse et al., 2015). Historically, iconicity was considered exceedingly rare in spoken languages, and exemplified only in onomatopoeia, where the forms of words have a direct resemblance to their referent *via* their phonology. However, more recent work has found iconicity to be both fundamental and pervasive in human communication (Perniss et al., 2010; Vigliocco et al., 2014; Akita and Dingemanse, 2019). This becomes particularly clear when looking beyond Indo-European languages, where many spoken languages have been found to possess rich inventories of words known as ideophones, which iconically represent a multitude of sensory impressions such as movements, textures, sounds, visual patterns, even cognitive states (Diffloth, 1972, 1979; Kita, 1997).

Sign languages provide further evidence of the pervasiveness of iconicity. Because they exist in the visual modality, sign languages bring with them new affordances. In much the same way that iconicity in spoken languages often makes use of sound-based symbolism (e.g., onomatopoeia), communicating in the visual modality allows for the iconic representation of visual information more readily. Because of this increased ease of visual-to-visual mapping, as well as the prevalence of visual information in everyday communication, it is perhaps unsurprising that sign languages are considered to be more iconic than spoken languages (Klima and Bellugi, 1979; Taub, 1997; Meier, 2009; Perlman et al., 2018)[4]. Although iconicity has

[1]We will be referring here to systematicity as it is used by Blasi et al. (2016) and Dingemanse et al. (2015) (among others), as a type of non-arbitrariness distinct from iconicity. Others such as Monaghan et al. (2014) label the whole of non-arbitrariness as "systematicity," which is then divided into "absolute iconicity" and "relative iconicity" (Gasser et al., 2011). Under this framework, "relative iconicity" aligns with what we have referred to here as "systematicity."

[2]This handshape may be derived from the emblem for "cuckold" or "cornuto" (horns) in Italian; however, neither hearing nor deaf Americans appear consider this resemblance as particularly iconic. This is evidenced by MOCK's very low iconicity rating (1.0 rating for non-signers and 1.7 rating for signers) on ASL-LEX (Sehyr et al., 2021).

[3]Iconicity as used here can also be thought of as "absolute iconicity" as described by Monaghan et al. (2011) and Gasser et al. (2011).

[4]As pointed out by Perlman et al. (2018), the claim that sign languages are overall more iconic has historically been based often on observation alone rather than empirical evidence. However, their cross-linguistic comparison of English, Spanish, ASL, and BSL found that "signs for particular meanings are fairly consistent in their level of iconicity in ASL and BSL, while there is greater variability between English and Spanish words...which may reflect that potential iconic mappings between form and meaning are more direct and transparent

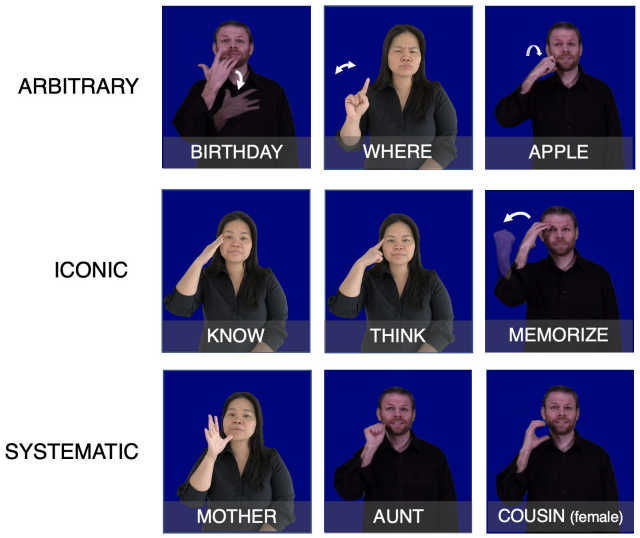


FIGURE 1 | Examples of arbitrary **(top row)**, iconic **(middle row)**, and systematic **(bottom row)** signs in ASL. The verbs of cognition in the middle row are all articulated on the head, which indicates their relationship to the brain through iconicity. The kinship signs in the bottom row are all articulated near the chin, which is conventionally associated with feminine roles among ASL kinship signs.

been noted to be more wide-spread in the vocabularies in sign languages, it is important to note that most signs in the lexicon are not highly iconic (see Caselli et al. 2017 and Sehyr et al. 2021 for a review of the distribution of iconicity in ASL).

Words can also combine elements of both systematicity and iconicity (as well as arbitrariness) together in a wordform. For example, in ASL, many signs relating to feelings or emotional states are articulated on or near the chest. This overlap in location is iconically motivated, based on these concepts relating to one's heart. Many of these sign are also articulated with an open-8 handshape (hand is open with the middle finger bent at the first knuckle). The overlap in handshape here is based on an ASL convention whereby this handshape connotes an association with feelings, and is systematic rather than iconic. **Figure 1** shows examples of arbitrary, systematic, and iconic signs in American Sign Language (ASL).

Together, this points to how spoken and signed languages make use of non-arbitrariness in the mapping of different wordforms to their referents, and demonstrates that non-arbitrariness may be derived iconically, systematically, or both to various degrees. While the pervasiveness of non-arbitrary form-meaning mappings can be seen cross-linguistically, many wordforms also retain completely arbitrary relations to their referents, and so a question remains regarding not only how, but also why non-arbitrariness is distributed across linguistic systems.

One factor influencing how form is mapped to meaning is the communicative and cognitive pressures[5] that shape the organization of the lexicon. One such pressure is toward a low degree of similarity or overlap between wordforms. There is evidence that phonological systems are shaped to be maximally distinctive while also cost-effective (see *Feature Economy* in Clements 2003). In other words, in examining how phonological features are combined across a lexicon, languages tend to combine the features available to them in as many ways as possible to maximize the number of distinct forms. Referred to as "dispersion" (Flemming, 2002, 2017; Dautriche et al., 2017a), this tendency appears to maximize perceptual clarity to reduce uncertainty for the perceiver. This is supported by evidence for the negative effect of neighborhood density on spoken word recognition, where words from high density neighborhoods tend to be processed more slowly and less accurately (Luce and Pisoni, 1998). Additionally, research suggests that young children struggle to assign distinct meaning to novel wordforms when those wordforms have a high degree of phonological overlap to ones already in their lexicon (Dautriche et al., 2015), suggesting that a lack of dispersion among lexical items could interfere with early vocabulary building.

There is also evidence for a contrasting pressure toward similarity among wordforms. While dispersion allows for high perceptual clarity on the part of the perceiver, there are additional functional advantages for "clumsiness" (Monaghan et al., 2011; Dautriche et al., 2017a), or the tendency toward higher phonological overlap between the wordforms in a lexicon. Words with many phonological neighbors show improved recall over more distinct words, and show facilitated production as evidenced by lower speech error rates (Vitevitch and Sommers, 2003; Stemberger, 2004; Vitevitch et al., 2012). There is evidence that this pressure shapes the distribution of phonological forms across lexicons, as demonstrated by Dautriche et al. (2017a)'s analysis showing that in spoken languages, lexicons are organized into phonologically similar clumps.

These contrasting pressures, toward increased dispersion on the one hand and increased similarity on the other, crucially interact with the presence of non-arbitrary form-meaning mappings in the lexicon. Evidence of the impact of this pressure toward similarity on the organization of the lexicon, and its inter-action with non-arbitrariness, can be seen in findings showing that phonologically similar words tend to be semantically similar within and across languages (Monaghan et al., 2014; Blasi et al., 2016; Dautriche et al., 2017b). For example, in one computational analysis comparing the semantic and phonological distance between words in 100 spoken languages, Dautriche et al. (2017b) found a weak trend where more semantically similar word pairs were also more phonologically similar. Likewise, in Blasi et al. (2016), there

for many signs, and hence realized to a greater degree across different signed languages" (Perlman et al., 2018, p.8) and notes that "...this may indicate that signed languages are iconic in a qualitatively different–and, specifically, a more widely intuitive way—than spoken languages." (Perlman et al., 2018, p.13).

[5]See Gibson et al. (2019) for an elaborated discussion of scholarship on the impact of the interaction between communicative pressures, including toward efficiency or toward retaining form-meaning mappings, on shaping linguistic systems.

was a consistent presence of non-arbitrary sound-meaning associations in the sounds used for a subset of basic vocabulary items across thousands of unrelated spoken languages. We can also see this relationship between converging form and meaning in the presence of non-arbitrariness in sign languages, as shown by groups of semantically related terms that have shared features that are represented iconically, such as the location of the signs KNOW, THINK, MEMORIZE in ASL (see **Figure 1**). Groupings of wordforms like this have been investigated in studies on both spoken and sign languages that have shown that denser semantic neighborhoods exhibit greater degrees of iconicity than more sparsely distributed neighborhoods (Sidhu and Pexman, 2018; Thompson et al., 2020a), suggesting further areas where aspects of meaning and form may come together. We aim to investigate the pervasiveness of non-arbitrariness in sign languages and their impact on the organization of the lexicon to provide further insight into how these contrasting pressures might shape the lexicons of sign languages.

However, understanding the distribution of these form-meaning relationships across an entire lexicon requires a way of defining a word's meaning such that it can be abstracted and compared to other word meanings in a quantitative way. One way that researchers have endeavored to do this is based on the distributional hypothesis (Harris, 1954; Firth, 1957; Turney and Pantel, 2010). Summarized by Firth (1957) as "know[ing] a word by the company it keeps," this principle proposes that the meaning of a word can be derived from the contexts across which it is distributed, such that words which occur in similar contexts are likely similar in meaning. This forms the basis of distributional models, such as vector space models (VSMs), where words are represented as vectors situated in a "semantic space." In these models, a word's proximity to other words indicates their relatedness in meaning. Similarity is then computed by deriving the cosine of the angle between the two vectors (for review, see Erk 2012). This concept is exemplified in **Figure 2**, which shows semantic similarity as represented through proximity in a simplified vector space of four English words[6].

Operationalizing meaning in this way provides an intuitive notion of distance, and allows us to compute similarity between words algebraically. This advantage has made VSMs a powerful and widely-used tool in computational linguistics (see Clark 2015 for review). VSMs have been shown by Thompson et al. (2020a) to be an effective tool in studying systematic correspondences in meaning between signs for sign languages, as demonstrated in an analysis wherein VSM models were used to test the relationship between semantic density and the distribution of iconicity in the lexicon of ASL. For the present analysis, vector space models can also serve as a useful tool for exploring how non-arbitrariness may interact with phonological form in the organization of the lexicon, as relatedness in meaning can be quantified using these models and compared to relatedness in form. **Figure 3** shows

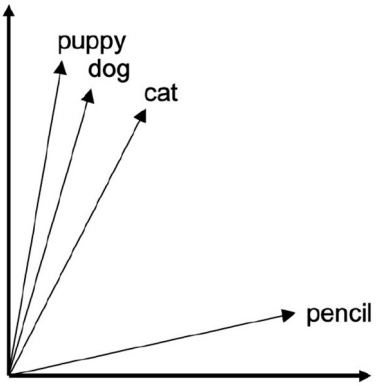


FIGURE 2 | Hypothetical vector space for four English words.

an example of this through a comparison of three hypothetical vector spaces in English, Arabic, and ASL.

For each graph, some of the words form a cluster due to their close semantic relationship. Note that in the leftmost vector space (English), the clustered words are phonologically dissimilar while in the center and rightmost vector spaces (Arabic and ASL, respectively), the clustered words share certain phonological features with each other. In the case of Arabic, this phonological overlap is due to the shared root k-t-b (root consonants noted in red), which in Arabic indicates that all of these words have some relationship to writing. In the ASL example, the shared phonological feature of these signs is their location on the head, which instead has an iconic motivation, as these signs all relate to mental states. In instances of non-arbitrariness in sign language, such as that exemplified above, we predict that phonological information should be evident in the organization of semantics, whether it be systematically or iconically derived. Sign languages in particular are a valuable area in which to apply this vector space approach, due to the pervasiveness of visual iconicity relative to many spoken languages, and computational approaches to the modeling of sign languages are an essential, yet under-explored area in the field.

We hypothesize that as a general property of sign language lexicons, there will be a positive correspondence between semantic similarity and phonological similarity, and test this hypothesis using a computational approach for two unrelated languages: ASL and BSL. For each sign language, we examine the relationship between the phonological overlap of signs and their semantic similarity as determined by their proximity to one another within the vector space model. We take two approaches to testing this hypothesis, first testing for correlations between phonological similarity and semantic similarity between all possible pairs of signs in our corpora (pairwise comparison), and then again within the boundaries of semantically similar clusters of signs (clustering analysis). Our pairwise analysis follows analyses of spoken languages like Dautriche et al. (2017b) and Blasi et al. (2016), that show a relationship between phonological and semantic similarity in the lexicons of many spoken languages, and allows us to test whether there is a

[6]In **Figure 2**, each word is represented as a vector, and the two axes represent the coordinate basis of the vector space.

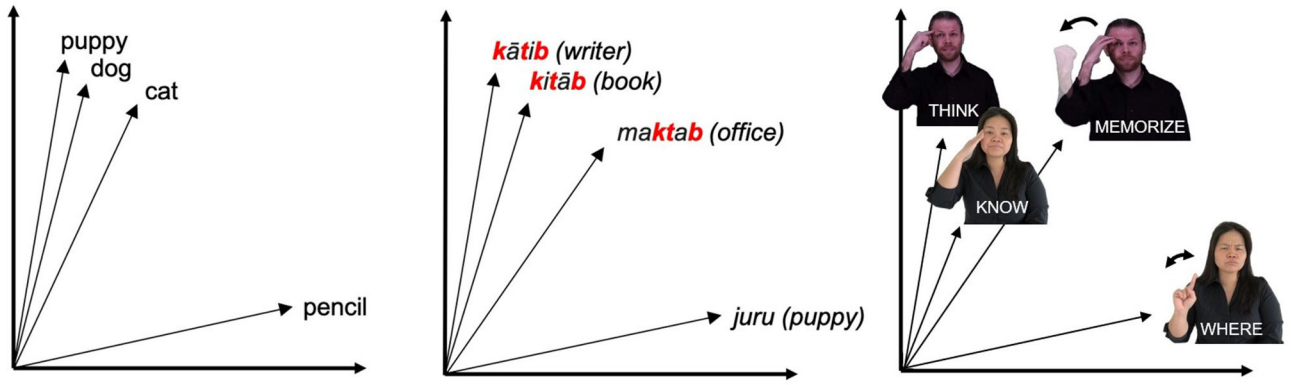


FIGURE 3 | Example English and Arabic words and ASL signs represented in vector spaces.

correspondence between semantic and phonological similarity across the lexicons for two unrelated sign languages. The clustering analysis then takes this a step further to test whether we see systematic patterns in the grouping of phonological and semantic information within the lexicons of ASL and BSL.

2. MATERIALS AND METHODS

2.1. Phonological Data

The phonological information about signs, used to determine phonological similarity, comes from annotated databases of signs from ASL and BSL. The data used for the analysis encompass two annotated datasets of signs that are drawn from existing lexical databases: *The Gallaudet Dictionary of American Sign Language* (Valli, 2006) and BSL SignBank (Fenlon et al., 2014). The American Sign Language dataset comprises annotations of videos of lexical signs from *The Gallaudet Dictionary of American Sign Language*, with the project dataset including 2,698 videos of lexical signs[7] from the video dictionary. The British Sign Language dataset comprises annotations of videos of lexical signs available in the public view web dictionary of the BSL SignBank (Fenlon et al., 2014), encompassing a total of 2,337 unique video entries of lexical items. For signs that have multiple variants, or entries, in the datasets we only use the first listed variant for the present analysis to avoid skewing the data. For example, in the BSL Signbank, there are 15 different entries for the sign MAUVE, but only the first listed was included in the analysis. After removing the duplicates, we were left with 2,335 unique ASL lexical entries, and 1,630 unique BSL lexical entries.

The signs included in the project dataset each received an annotation for their phonological properties within the handshape, location, and movement parameters. The project datasets were annotated by research assistants in the *Sign Language Linguistics Laboratory* at the University of Chicago. Handshape was annotated using the system developed in Eccarius and Brentari (2008). This annotation system uses a combination of letters and numbers to represent the distinctive features that comprise each handshape as represented in the Prosodic Model (Brentari, 1998, 2019). This encompasses not only distinctions in selected finger groupings, but also in joint configuration and the position of the thumb. The location coding system captures specific distinctions in minor location within five major location zones (the head, body, arm, hand, and neutral space). For the handshape and location annotation schema, there are separate annotations for the dominant and non-dominant hands, as well as for their specifications at the beginning and the end of each sign. The movement annotation system is based on meaningful contrasts in the movement parameter as outlined in Brentari (1998). The movement annotation system encompasses distinctions within the categories of local movement, path movement, axis, and the behavior of the non-dominant hand with respect to the dominant hand.

2.2. Similarity Measurements: Semantic and Phonological Similarity

Both semantic and phonological similarity were determined through computational modeling by calculating the semantic and phonological distance between signs. More specifically, within these models, the phonological and semantic relationships between signs are represented through multi-dimensional vector spaces, where similarity is determined by proximity within these spaces. As a way to quantify and compare similarity between words, we use cosine similarity to measure the distance between two vectors in the embedding space.

Beginning with **semantic similarity**, in computationally modeling word meanings, the meanings of words are represented by a vector in a high-dimensional semantic space. For our analysis, we used pre-trained English word embeddings to measure semantic similarity between pairs of signs, because the lack of a large enough sign language corpus to train a reliable vector space necessitated that we use word embeddings trained on spoken English corpora. We made this decision following Thompson et al. (2020b)'s cross-linguistic study which shows that cultural proximity is an indicator of semantic alignment between languages. We used the embedding vectors from the *Global*

[7]Multi-syllabic compounds and signs with multiple distinct sequential morphemes were not included in the project datasets.

Vectors for Word Representation (GloVe) algorithm (Pennington et al., 2014)[8]. Only signs with corresponding semantic vector representations in the GloVe vectors were included in the analysis. This left us with 1946 signs for ASL and 1480 signs for BSL. The two datasets overlapped partially in meaning, with 590 signs overlapping in meaning between the two datasets. This difference may be due in part to the differing nature of the datasets, where one is a dictionary and the other a signbank, or simply due to different decisions made in compiling the two lexical databases.

While semantic similarity was calculated using pre-trained word embeddings, **phonological similarity** was calculated from a vectorized phonological space that was constructed using the phonological datasets. This was achieved by vectorizing the phonological specifications for each of the signs in each dataset, using one-hot-encoding to assign each sign a phonological vector. We used the annotated labels of the phonological specifications for each of the phonological parameters—handshape, location, and movement—for the one-hot-encoding process.

Each sign was represented as a vector with dummy variables (0 or 1) after applying one-hot-encoding to the phonology data. We then applied dimensionality reduction by means of truncated singular value decomposition (SVD) to the one-hot encoded data, a commonly used computational method to transform data for efficient computation and capturing generalizations[9]. We approximated the phonological similarity through the phonological distance between the vectorized representations of the signs in our dataset. Phonological similarity, as with semantic similarity, was obtained by calculating the cosine similarity between the phonological vector representations for each sign pair.

This approach to calculating phonological similarity was chosen because it provides a similarity metric that is comparable to the vector-based metric used to determine semantic similarity. While this is the approach chosen for this analysis, it is worth noting that there exist other measures of phonological similarity that might yield different results. For example, there are finer grained methods of calculating phonological similarity, such as the handshape similarity metric elaborated in Keane et al. (2017). Because the current method of calculating phonological similarity does not capture finer grained distinctions between phonological specifications, such as, for example, gradient differences in joint flexion, we expect that methods incorporating these distinctions would potentially show stronger relationships between phonologically similar signs, but we leave this to future work.

3. RESULTS

We take two perspectives on analyzing the data: (i) a pairwise comparison and (ii) a clustering analysis. The same approach to calculating phonological and semantic similarity was used for both analyses. In the first of these, the **pairwise comparison**, we look at the relationship between semantics and phonology across the lexicon as a whole, by finding the phonological similarity and the semantic similarity between all possible pairs of signs in the available vocabularies. In the **clustering analysis**, we first break the vocabulary into groups of semantically similar signs and then run our similarity metrics within the boundaries of these semantic clusters. The two analyses were chosen to test different generalizations about how the phonology of sign languages might be mapped onto meaning components.

3.1. Pairwise Comparison

When we look at general trends in the relationship between semantic and phonological similarity for the vocabularies of ASL and BSL, we predict a positive relationship between the two. This prediction is based on trends from spoken languages where there is a present, albeit weak, association between form and meaning, as well as due to the noted pervasiveness of form-meaning mappings in sign language. We test this by finding the semantic and phonological similarity between each pair of signs for all of the unordered pairs of signs in each dataset. For instance, the filtered ASL vocabulary of size 1946 has 1892485 unordered sign pairs. For every one of these pairs, we find the phonological and the semantic similarity between the two members of the sign pair.

We analyzed the relationship between the semantic and phonological similarity of pairs of signs in the ASL and BSL datasets using a Pearson correlation. We report the results for the correlation analysis across sign pairs in both the ASL and the BSL datasets. Results are reported for the 100 dimensional semantic space, as each of the semantic spaces tested (100, 200, and 300 dimensions) show negligible differences between them in the pairwise analysis. This relationship between the semantic and

[8]GloVe is known to have advantage of reflecting both the local statistics and global statistics. It incorporates not only the local context information of words (as in the global matrix factorization methods (e.g., latent semantic analysis Deerwester et al., 1990) but also word co-occurrence, as in the local context window methods (e.g., the Word2vec model Mikolov et al., 2013).

[9]For example, the BSL sign CUDDLE is assigned with categorical labels for each feature (i-a) in the annotated phonology data. Once one-hot-encoded, the sign can be represented as a vector expressed with 0 and 1 values for each possible phonological feature (i-b). Once dimensionality reduction is applied to the one-hot-encoded representation of CUDDLE, the sign is represented in a vector of a lower dimension with real numbers as in (i-c). The vector in (i-c) is the actual vector representation of CUDDLE we used for calculating phonological similarity between signs. The vector size and numeric values for each sign varies by parameter (i.e., handshape, location, movement). More than 96% of the original information was retained after dimensionality reduction for all parameters.

(i) CUDDLE

a. Annotated with labels for each feature: {Spread: "unspread," Joint Configuration: "flexed," SelectedFingers: "all"... }

b. One-hot-encoded sign: [Spread_spread: 0, Spread_unspread: 1, Joint_Configuration_curved: 0, Joint_Configuration_stacked: 0, Joint_Configuration_flexed: 1, SelectedFingers_ring: 0, SelectedFingers_middle: 0, SelectedFingers_all: 1...]

c. Final vector representation output after dimensionality reduction: [1.8510536316565696, 1.5249889622005965, 0.629900379775755,..., 0.003631133800598263].

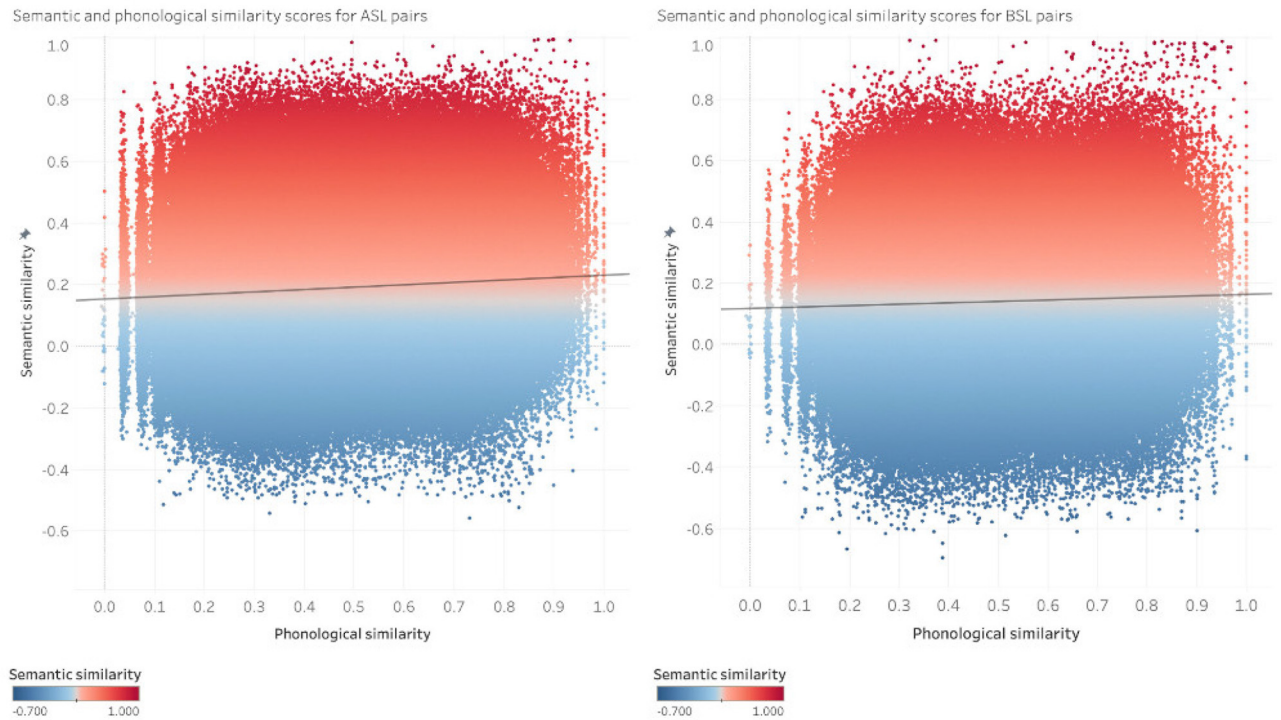


FIGURE 4 | Pairwise comparisons in 100-dimensional GloVe vectors in ASL **(left)** and BSL **(right)**. Each point is a pair of signs *[s1, s2]*; *x*-axes show phonological similarity, *y*-axes show semantic similarity.



FIGURE 5 | Different groupings by pruning height of signs in the ASL dataset with respect to different pruning heights indicated with the red lines. As the pruning height decreases from left to right, the number of clusters increases. Lower heights prune the hierarchical tree at junctions closer to the terminal leaf nodes; hence, a larger number of resulting clusters with fewer members.

phonological similarity for every pair of signs in the ASL dataset and BSL datasets is shown in **Figure 4**.

Our results show a weak but significant positive relationship between semantic and phonological similarity for both of the ASL or the BSL vocabularies (ASL: $r(1892483) = 0.074$, $p<0.001$; BSL: $r(1094458) = 0.044$, $p<0.001$). The correspondence between semantic and phonological similarity is evidenced by pairs of signs in the dataset like [THURSDAY, TUESDAY] in ASL and [FOUR, THREE] in BSL, which are semantically highly related while also phonologically very similar. Although there is a positive relationship between semantic and phonological similarity between the sign pairs, the correlation coefficients for both languages are quite low (all $r < 0.1$), showing that while there is a positive correlation between phonological and semantic similarity in the lexicons for both languages, this is not a strong trend. This weak trend is exemplified by the highly dispersed distribution of semantic and phonological similarity between sign pairs across the vocabularies of ASL and BSL. As seen in **Figure 4**, for ASL and BSL pairs of signs are distributed such that there are not only pairs of signs that show a correspondence between phonological and semantic similarity, but there are also a considerable number of pairs that are semantically similar and phonologically quite distinct, like [GRASS, FLOWER] in ASL and [BANANA, APPLE] in BSL, as well as pairs of signs that are phonologically similar and semantically distinct, like [LOTION, SENIOR] in ASL and [ADDITION, VOMIT] in BSL.

3.2. Clustering Analysis

In the previous section, we showed that pairwise comparisons between signs do not reveal strong correlations between semantic similarity and phonological similarity. Here, we take a different perspective from the pairwise comparison and report our findings on the dataset when it is clustered into sets of semantically related signs, with the prediction that we will see a stronger positive correspondence between phonological and semantic similarity within these groupings. This approach is motivated by evidence that lexicons not only exhibit some degree of clustering in their phonological material (Dautriche et al., 2017a), but also by evidence that areas of more densely clustered semantic space tend to be more iconic (Sidhu and Pexman, 2018; Thompson et al., 2020a).

We use a hierarchical clustering algorithm in this analysis. Hierarchical clustering is a statistical clustering technique which creates a tree hierarchy of inter-connected clusters instead of creating independent ones. We take the bottom-up (agglomerative) approach where each point in the high-dimensional space starts out as its own cluster and merges with other nodes or clusters hierarchically with respect to their Euclidean distance from one another. We use Ward's method (Ward, 1963) where the decision to merge clusters at each step is made based on the optimal value of a loss function—this method minimizes the within-cluster variance.

Hierarchical clustering creates a tree of inter-connected branches and leaves where the final clusters are determined by a **pruning height**. **Figure 5** shows how different values of pruning heights for ASL form different sized clusters of signs grouped by their semantic proximity to one another. In this study, we investigated the data clustered using 100 different pruning heights (height of 0% through 100% at 1% intervals). Different height values produce vastly different groupings in the hierarchical tree with smaller values producing a larger number of clusters composed of fewer members and larger values producing a smaller number of clusters with larger populations.

After the clustering step, we took the same steps as we did with the pairwise comparison method. We identified the unordered pairs of signs in each cluster and measured the semantic and phonological similarity within each pair; however, the pairing step did not cross cluster boundaries. We evaluated the quality of our clustering algorithm across variable dimensions and heights using silhouette scores. **Silhouette scores** are commonly used as a measure of consistency within clusters and distinctiveness from other clusters, providing a metric of how well the models are grouping the semantic space. Higher silhouette scores indicate that data points within a cluster are better matched to each other, and the cluster is dense and more easily separable from other clusters.

Figure 6 illustrates the silhouette scores for each pruning height and dimension. Analysis of the scores reveals a consistent pattern across the different numbers of dimensions and across both sign languages, where the silhouette scores rise sharply as pruning height begins to increase, peak within a pruning height range between 5 and 10%, and then drop back down as the pruning height continues to increase, eventually appearing to plateau. This indicates that our sign clusters are the most well-defined within this 5 and 10% range in each of these vector spaces, in particular for the 100 dimension space, where these peaks were the highest in both ASL and BSL. It is at these pruning heights and dimensionality of the vector space that the semantic space is most well organized.

When we examine the correspondence between semantics and phonology within clusters across these pruning heights, we find a range of small to moderately large positive correlations, the majority of which are significant. We calculated the strength of the relationship between semantic and phonological similarity in all sign pairs by using Pearson's correlations. **Figure 7** shows the correlation coefficients for the 100-dimension semantic vector space in ASL and BSL from pruning heights 5–10 for each phonological parameter.

As shown in **Figure 7**, as pruning height increases, the strength of the relationship between semantic and phonological similarity increases. This trend is broadly applicable to both languages and all three phonological parameters we investigated. However, the correlation strength between semantic and phonological similarity is different between ASL and BSL. In BSL, the correlations are consistently weaker than in ASL, as evidenced by the lower correlation coefficients.

The languages also exhibit different trends with regard to which phonological parameters (handshape, location, and movement) show stronger correlations with semantic similarity. For example, along the movement parameter in ASL, there is a consistent positive correlation between phonological and semantic similarity that increases along with increased pruning height. In contrast, for many of the pruning heights examined

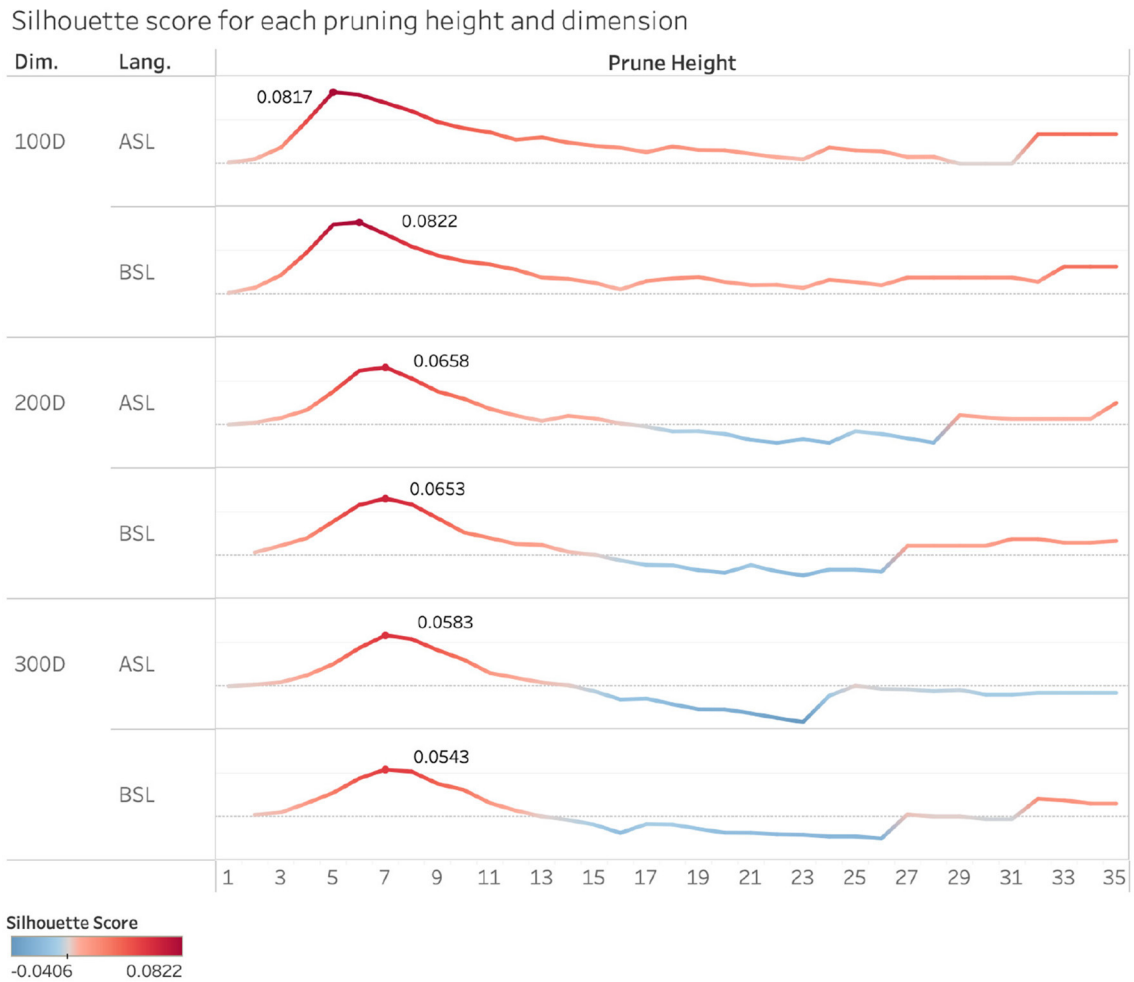


FIGURE 6 | Silhouette scores in ASL and BSL across semantic spaces (100-, 200-, and 300-dimensional semantic space) and pruning heights. (1–35%). A score of 0 indicates there are multiple data points that overlap in clusters. A scores of -1 indicates that data points are assigned to incorrect clusters.

for BSL, this relationship was either not significant, or was lower in strength than for ASL.

4. DISCUSSION

In this investigation, we used a vector space approach to investigate and quantify the form meaning relationships within the vocabularies of two unrelated sign languages. This method of modeling the semantic and phonological spaces allows us to probe this relationship quantitatively. The first analytic approach taken tested the relationship between the semantic and phonological similarity of *all* of the sign pairs in the BSL and ASL lexicons, while the second of these analyzed this relationship within the bounds of semantically clustered groups of signs in the ASL and BSL lexicons.

4.1. Discussion of the Pairwise Comparison

For the pairwise comparison, our results showed a significant, but weak correlation between the semantic and phonological similarity for pairs of signs across the lexicons of ASL and BSL. These results align with previous studies on spoken languages, for example in those of Dautriche et al. (2017b) and Blasi et al. (2016), that show some degree of systematic patterning between the meaning and form of vocabulary items for spoken languages. The positive relationship seen here may stem not only from the affordances of signed languages, which can leverage the visual modality to represent particular systematicities between form and meaning, but also from other wider pressures. For example, non-arbitrariness has been shown to have a positive contribution to the learnability of words (Imai et al., 2008; Monaghan et al., 2011), which might then contribute to a pressure toward retaining non-arbitrary forms.

The strength of the correlation found in the analysis can also be explained in part by the multiple competing forces that contribute to the phonological organization of the lexicon. As discussed previously, phonological systems are shaped in part by a pressure to be maximally distinctive and to combine all the features available to them in a cost-effective way (Clements,

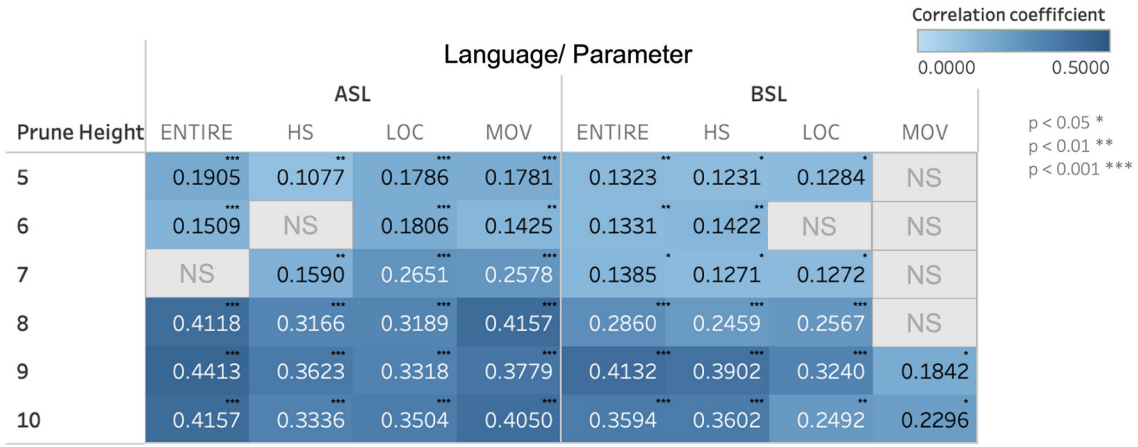


FIGURE 7 | Pearson's correlation coefficients between semantic and phonological similarity for the 100-dimension semantic vector space for ASL and BSL. Correlation coefficients are listed for all of the parameters combined ("ENTIRE") and each of the parameters individually ("HS" = handshape, "LOC" = location, and "MOV" = movement). Relationships that were not significant are marked with "NS."

2003). If we expected that the only factor driving phonological form lay in the semantics of signs, we would bypass this cost-effective property of phonology. Following from this, when we think of the lexicon as a whole, sign pairs that are distant in their semantics but similar in their phonological form are expected, due to the maximization of the combinatorial possibilities of the phonological features available.

Lexical items that are more similar to one another may also be more confusable, leading to additional pressures on forms to be more phonologically dissimilar from one another (Dautriche et al., 2017b). There is also evidence from ASL that signs in denser phonological neighborhoods are recognized more slowly for lower frequency signs (Caselli et al., 2021), and so phonological distinctiveness may play a role in facilitating sign recognition. Together these provide evidence of some pressure toward distinctiviness, which might be contributing to the weak trend seen in this analysis.

In a similar vein, although there are signs that are broadly conceptually similar, there are reasons that lie within their visual properties and iconic affordances that would lead us to expect them not to share phonological properties. For example, consider the broad semantic category of animals. While we might expect some animals to share some iconic properties that might be reflected in their signs, such as body parts (beaks, ears, or tails) or aspects of how they are handled by humans, these properties would not be shared across the entire semantic category of animals. In fact, signs that mapped their phonological form to some of these visual properties, such as beaks and tails, would in fact be more dissimilar from one another due to the differing properties of their referents. On the other hand, within a narrower semantic category, such as that of birds, there are more shared visual features between referents that might result in increased similarity in their phonological form. In this way, sign pairs within more narrowly delineated semantic categories would be more likely to share phonological properties, but it would be unexpected for them to share properties across broader semantic categories. For this reason, we don't necessarily expect a linear relationship between similarity in meaning and in form across the broader lexicon. However, this leads to the prediction that signs grouped at particular levels might still show systematic relationships between their phonological form and their meaning.

4.2. Discussion of the Clustering Analysis

This leads us to our hierarchical clustering analysis, which showed that when signs in ASL and BSL are organized into semantic clusters, we find a systematic correspondence between semantics and phonology among sign pairs. The analysis of the silhouette coefficients demonstrated that the lexicon was most semantically well-organized between pruning heights of approximately 5 and 10% (as seen in **Figure 6**). Examining this alongside our correlation analysis, there was a significant positive correlation between semantic and phonological similarity at these pruning heights. This means that when the sign language vocabularies are organized at these levels, that is, into categories that are neither too broad nor too narrow, we see a relationship between semantic and phonological organization.

The findings of the clustering analysis provide further insight into the distribution of non-arbitrary relationships in the lexicons of sign languages by revealing a textured vocabulary where form and meaning are grouped, or clustered, together in systematic ways. The lexicon of ASL has been shown previously to include multiple clusters of highly iconic, semantically related signs (Thompson et al., 2020a). Following from this, if these clusters also share some degree of phonological similarity, this may contribute to the positive correlation between phonological and semantic similarity within the clusters in the present analysis. The relationships within these clusters also aligns with accounts that suggest a pressure toward a "clumpier" lexicon (Dautriche et al., 2017a), as in this case, the distribution of phonological material

of signs is drawn closely together into clumps within the bounds of particular semantic groupings.

Although both ASL and BSL both showed a correspondence between phonological and semantic similarity within clusters, as noted in the analysis of the correlation patterns for ASL and BSL, differing trends appeared both between the two sign languages analyzed and between the correlation strengths for the different phonological parameters, as can be seen in **Figure 7**). As one example, the strength of the correlations for the movement parameter differed between ASL and BSL. In ASL, the movement parameter had stronger correlation coefficients at most pruning heights when compared to handshape and location. The opposite was true for BSL, where the correlation coefficient for the movement parameter was either not as strong as the other parameters or did not show a significant relationship. This suggests that within each language there may be differing tendencies in how meaning is mapped onto particular parts of the phonology in forming lexical items. One possible explanation for this pattern is that, for ASL, movement may be employed in more systematic ways to convey aspects of meaning, iconic or otherwise, while this may be relegated to the other parameters for BSL. For example, in ASL, the set of signs SCIENCE, CHEMISTRY, and BIOLOGY are all articulated with same circular path movement. ASL may employ the movement parameter to a greater degree than BSL to connect signs in semantically related schema like the one exemplified by this set of signs.

Another notable tendency in the clustering correlation analysis was in the differing strengths of the correlations for ASL and BSL as a whole. More specifically, across the pruning heights examined, ASL tended to have stronger correlations, evidenced by higher correlation coefficients between semantic and phonological similarity than BSL. Possible explanations for these differences can be drawn from the histories of the languages themselves and from the composition of the datasets used for the analysis. One explanation might lie in the relative age of the two languages examined in the study. ASL is a fairly young language, with its history stretching back roughly 200 years, while BSL is considerably older than ASL. One potential explanation for the weaker correlation in BSL is that signs that may have been iconic, over time, changed in their form enough that the strength of the association between form and meaning decreased. This would be in line with trends shown in previous research wherein phonological forms become less iconic and more abstract over time (Frishberg, 1975; Sandler et al., 2011). However, recent scholarship on iconicity and language change in spoken English also suggests that iconic forms are more stable and less likely to change over time (Monaghan and Roberts, 2021) and so the appealing to the age of ASL and BSL may not provide a comprehensive explanation of the patterns seen here. Another potential explanation is a methodological one. The datasets used in the analysis for ASL and BSL were of different sizes. The smaller size of the dataset used for BSL could provide one explanation for the difference in effect size seen for the two languages. Further research, with datasets of equal sizes, will provide more insight into any potential differences between the semantic and phonological organization of these two languages, as the trends seen here could be explained as reflecting cross-linguistic differences or could be a result of the project methodology. Because differences in the results could be due to the different vocabularies and dataset sizes used for each language, these comparisons and interpretations are all drawn tentatively.

4.3. Individual Clusters, Iconicity, and Systematicity

When considering what types of semantic features will organize clusters of non-arbitrary forms, there are likely multiple influences at play. One constraint influencing the presence of iconicity is the kinds of correspondences possible in a given part of the vocabulary. For example, meanings related to magnitude, intensity, or timing allow for iconic representations fairly well through characteristics such as word-length, volume, repetition, or speed of articulation. However, for more abstract concepts, there exists little opportunity for any form of imitative representation. Likewise, the possibilities for iconicity vary with the affordances of a given modality. Meanings related to sounds, or referents for which sound is an identifying feature, can be readily represented iconically in a spoken language, while visual and spatial information lends itself to iconic representation to a greater degree in a signed language (Dingemanse et al., 2015). These factors interact with pressures toward distinctiveness and similarity, and thus will likely influence how signs cluster together in our data. For example, in spoken language, a trend toward dispersion tends to also yield more divergence in form and meaning, due to the fact that "the dimensions available to create variation in the signal are limited to sequences of sounds, expressed in segmental and prosodic phonology" (Monaghan et al., 2014). However, in sign languages, dispersion does not inevitably lead to arbitrariness, because signs can be iconically mapped to referents along multiple dimensions and are not restricted to representations of sound properties of the referent (Sandler and Lillo-Martin, 2006). Additionally, because sign languages allow for simultaneous production of multiple dimensions of a sign, they are much less restricted in where distinctiveness appears in the wordform, while distinctiveness in spoken words is restricted temporally due to its sequential nature (Monaghan et al., 2014).

Our current analyses do not allow us to determine to what extent our semantic-phonological clusters are grouped on the basis of iconicity as opposed to systematicity. However, because the possibility of iconicity is dependent on both semantic domain and modality affordances as discussed above, we would expect clusters based on iconicity to have more constrained distribution relative to those based on systematicity. Moreover, although the presence of iconicity is more restricted, it is also more likely to pattern cross-linguistically. Because iconic wordforms make use of structural similarity and are mapped to meaning on the basis of real-world features of the referent, iconic patterns are more likely to be shared across languages, while systematicity is likely to be language-specific (Iwasaki et al., 2007; Gasser et al., 2011; Kantartzis et al., 2011; Monaghan et al., 2014; Dingemanse et al., 2015; Lockwood and Dingemanse, 2015). *Post-hoc* manual inspection of the clustering results can provide insight into the

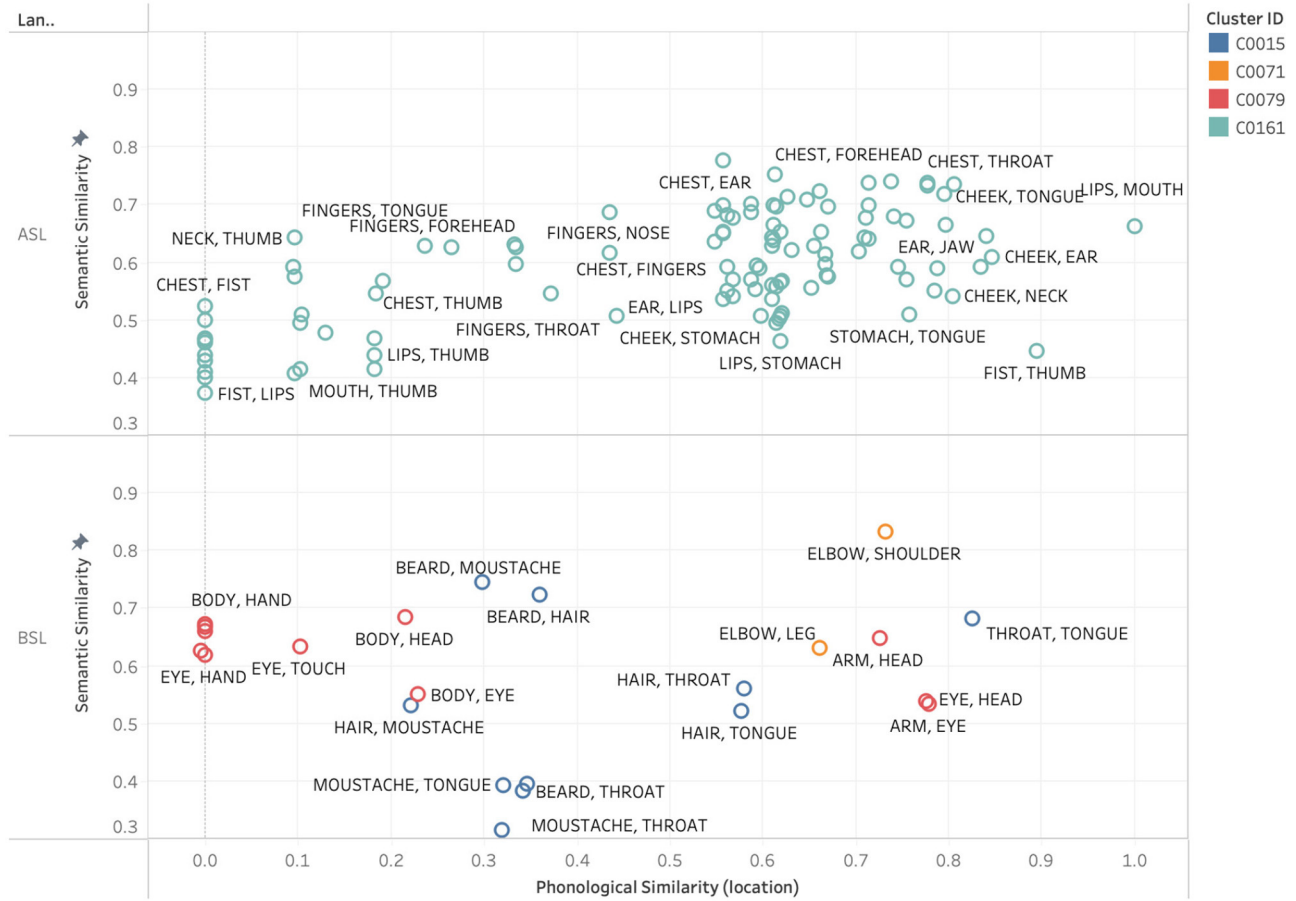


FIGURE 8 | Example sign pairs relating to parts of the body in ASL and BSL.

nature of these clusters and how they manifest across our two sign languages.

As discussed above, certain types of meaning are more likely to be iconically realized than others, and in certain cases, this will be particularly facilitated in signed communication. For example, when considering how body parts are likely to be represented in a sign language, one might expect the default presence of the signer's own body in the visual space during communication to influence how various parts of the body are indicated. Locations on the body can be referenced *via* deixis, or pointing, without the need for any further abstraction. It is the affordances of the visuo-spatial modality that allow for this mapping between form and meaning for these concepts. However, we would only expect this location-based iconicity to give rise to phonological similarity between signs in cases where these locations are similar to each other. For signs, such as LIPS, TEETH, TONGUE, and MOUTH, the iconic use of location should yield a high degree of phonological overlap. However, when we look at signs, such as HEAD, HIP, LEG, and STOMACH, making use of location in this way should drive these signs apart phonologically. We would predict this location-based iconicity to be used in both ASL and BSL, as these affordances are not language specific, ultimately yielding a similar pattern regarding when iconicity should phonologically cluster these signs and when it should drive them apart. This ties into scholarship noting that there are particular locations in sign languages whose iconicity ties together particular families of signs that share similar meaning (Fernald and Napoli, 2000; van der Kooij, 2002). **Figure 8** shows various sign pairs relating to parts of the body selected from a subset of clusters in the ASL and BSL datasets.

One obvious difference in the ASL and BSL data in **Figure 8** is the number of data points, where the ASL data includes many more body-related signs than the BSL data. Additionally, the body-part signs all formed a single cluster in ASL, represented in the figure with the same cluster ID. The BSL body-part signs, in contrast, were distributed across three, indicated by three different colors on the plot. However, the strength of the phonological relationship, specifically in regards to location (*X*-axis), does appear to be largely dependent on the locations of the real-world referents for both ASL and BSL among this subset of signs. Note also that there exist constraints on the iconic use of location regarding body parts outside the signing space

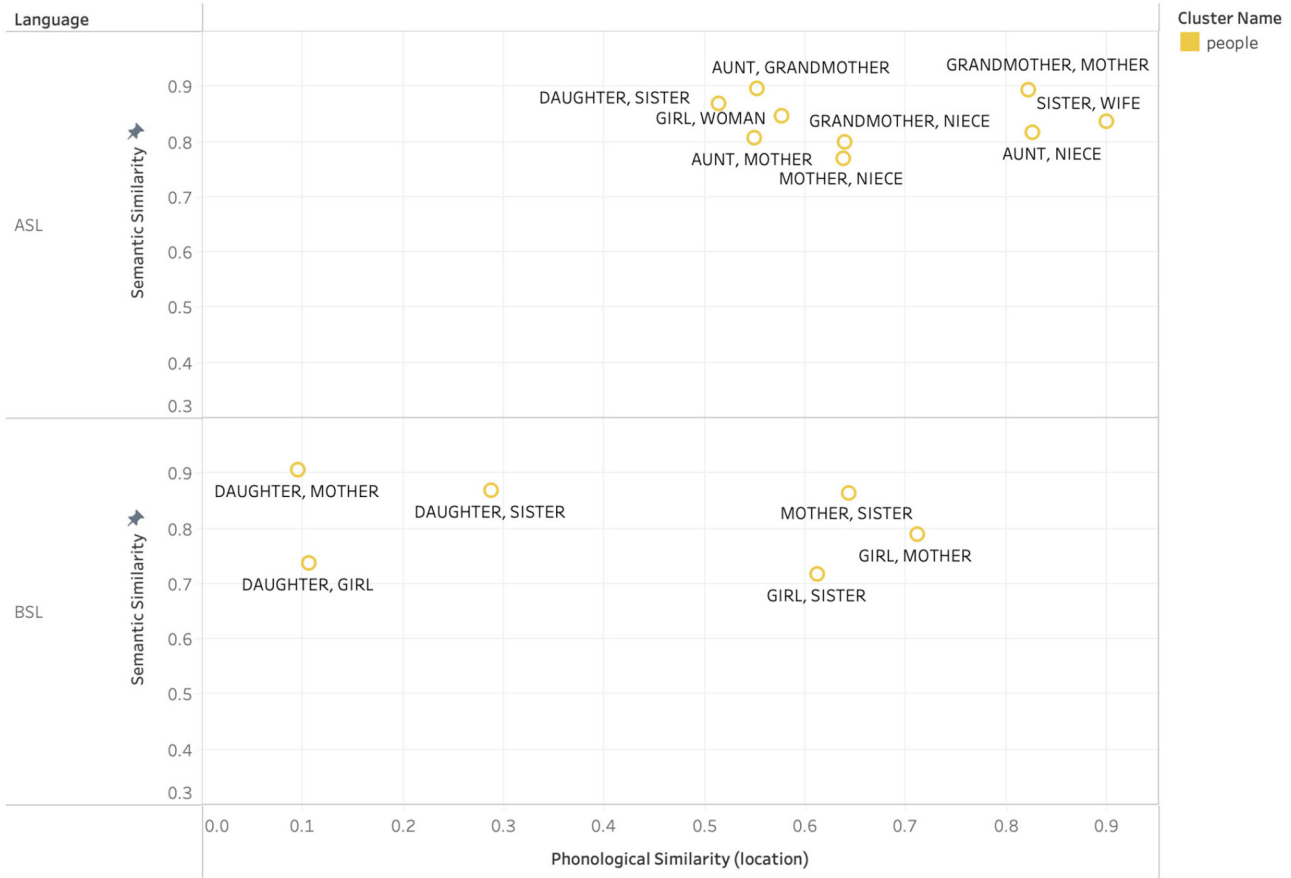


FIGURE 9 | Example sign pairs relating to gender and family roles in ASL and BSL.

(e.g., feet) or taboo parts of the body (e.g., penis) which wouldn't use locative iconicity. Because of cases like these, we would not expect location to be used iconically across all body-part signs, thus weakening this correspondence.

The patterns observed for body-part signs appear to be driven by location-based iconicity, and apply to both ASL and BSL. However, there are other non-arbitrary influences driving the clusters in our data that are systematic rather than iconic, and thus not likely to apply cross-linguistically. For example, in ASL many gendered signs such as those for family members adhere to a pattern wherein signs with female referents are articulated near the lower half of the head and signs with male referents are articulated near the upper half. While there may be iconic origins to the use of these locations, this pattern ultimately represents a non-arbitrariness that is systematic rather than iconic in contemporary ASL. Because of this, we would not expect this pattern to necessarily hold cross-linguistically, in much the same way that phonesthemes (e.g., the /gl-/ onset used in "glimmer," "glow," "gleam," "glisten," etc.) are often language specific. This point is exemplified in **Figure 9**, which shows a subset of female-gendered family signs from ASL and BSL clusters, specifically looking within phonological location. Within the ASL signs we see a higher degree of phonological overlap than within the BSL signs, with the ASL signs clustered to the right of the graph, while the BSL signs are distributed across a wider range. This exemplifies the expected pattern where a language specific schema that connects the meaning and form of a group of signs is reflected in the high degree of similarity between this cluster of forms in ASL, but not in BSL.

Taken together, the current findings contribute to our understanding of how and why non-arbitrariness is distributed across the linguistic systems of signed languages. Discussions of non-arbitrary relationships between form and meaning have been highlighted throughout much of the history of scholarship on sign languages, spanning not only discussions of iconicity, but also wider discussions of systematicities in form that rely on the affordances of the visual modality. Here, we used computational methodologies to contribute to this area of inquiry, using vector space models to quantify and examine patterns in the relationships between form and meaning in sign language lexicons. Our analyses suggest that the meaning of signs does, to some degree, contribute to the organization

of their phonological properties. This relationship between form and meaning is most evident when we look at lexicons that are organized into more narrow semantic categories, with correspondences in phonological form being bounded by the semantic categories themselves. We see these relationships in both ASL and BSL, suggesting that these connections between the phonological form and the meaning of signs is not the property of just one sign language, but might be more generalizable, although the strength of this relationship may differ between languages.

However, the distribution of these non-arbitrary forms across the lexicon is mediated by several communicative and cognitive pressures. Not only do pressures toward phonological dispersion and clumsiness shape these trends, but so do various pressures from both real world referents as well as the constraints of the signing space. Certain pressures toward iconicity will likely influence the forms of signs across diverse sign languages, such as visual salience and affordances of the signing space, while other pressures would be expected to exist only within a given language or culture, such as gender pattern we see in ASL signs for people and family members. Additionally, the influence of iconicity does not always result in clustering signs together in phonological space. In many cases, signs that adopt similar iconic mappings to their referents are dispersed in the space, such as in the case of MOUTH and TEETH versus MOUTH and LEG. Expanding this analysis to larger datasets in future work will reveal further trends in the distribution and strength of these relationships.

Methodologically, the current work also contributes to a growing body of research on lexicon-wide computational analyses of sign languages, contributing a new way to approach the identification of form-meaning correspondences and their dispersion across the lexicon. Our analysis, similar to work like that of Thompson et al. (2020a), demonstrates that a vector space approach can be useful in modeling the semantic spaces of sign languages and we further show that VSMs can be harnessed to study patterns in non-arbitrary form-meaning correspondences for sign languages, even when using a relatively sparse representation of the lexicon. Because this computational approach enables the quantification of semantic and phonological similarity between many sign pairs, it is particularly useful for large scale, cross-linguistic comparisons of sign languages. We hope vector space approaches can be used in future work to further explore the pervasiveness of non-arbitrariness in different signed languages, expanding our understanding of the linguistic pressures that shape these systems.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://github.com/EmreHakguder/SL_VSMS.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

AM: contributed funding acquisition, data collection, writing, and draft preparation. CF and SK: contributed conceptualization, methodology, analysis, writing, and draft preparation. EH: contributed conceptualization, methodology, analysis, and writing. DB: contributed to the methodology, review-editing, and supervision. All authors contributed to the final version of the article and approved the submitted version.

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Associations Between Sign Language Skills and Resting-State Functional Connectivity in Deaf Early Signers

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The processing of a language involves a neural language network including temporal, parietal, and frontal cortical regions. This applies to spoken as well as signed languages. Previous research suggests that spoken language proficiency is associated with resting-state functional connectivity (rsFC) between language regions and other regions of the brain. Given the similarities in neural activation for spoken and signed languages, rsFC-behavior associations should also exist for sign language tasks. In this study, we explored the associations between rsFC and two types of linguistic skills in sign language: phonological processing skill and accuracy in elicited sentence production. Fifteen adult, deaf early signers were enrolled in a resting-state functional magnetic resonance imaging (fMRI) study. In addition to fMRI data, behavioral tests of sign language phonological processing and sentence reproduction were administered. Using seed-to-voxel connectivity analysis, we investigated associations between behavioral proficiency and rsFC from language-relevant nodes: bilateral inferior frontal gyrus (IFG) and posterior superior temporal gyrus (STG). Results showed that worse sentence processing skill was associated with stronger positive rsFC between the left IFG and left sensorimotor regions. Further, sign language phonological processing skill was associated with positive rsFC from right IFG to middle frontal gyrus/frontal pole although this association could possibly be explained by domain-general cognitive functions. Our findings suggest a possible connection between rsFC and developmental language outcomes in deaf individuals.

Keywords: sign language, resting-state functional connectivity, deafness, brain-behavior association, fMRI

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INTRODUCTION

Sign languages are the primary mode of communication in Deaf communities across the world. Similar to spoken languages, signed languages have syntactical, lexical, and sub-lexical structures that differ between languages across geographical regions (Mathur and Rathmann, 2014). However, sign language is expressed in the manual-visual domain, whereas speech is formed in the oral-aural modality. In spite of the modality differences, the existing evidence suggests that neurobiological correlates of language processing overlap to a great deal across modalities

(MacSweeney et al., 2008; Malaia and Wilbur, 2010; Cardin et al., 2020a; Trettenbrein et al., 2021). Most previous studies have applied task-based functional magnetic resonance imaging (fMRI) to identify brain regions that are associated with the processing of sign language. These studies have improved our understanding of neural structures involved in sign language perception and understanding. However, functional connectivity can advance our understanding of how different language-relevant brain regions work together for optimal language processing (Fedorenko and Thompson-Schill, 2014; Hagoort, 2019). In the present study, we investigate associations between sign language proficiency and resting-state functional connectivity (rsFC) in deaf early signers. Thus, we explore whether individual differences in sign language skills are associated with how brain regions are intrinsically and functionally related.

Hickok and Poeppel (2007) proposed a neural model of language processing with core language regions in the superior temporal cortex bilaterally, and dorsal and ventral processing streams representing different functional operations. The dorsal stream is left-hemisphere biased and includes the parieto-temporal intersection region, as well as premotor and inferior frontal cortical nodes. The ventral stream, on the other hand, covers bilateral posterior middle and inferior temporal cortical regions, and the left anterior middle temporal gyrus and inferior temporal sulcus. The ventral stream is related to the mapping of an incoming language signal to its meaning, whereas the dorsal stream deals with production. However, it should be noted that consensus does not exist regarding the exact functions and anatomical distribution of the streams, and alternative accounts (e.g., Friederici, 2012; Bornkessel-Schlesewsky and Schlesewsky, 2013; Ullman, 2016; Hagoort, 2019) have a somewhat different emphasis than the model proposed by Hickok and Poeppel (2007). Nevertheless, models overlap with similar functions located across temporal, parietal, and frontal regions, and a dual-stream model finds support in meta-analytic work on speech processing (Adank, 2012; Walenski et al., 2019).

Several studies have reported shared neural activation across spoken and signed language (Söderfeldt et al., 1994b, 1997; Petitto et al., 2000; MacSweeney et al., 2002; Sakai et al., 2005; Emmorey et al., 2007, 2014; Courtin et al., 2011; Zou et al., 2012; Johnson et al., 2018; Moreno et al., 2018; Finkl et al., 2020), although a recent study by Evans et al. (2019) indicated that only semantic, not form-based, representations share neural activation patterns. Due to modality-specific operations needed for processing of manual-visual language, some suggest that certain brain regions (e.g., the superior parietal lobule) might be specifically engaged for sign language (Söderfeldt et al., 1994a; Zou et al., 2012; Emmorey et al., 2014). It has also been suggested that the involvement of the right hemisphere might be more prominent for sign language than for speech (Newman et al., 2002, 2010; Emmorey et al., 2005, 2014; Sakai et al., 2005). The role of the right hemisphere has further been proposed to be dependent on proficiency (Malaia and Wilbur, 2010) and the age of acquisition (AoA) of sign language (Neville et al., 1997; Newman et al., 2002; Mayberry et al., 2011). In addition, Stroh et al. (2019) suggested that deaf signers compared to hearing signers might recruit regions in the right hemisphere to a greater degree for certain linguistic tasks.

In a recent meta-analysis of the neural underpinnings of sign language processing, Trettenbrein et al. (2021) proposed that the right inferior frontal gyrus (IFG) and right middle temporal gyrus are specifically recruited for sign language processing. These two regions are typically not regarded as "language regions", but based on a recent meta-analysis by Walenski et al. (2019), temporal lobule activation for spoken language processing was described as bilateral, in line with the dual-stream model proposed by Hickok and Poeppel (2007). Trettenbrein et al. (2021) further identified critical nodes for sign language processing in the left IFG and precentral/middle frontal gyrus, corroborating reports from spoken language (Walenski et al., 2019). Trettenbrein et al. (2021) also noted that previous literature indicates a role of left middle gyrus, superior temporal gyrus (STG), supramarginal gyrus, and bilateral superior parietal lobules in sign language processing. These regions did show an effect of sign language processing when compared to rest conditions, but the activation overlapped with activation from non-linguistic sign-like actions from an independent set of studies. Thus, these regions might not be critically involved in linguistic aspects of sign language processing although the studies were not designed to test this directly. Due to the limited number of studies, Trettenbrein et al. (2021) could not differentiate between regions that might be specific for production versus comprehension, or syntactical, lexical, and phonological levels of processing. It thus remains unclear how different regions relate to the type of linguistic processing in sign language. Some propose that the left supramarginal gyrus is particularly important for phonological analysis in sign language (Corina et al., 1999; Emmorey et al., 2003; MacSweeney et al., 2008), and activation of the inferior frontal and superior and middle temporal cortices is associated with sentence level processing of speech (Walenski et al., 2019). In addition, language comprehension seems to be bilaterally distributed to a larger degree than language production (Walenski et al., 2019).

The literature indicates that sign language proficiency might influence neural responses. For example, AoA, which likely influences proficiency (Twomey et al., 2017), seems to produce lateralization effects (e.g., Newman et al., 2002; Mayberry et al., 2011). Newman et al. (2002) compared neural activation for real American Sign Language sentences compared to sentence-like pseudo-sign utterances, and reported a right hemisphere effect of AoA, with activation of angular gyrus in early, but not late, learners. AoA effects have further been reported to be associated with the level of activation in other regions. Mayberry et al. (2011) regressed neural activation on AoA and showed that, with earlier AoA, there was stronger activation in bilateral dorsolateral prefrontal cortex, left anterior insula/frontal operculum, left IFG, left ventral premotor region, and bilateral STG. Later AoA, on the other hand, was associated with stronger activation of left lingual gyrus and left middle occipital gyrus. Twomey et al. (2020) reported that late as compared to early signers, regardless of hearing status, had stronger activity in the occipital segment of the left intraparietal sulcus. Further, early deaf signers showed greater activation in the left posterior

superior temporal cortex in response to real sign language sentences as compared to made-up signs. In yet another study, Cheng et al. (2019) reported that language deprivation in three cases of deaf individuals was associated with altered structural connectivity in the left dorsal arcuate fasciculus pathway, a fiber tract connecting superior temporal to frontal regions. Thus, early access to sign language seems to produce effects on neural activation in occipital, parietal, temporal, and frontal regions, but also influences the development of language-relevant structural pathways. It is likely that level of proficiency is associated with differences in neural activation patterns. Emmorey et al. (2015) reported that the regional neural activation that correlates with behavioral performance on linguistic tasks differs depending on the specific linguistic operation of the task. For example, they saw that fingerspelling ability was negatively associated with neural activation in right frontal regions, whereas sentence processing of sign language was negatively associated with activation in angular gyrus and middle temporal gyrus.

Apart from the above-described association between sign language skills and region-specific activations, associations between language skills and brain activity have also been investigated using rsFC. For example, Qian et al. (2016) saw associations between reading skills and rsFC of visual dorsal stream regions (i.e., involved in spatial processing) and regions invoked by reading tasks, such as the fusiform gyrus. In another study, Koyama et al. (2011) reported an association between reading skills and rsFC between the left fusiform gyrus and left frontal and inferior parietal regions. In addition, Chai et al. (2016) investigated associations between second language acquisition and rsFC based on two regions of interest, the anterior insula/frontal operculum and the visual word form area in the fusiform gyrus. They reported positive associations between degree of second language acquisition and connectivity between anterior insula/frontal operculum and left posterior STG as well as the dorsal anterior cingulate cortex. In a study on associations between rsFC and language skills in deaf adults, Li et al. (2013) investigated rsFC within and between superior temporal regions and how connectivity was related to written language skills in congenitally deaf adults, adults with acquired deafness, and hearing adults with no knowledge of sign language. Connectivity between the middle and anterior parts of the superior temporal cortex was associated with written language skills in participants with deafness, but not in hearing participants. However, Li et al. (2013) did not report any associations between written language skills and rsFC outside superior temporal regions. In summary, there are studies showing associations between spoken language skills and rsFC in both hearing (Chai et al., 2016) and deaf (Li et al., 2013) individuals, but as far as we know, associations between sign language proficiency and rsFC have hitherto not been described in the literature.

Given the available evidence, there is a multitude of potentially relevant brain regions to include in an analysis of associations between rsFC and sign language proficiency. For the purposes of the present study, we based the selection of seeds of interest in our connectivity analysis on two of the most studied regions in relation to language processing, i.e., the IFG and STG (e.g., Trettenbrein et al., 2021). To restrict the number of statistical tests performed in our exploratory analysis, only four nodes were included as seeds: bilateral IFG and posterior STG. This selection of regions does not include all potentially relevant regions proposed by dual-stream models, such as the one by Hickok and Poeppel (2007), but it overlaps with such models. For the selected regions, we estimated seed-to-voxel based connectivity for each individual and correlated with behavioral performances. We included two separate measures of sign language proficiency, one that taps onto phonological skill and another that represents sign language sentence processing skill. This was because there is reason to believe that the type of linguistic operation might affect which specific neural networks that are involved (Hickok and Poeppel, 2007; Friederici, 2012; Bornkessel-Schlesewsky and Schlesewsky, 2013; Hagoort, 2017).

MATERIALS AND METHODS

Participants

Participants were recruited for a larger project (see Andin et al., 2021) and 15 (out of 17) had complete data on measures of sign language phonological and sentence processing, as well as an fMRI resting-state session (mean age = 35.0, *SD* = 7.8, min 22, max 48). All were right-handed and had normal or corrected-to-normal vision. Non-verbal cognitive ability was normal or above normal, as assessed on the Visual Puzzles subtest from the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV, Wechsler, 2008). The Visual Puzzles subtest has one of the highest factor loadings (0.72) on the index of non-verbal ability (the Performance Index) in the Swedish version of WAIS-IV, which makes it a good proxy for non-verbal cognitive ability when time constraints limit the number of tests to include. Six participants had a university degree, and the rest had completed high school. Nine were deaf from birth and the remaining six became deaf before the age of three. Five were native signers, and the rest were exposed to sign language before the age of three. All used Swedish Sign Language (*Svenskt teckenspråk*; STS) as their primary language. The study was reviewed and approved by the regional ethical review board in Linköping (Dnr 2016/344-31). Participants gave their written informed consent and received a gift as a compensation for their participation.

Sign Language Proficiency Measures

Cross-Modal Phonological Awareness Test

The Cross-modal Phonological Awareness Test (C-PhAT; Holmer et al., 2016) was used as a measure of sign language phonological awareness. Pairs of printed characters (two letters or a letter and a number) were presented and the participant had to respond whether the STS handshapes representing the two characters were the same or not, regardless of their orientation and location. Two lists of 24 pairs, eight of which overlapped in handshape (see Holmer et al., 2016), were presented in counterbalanced order across participants. The order of pairs was randomized for each participant. Stimuli were presented until the participant made a response, or for a maximum of 20 s. The interstimulus interval was 1 s. The dependent measure was

average response time in ms. Reliability was estimated based on the correspondence in performance across lists, $r = 0.75$.

Swedish Sign Language Sentence Repetition Test

To assess sign language sentence reproduction, the Swedish Sign Language Sentence Repetition Test (STS-SRT, Schönström and Hauser, 2021), a Swedish adaptation of the American Sign Language Sentence Repetition Test (ASL-SRT; Hauser et al., 2008), was used. Filmed STS sentences ($N = 31$), of different length and difficulty, produced by a deaf native signing man, were presented to the participant. The participant watched each sentence and was instructed to reproduce it exactly as it was signed in the video. Video clips were presented on a laptop (12" screen), and approximately 8 s were left for a response before the next trial started. The front camera on the laptop was used to film responses, which were scored on a later occasion by the second author (who is a deaf native user of STS). One point was awarded for each sentence that was an exact replication of the sentence presented in the video. The dependent variable was the number of correctly reproduced sentences. As estimates of reliability, internal consistency and inter-rater reliability provided excellent values in a previous study, with Cronbach's $\alpha = 0.92$ and ICC = 0.90 (Schönström and Hauser, 2021). Furthermore, the test provides evidence for good validity as suggested by better performance in adults than in children, and that delayed language acquisition is associated with lower scores.

Resting State Functional Connectivity

Data Acquisition

MR imaging was performed on a 3T scanner (Siemens Magnetom Prisma, Siemens Healthcare, GmbH) with a 64-channel head coil at the Center for Medical Image Science and Visualization (Linköping University, Sweden). Functional images were acquired during continuous scanning using a BOLD multi-plex EPI sequence during a 10-min resting-state scan with the following parameters: FOV = 192 × 192 mm, voxel size 3 × 3 × 3 mm, TR = 1,340 ms, TE = 30, FA = 69°, number of slices = 48, 440 volumes, interleaved/simultaneous acquisition. Structural images were acquired in the beginning of the session using a T1 MPRAGE 3D-sequence; FOV = 288 × 288, acquisition matrix = 208 × 288 × 288, voxel size 0.90 × 0.86 × 0.86 mm, TR = 2,300 ms, TE = 2.36 ms, TI = 900 ms, FA = 8°. Between the structural and resting-state scans, four runs of task-based fMRI were performed (see Andin et al., 2021).

Connectivity

Resting-state functional connectivity (rsFC) was analysed using Conn functional connectivity toolbox (version 20b, RRID:SCR_009550).[1] For each participant, seed-to-voxel connectivity estimates were obtained by correlating the BOLD time series in selected seed regions with all other voxels in the brain. The four seeds (bilateral IFG and posterior STG) included all nodes from the language network in the network atlas defined by Conn. Data were preprocessed using the standard preprocessing pipeline in Conn, including functional realignment, unwarping and co-registration to the first scan, slice-timing correction, outlier detection by computation of framewise displacement, normalization into standard MNI space, structural segmentation into gray matter, white matter, and CSF tissue classes, and smoothing using a Gaussian kernel of 8 mm full width half maximum to reduce signal-to-noise ratio. Linear regression using the anatomical component-based noise correction (aCompCor; Chai et al., 2012) algorithm was implemented at the first level to remove confounding factors including subject-specific physiological noise from white matter and cerebrospinal areas, motion parameters, outlier scans (scrubbing), and session-related slow trends. Finally, a band-pass filter of 0.008–0.09 Hz was applied to remove high-frequency noise and low-frequency drift.

Statistical Analysis

Descriptive statistics were calculated for the behavioral measures, i.e., C-PhAT (response time), STS-SRT (raw score), and Visual Puzzles (raw score). Further, parametric correlations were used to estimate associations between predictor variables. Statistical analyses of behavioral measures were performed in IBM SPSS Statistics (version 26). Then, associations between sign language skills and brain connectivity were estimated using the Conn toolbox (see above). For each seed region, we tested whether any statistically significant rsFC associations could be observed for either response time on C-PhAT, or number of correct responses on STS-SRT. These tests were corrected for age since variability in age has been reported to influence rsFC even in young to middle-aged adults (Xiao et al., 2018). When appropriate, we also controlled for non-verbal cognitive ability. In the second-level analyses, mean-centered predictors were entered as covariates in the seed-to-voxel analysis for each seed. Two statistical tests were conducted for each of the four seeds, one for C-PhAT and one for STS-SRT. Thus, seeds were treated as four separate groups of tests, and the p-value was corrected for multiple tests within each group by applying Bonferroni correction. With an α of 0.05, an association between performance on one of the behavioral tasks and rsFC was considered statistically significant with a false discovery rate (FDR) p-value < 0.025 at the cluster level (0.05 divided by the two tests for each seed). This liberal approach to correction for multiple tests was applied to maximize statistical power. For testing of statistically significant peaks within a statistically significant cluster, an uncorrected p-value of 0.001 was applied.

Procedure

Before arriving at the laboratory, the experimenter checked if the participants adhered to the inclusion criteria based on responses in an online questionnaire. Testing started with participants being informed about the study and signing an informed consent form. Half of the participants then continued with behavioral testing and the other half with MR-scanning. Tests included screening of visual acuity and contrast sensitivity, the Visual Puzzles subtest from WAIS-IV, C-PhAT, and STS-SRT, as well as a set of cognitive tasks not reported here. Behavioral testing lasted for approximately 60 min. The MR-scanning, including a structural run, an experimental task, and the 10-min long

[1] www.nitric.org/projects/conn

resting-state run, lasted for 45 min. During the resting-state run, participants were instructed to focus on a white plus sign on a black background, presented virtually through MR-goggles (VisuaStim Digital, Resonance Technology, Inc.). Participants were also instructed not to fall asleep. An accredited STS interpreter was present during testing and provided verbatim translation of instructions of responses to questions. Participants communicated in STS via a video camera in the scanner.

RESULTS

Performance on Behavioral Measures

For descriptive statistics on, and correlations between, behavioral measures see **Table 1**. One significant outlier was detected on C-PhAT, and this individual was excluded from further analyses that included this task. The association between C-PhAT and STS-SRT was not statistically significant (see **Table 1**), suggesting that these measures tap onto different language processes. Further, performance on C-PhAT, $r(14) = -0.54$, $p = 0.045$, but not STS-SRT, $r(15) = -0.07$, $p = 0.82$, was associated with performance on Visual Puzzles, our index of non-verbal cognitive ability. To control for the influence of non-verbal cognitive ability in associations observed between C-PhAT performance and resting-state functional connectivity (rsFC), performance on Visual Puzzles was used as a covariate in connectivity analyses involving C-PhAT.

Performance on Cross-Modal Phonological Awareness Test and Intrinsic Connectivity

For C-PhAT, connectivity from right IFG to a cluster peaking in the left middle frontal gyrus/frontal pole was negatively associated with response time, $t(11) = 8.26$, $\beta = 0.00058$, $R^2 = 0.87$, $p < 0.001$. However, when controlling for performance on Visual Puzzles, the association was not statistically significant ($p = 0.18$ for a similar association including a smaller cluster in the left middle frontal gyrus/frontal pole). Thus, better performance (shorter response time) was associated with stronger connectivity from right IFG to left middle frontal gyrus/frontal pole when controlling for age, but not when also controlling for the influence of non-verbal cognitive ability (i.e., Visual puzzles). There were no significant associations between C-PhAT performance and rsFC from left IFG or bilateral posterior STG.

TABLE 1 | Descriptive statistics (means and standard deviations) on behavioral measures and their Pearson r correlations.

				Correlations	
	N	*M*	*SD*	STS-SRT	VP
C-PhAT	15	1.698	406	0.29	−0.54*
STS-SRT	15	17.9	4.1		−0.07
VP	15	17.8	4.6		

C-PhAT, Cross-modal Phonological Awareness Test; STS-SRT, Swedish Sign Language Sentence Repetition Test; VP, Visual Puzzles subtest from WAIS-IV.
*$p < 0.05$.

Performance on Swedish Sign Language Sentence Repetition Test and Intrinsic Connectivity

A negative association was found between STS-SRT performance and rsFC from the left IFG to a cluster with a peak in the precentral gyrus, $t(12) = 6.06$, $\beta = -0.032$, $R^2 = 0.75$, $p < 0.001$ (see **Table 2**). Worse sign language sentence processing skill was thus associated with stronger positive connectivity from left IFG to sensorimotor regions, after controlling for age-related differences in rsFC. The statistically significant cluster, and strength of connectivity within this cluster, is displayed in **Figure 1**. For a scatterplot of the association see **Figure 2**. There were no significant associations between STS-SRT performance and rsFC from right IFG or bilateral posterior STG.

DISCUSSION

In the present, explorative study, we investigated how individual variability in sign language proficiency, at phonological and sentence levels, is associated with resting-state functional connectivity (rsFC). More specifically, we investigated associations between two different types of sign language skills: phonological skill and sentence processing skill, and rsFC from bilateral IFG and posterior STG to the rest of the brain. Faster phonological processing was positively associated with stronger connectivity between right IFG and left middle frontal gyrus/frontal pole; however, this association did not remain after controlling for non-verbal cognitive ability. Worse sign language sentence processing ability was associated with stronger positive connectivity from left IFG to sensorimotor regions. Thus, rsFC between prefrontal and sensorimotor language regions seems to co-vary with sign language reproduction skill.

Resting-State Functional Connectivity and Sign Language Processing

We saw that rsFC from the right IFG to left middle frontal gyrus/frontal pole is negatively associated with performance on a speeded phonological awareness task, which might suggest that the strength of communication between these regions at rest is indicative of phonological skill. However, this association was not statistically significant after control for non-verbal cognitive ability (as measured on the Visual Puzzles sub-test from WAIS-IV, Wechsler, 2008). Thus, it is possible that the association we see is driven by non-linguistic, cognitive skills. Due to the small sample in the present study, we had limited power to detect associations, and controlling for multiple covariates (i.e., age, non-verbal cognitive ability), as we did here, reduces the degrees of freedom even more. Thus, associations might exist that we could not detect. On the other hand, a small sample might produce spurious and random results that do not replicate. That is, the association we saw in the first

TABLE 2 | Statistically significant associations between Sign Language Proficiency Variables (STS-SRT and C-PhAT) and Resting-State Functional Connectivity, controlling for age.

Behavioral measure	Seed	Cluster peak location	Association	Cluster size (voxels)	Cluster size p^a	Cluster peak (MNI)			Peak *t*	Peak p^b	R^2
						x	y	z			
C-PhAT	r. IFG	l. MFG/FP (BA 45)	Positive	98	0.014	−40	48	18	8.26	0.000005	0.87
STS-SRT	l. IFG	l. PG (BA 6)	Negative	102	0.016	−18	−28	66	6.06	0.00006	0.75

C-PhAT, Cross-modal Phonological Awareness Test; STS-SRT, Swedish Sign Language Sentence Repetition Test; l, left; r, right; IFG, inferior frontal gyrus; MFG, middle frontal gyrus; FP, frontal pole; PG, precentral gyrus.
[a]*FDR-corrected ($p < 0.025$ is regarded as statistically significant).*
[b]*Uncorrected ($p < 0.001$ is regarded as statistically significant).*

place might have occurred by chance. In their recent meta-analysis, Trettenbrein et al. (2021) noted that the right IFG is involved in sign language processing. However, based on the available literature we see no particular reason why rsFC between this region and left middle frontal gyrus/frontal pole should be associated with phonological processing of sign language. Instead, such connectivity might reflect intrinsic activation within a lateral frontoparietal network used in the processing of executively demanding tasks (Uddin et al., 2019; Witt et al., 2021). This could possibly explain why the association we first saw disappeared when controlling for non-verbal cognitive ability.

We further saw that those who struggle more with reproducing sign language sentences correctly have stronger rsFC between left IFG and a cluster peaking in the left precentral gyrus. In the context of language processing, left IFG is typically described as a control region involved in language production and complex linguistic analysis (Hickok and Poeppel, 2007; Friederici, 2012; Bornkessel-Schlesewsky and Schlesewsky, 2013; Hagoort, 2017), and Corina et al. (1999) concluded that left IFG is critically involved in sign language production. Precentral regions have been proposed to be involved in the processing of movement of sign language (Emmorey et al., 2014). However, in recent meta-analytic work on both signed and spoken language, motor regions have been reported to be invoked also by linguistic processing (Walenski et al., 2019; Trettenbrein et al., 2021). In the dual-stream model proposed by Hickok and Poeppel (2007), left IFG and premotor cortex are included in the dorsal language stream, which also includes temporoparietal junction regions. In speech, this stream is assumed to integrate language representations with motor representations, and it is therefore critical for language development. The STS-SRT task involves the forming of linguistic output, and our finding might thus be interpreted as support of the idea that left IFG and sensorimotor regions work together to support integrative language processes. In extension, our finding suggests that the proposed neurocognitive underpinnings of spoken language production might apply also to sign language production. This is not to say that all neurocognitive mechanisms are shared across language modalities (cf., Evans et al., 2019), but as suggested by many before us (e.g., Cardin et al., 2020a; Rönnberg et al., 2021; Trettenbrein et al., 2021), we believe that mechanisms are not unique.

Our results point to that the intrinsic connectivity between left IFG and left sensorimotor regions is sensitive to sign language proficiency and might be stronger in individuals with poor

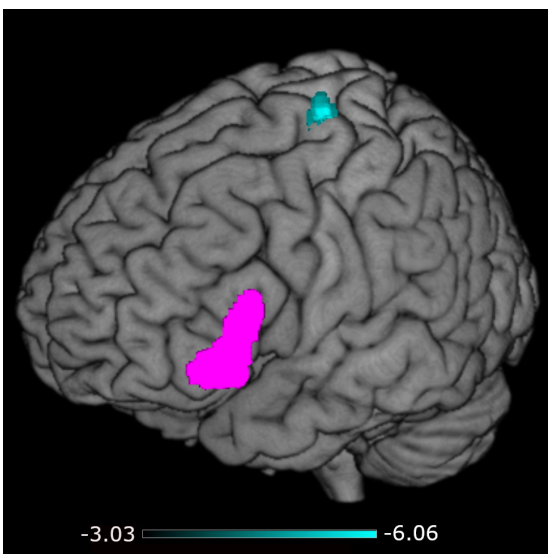


FIGURE 1 | Connectivity from the left inferior frontal gyrus (seed in pink) to the cluster in sensorimotor regions (in cyan). The color map indicates the strength (as *t*-values) of connectivity within the cluster.

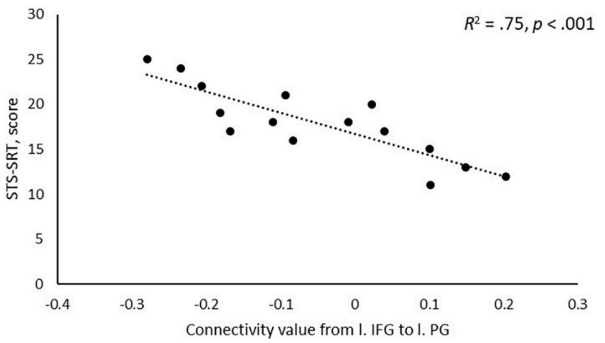


FIGURE 2 | Scatterplot of the association between performance on Swedish Sign Language Sentence Repetition Task (STS-SRT; score on *y*-axis) and resting-state functional connectivity (connectivity value on x-axis) between the seed in left inferior frontal gyrus (l. IFG) and the peak in left precentral gyrus (l. PG).

language skills as compared to better skill. Flinker et al. (2015) reported that the left inferior frontal region (Broca's Area) is typically not co-activated with motor regions in language production. Instead, when activation goes up in motor regions during production, activation in Broca's Area goes down, and when activation increases in Broca's Area in pre-articulatory stages, motor regions are relatively silent. As displayed in **Figure 2**, individuals with stronger sign language sentence reproduction skill tend to have negative intrinsic connectivity between left inferior frontal and sensorimotor regions, whereas individuals with worse skill have positive connectivity between these regions. Thus, intrinsic positive functional connectivity between these regions in deaf adults might be a marker of a language network that is sub-optimally (dis)-integrated, and this might be what we see evidence of in the present study. Proficiency is linked to different developmental trajectories, and the idea that we propose here is thus loosely related to the notion that the dorsal stream is important for language development via input–output matching mechanisms (Hickok and Poeppel, 2007). Sub-optimized network integrity might mean that individuals with weaker proficiency use non-linguistic motor representations to compensate for poorly defined language representations, or that access to language-based motor representations requires greater involvement of language-control functions. Based only on the present study, any definitive conclusion is of course premature. Nevertheless, our results suggest that the strength of intrinsic connectivity between dorsal stream left inferior frontal and sensorimotor regions might be a marker of the level of ability to reproduce sign language sentences.

Individual Differences in Sign Language Proficiency and Functional Connectivity

Banaszkiewicz et al. (2021) reported a sign language-specific change in task-invoked connectivity between left IFG and left lateral superior occipital cortex in hearing adults who were beginning learners of Polish Sign Language. The task was a sign-based lexical decision task (deciding whether visually presented signs were real or not), which represents an intermediate level of linguistic processing compared to the behavioral measures used in the present study. In our case, we saw a connection that suggests an effect related to effective perception-production processing (the STS-SRT), whereas the results reported by Banaszkiewicz et al. (2021) might reflect improved effectiveness of a perception-identification interface. Another important difference is that Banaszkiewicz et al. (2021) investigated task-based connectivity and not rsFC. Despite the methodological differences between the present study and the study by Banaszkiewicz et al. (2021), both studies suggest that the left IFG might be a critical node in functional networks related to sign language proficiency. How this region is connected functionally and structurally to other regions of the brain should thus be further studied in relation to (sign) language proficiency in future research. To our knowledge, no previous study has investigated task-based functional connectivity in relation to different types of sign language processing skills. Such a study could reveal, by experimental manipulation, what the rsFC-behavior associations revealed in the present study reflect.

In contrast to Li et al. (2013), which was the only previous study on rsFC-behavior associations including deaf participants that we found, we did not see that rsFC within the STG was associated with language proficiency. Although Trettenbrein et al. (2021) noted that the STG might not respond to linguistic sign-based stimuli *per se*, the broader literature indicates that this region is involved in language processing (Hickok and Poeppel, 2007; Friederici, 2012; Bornkessel-Schlesewsky and Schlesewsky, 2013; Cardin et al., 2020a). The lack of statistically significant associations between any of our behavioral measures and connectivity from this region might thus be surprising, although different methodology across studies is a likely explanation. The previous study most like the present study, conducted by Li et al. (2013), reported a correlation between story writing ability and connectivity between right middle superior temporal sulcus and left superior temporal sulcus/STG. Li et al. (2013) did however not observe any statistically significant association between their measure of language skill and rsFC from the superior temporal cortex to other regions of the brain. The lack of similar associations in the present study and the study by Li et al. (2013) might be explained by that the type of language skills investigated were different, or that different seeds were used in the analyses. In the present study, we used the posterior STG language network nodes in Conn as our seeds. This seed is relatively large, and it might therefore be difficult to capture meaningful connectivity in a small sample. On the other hand, using a pre-defined seed makes the design more transparent and facilitates replication. Both we and Li et al. (2013) failed to find that inter-regional rsFC from the STG predicts language skill in deaf adults, and it might be the case that it does not. However, a future study aiming at capturing this might fare better than us by including a larger sample and more precisely delineated seeds.

Since the connectivity observed here is based on rsFC, that is, co-activation between brain regions when the participants have no specific task to perform, the associations between regions are not invoked by a language task and therefore might not have anything specific to do with language processing. As mentioned earlier in the Discussion, one risk with a small sample is that findings are random. We tried to minimize the risk for this by restricting the number of statistical tests we performed. However, we also wanted to maximize statistical power and therefore applied a liberal approach when correcting for multiple statistical tests. Since the one association that we saw fits reasonably well with the existing literature, we believe that it is a meaningful association. At the same time, it does probably not represent the only relevant association. Based on previous empirical findings (Trettenbrein et al., 2021) and theoretical considerations (Hickok and Poeppel, 2007), we selected four language-relevant nodes as our seeds, but several potentially relevant regions were not included (e.g., supramarginal gyrus, anterior temporal regions, lateral occipital cortex). Another limitation is that we were only able to detect effects that were strong. This is reflected in the effect sizes of observed statistically significant effects, ranging from R^2 0.75 to 0.87. Thus, in addition to the risk of finding random association, the small sample we included

also carries a risk of missing out on meaningful effects that are small in magnitude.

Our results indicated an association between only one of the behavioral measures and rsFC. This might be because the measures tap onto different aspects of linguistic processing, or that task demands differ. We cannot determine whether the results we see are driven by a specific linguistic skill, or by any other skill or task-dependent factor. C-PhAT is performed by mentally converting orthographic input to sign-based representations, and then comparing representations before a decision is made explicit by a timed button press. In the STS-SRT task, on the other hand, the participant views and repeats a sign language sentence, with no further decision to make. The STS-SRT demands that a sentence is produced and the C-PhAT includes covert production of signs, as the individual mentally represents handshapes and compares them. Additionally, the STS-SRT includes phonological, lexical, and syntactical knowledge-structures, combined into a coherent expression, whereas C-PhAT taxes isolated phonological processing ability, and, given its design, orthographic-phonological mapping. On top of this, the STS-SRT has a social component (i.e., viewing another person producing a sentence) that the C-PhAT does not. Taken together, it is difficult to identify a specific origin of differences in associations observed between these tasks. We saw that better performance on C-PhAT had a positive association with non-verbal cognitive ability, and we controlled for scores on the Visual Puzzles task in connectivity analysis on C-PhAT. Thus, the influence of general cognitive factors in the association for that task was controlled for. We did not make the same control for STS-SRT, since no association with non-verbal cognitive ability was observed and adding a covariate to the analysis would then only reduce statistical power. However, non-linguistic processing skills might explain the observed relationships and differences in associations between tasks in the present study. In summary, our study has some methodological issues that future studies should correct, including the small sample size and the selection of seeds. In addition, future work should also carefully consider which behavioral measures to include. However, given that the studied population is a unique group and our approach here is novel we believe that the present findings represent an important contribution to the field.

Both structural and functional plasticity as a result of deafness and sign language use has been reported in the literature (Sadato et al., 2004; Cardin et al., 2013, 2018; Olulade et al., 2014; Ding et al., 2015; Twomey et al., 2017; Benetti et al., 2018; Trumpp and Kiefer, 2018; Bonna et al., 2020; Finkl et al., 2020; Andin et al., 2021; Dell Ducas et al., 2021; for reviews see Alencar et al., 2019; Cardin et al., 2020b). Thus, brain connectivity patterns that underlie linguistic operations in deaf sign language users might not be the same as for hearing individuals who use speech (or sign language). In our design, we did not compare across groups and previous studies on hearing individuals with a similar design as the present study are lacking. Although the general pattern of the available studies is that there is a great deal of overlap in the neural underpinnings of language processing regardless of modality (Walenski et al., 2019; Cardin et al., 2020a; Trettenbrein et al., 2021), a few regions might be modality-specific (Trettenbrein et al., 2021) and differences might exist at a form-based representational level (Evans et al., 2019). In addition, the type of linguistic operation might interact with modality effects. Studies with a design that allows for comparisons across language modality and different types of linguistic tasks are well needed to improve our understanding of how language processing is represented neurally, both in terms of modality–specificity and modality–generality.

CONCLUSION

Intrinsic functional connectivity between inferior frontal and sensorimotor cortical regions is associated with accurate sign language reproduction. This suggests that the cortical interaction at rest between dorsal language stream regions might be a marker of sign language proficiency, and more specifically the ability to reproduce sign language. Development of sign language skill might be determined by brain connectivity, or language development might form the connectivity between brain regions.

DATA AVAILABILITY STATEMENT

Data is provided by the first author upon request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Regional Ethical Review Board in Linköping (Dnr 2016/344-31). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

EH and JA conceptualized and designed the study, collected data, and performed data analysis. KS scored performance on the STS-SRT. All authors were involved in the interpretation of results as well as preparing and finalizing the manuscript after a draft was prepared by EH.

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Argument and Verb Meaning Clustering From Expression Forms in LSE

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Languages use predicates and arguments to express events and event participants. In order to establish generalizations concerning the variety languages show regarding the strategies for discerning some arguments from the others, the concept of roles—and, particularly, macroroles, mesoroles, and microroles—associated with participants provides a widely studied starting point. In this article, the formal properties in the arguments of a set of 14 verb meanings in Spanish Sign Language have been analyzed. Arguments have been studied by considering their microroles, and a quantitative method for measuring distances from a plurality of properties has been adopted. The novelty of this analysis is that it focuses on how arguments group in terms of these properties. Subsequently, some generalizations justifying why some verb meanings have a tendency to associate with certain forms of argument expression are highlighted in this study.

Keywords: valency, argument, micro-role, verb meaning, clustering, Spanish Sign Language

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INTRODUCTION

This study deals with expression strategies used to distinguish participant roles in Spanish Sign Language (LSE) and has as its main goal to compare arguments of different verb meanings and to cluster them according to those strategies.

It is assumed that, in every language, it is possible to talk about events involving one or more participants. This is usually made by means of verbs used to predicate something about one or more arguments, i.e., people or things typically referred to by means of nouns. Argument structure, the set of constructions consisting of a predicate and the arguments depending on that predicate, is a core topic in (almost) every linguistic approach. However, relatively little research has been conducted on argument structure in sign languages. Each participant in a particular event performs a different role (microrole); for example, in an eating event, there is an "eater" microrole and a "food" microrole; in a breaking event, there can be a "breaker" and a "broken thing." Microroles are, thus, event-specific; although they can be generalized across different event types at different levels of abstraction. For example, the "eater" and the "breaker" have in common that they can volitionally initiate the event; so they are both a so-called "Agent." Labels of this kind are known as *semantic roles*, thematic roles, case roles (Fillmore, 1968), or mesoroles (Hartmann et al., 2014). At the higher level of generalization, some concepts, such as macroroles (Van Valin, 2004), proto-roles (Dowty, 1991), and the typological comparative concepts A, S, and P (Comrie, 1981; Haspelmath, 2011), have been formulated to capture the commonalities among different one-participant or two-participant events.

Languages differ in the coding strategies (morphosyntactic forms) used to distinguish participant roles in an event, but in general, these expression strategies can be classified into

three main types (Haspelmath and Hartmann, 2015): (1) word order; (2) "flagging," which subsumes case marking and adpositions; and (3) "indexing," which subsumes person agreement or cross-referencing in the verb (cf. Haspelmath, 2013).

Signed languages, like any other language, also have strategies to refer to participants and their roles in an event, but the different modality (associated with the pervasive use of space, iconicity, and simultaneity) implies many relevant differences with spoken languages in the coding of argument structure (Geraci and Quer, 2014; Oomen, 2017; Kimmelman, 2022): "Flagging," i.e., case-marking and adpositions, is (almost) absent in signed languages for the coding of core arguments. Word order is relevant in signed languages, but only a subset of arguments is referred to in discourse by means of an "independent" noun or pronoun sequentially placed before or after the verb. Many are left implicit (the referent being recoverable from context) or expressed somehow in simultaneity with the verb using indexing, classifiers, or role-shifting. Argument "indexing" (i.e., "agreement") in spoken languages may have an analogous equivalent in many signed languages, which is known as agreeing or indicating verbs. These verbs have a path movement and use locations in the signing space so that the initial place of articulation matches the locus of an argument, whereas the final place aligns with the locus of a second argument. Some linguists analyze this as verbal agreement (Lillo-Martin and Meier, 2011) although some other researchers contest the validity of the parallel between spatial modification in sign languages and verbal agreement in spoken languages (Liddell, 2003; Schembri et al., 2018). We treat these phenomena as indexing and talk of "indicating" verbs. Classifier or depicting predicates are non-conventionalized (partly lexical) complex signs that include a handshape (a "classifier") specifying a class of objects (e.g., an animate entity) and a movement depicting the sort of movement this entity performs in space (Supalla, 1986; Cuxac, 2000; Schembri, 2003; Morgan and Woll, 2007).[1] Finally, facial expression and other non-manual components may be used in what is known as constructed action and role-shift, in which the signer is depicting the actions of a referent (Janzen, 2008; Cormier et al., 2013; Ferrara and Johnston, 2014); then, the role-shift becomes an additional device to refer to a participant in an event.

The morphosyntactic expression of arguments has served as the basis for the traditional classification of verbs in sign languages into three main types (Padden, 1988): agreement verbs, spatial verbs, and plain verbs. Other classifications (Oomen, 2020) distinguish between agreeing, classifier, body-anchored, and neutral verbs. Oomen (2018, 2020) has also developed the hypothesis that verb semantics impact on sign language verb type similarly to how it affects case-marking for transitivity in spoken languages (Malchukov, 2005) and subsequently she applies a semantic map for transitivity splits to German Sign Language (DGS) data. As an alternative approach, we propose an inductive quantitative method for the verb classification.

So far, we have been avoiding terms like "subject" and "object." It is difficult to provide them with cross-linguistic valid definitions, but they are mainly used to refer to the first and second most prominent or core participants, as far as they can be identified in a given language by morphosyntactic properties, such as word order, case, or verbal agreement. However, the distribution of these properties is language-specific and leads to different alignment systems.[2] As for signed languages, it is also difficult to find constant morphosyntactic properties that consistently identify grammatical relations such as "subject" and "object." Agreeing or indicating verbs are only a subset of the verb inventory, and even with them, the path movement associated with core arguments (reportedly "subject" and "object") is not always obligatory. Nevertheless, Meir et al. (2007) defend an association of the subject with the signer's body ("body as subject"). Their research based on data from American Sign Language (ASL) and Israeli Sign Language (ISL) defends the hypothesis that, in sign languages, the body is generally associated with the single argument of mono-actant verbs and, in the case of bi- and tri-actant verbs, it is the agent argument, or the most similar to the agent, the one expressed with reference to the body (Meir et al., 2007, §. 4.1). If this is indeed the case, these arguments will tend to use expression strategies based on the signer's body. In particular, indicating may point to the body even if it does not refer to the signer, and reference may be accompanied by constructed action and role-shifting.

Instead of taking semantic roles and grammatical relations as a starting point, Hartmann et al. (2014) proposed comparing languages at the level of the participant roles of individual verb meanings (microroles) and identifying semantic role clusters by studying cross-linguistic coexpression tendencies, i.e., the ways in which the individual microroles cluster with respect to their coding across a range of diverse languages. In particular languages, coding properties cluster arguments around specific regions of the semantic space, but "subject" and "object" are not used in that work as cross-linguistic categories. The valency patterns database ValPaL (Hartmann et al., 2013) is also built around verb meanings, microroles, and coding strategies in several dozens of languages.

In this study, we took microroles as the starting point and compared them by studying non-cross-linguistic but intra-linguistic coexpression tendencies in LSE. The main reason for doing so is the variability in discourse. None of the expression strategies (word order, indexing, role-shifting, etc.) used to refer to arguments is obligatory in continuous discourse, not even for verbs and arguments of a particular type. Consequently, we proposed analyzing the discourse distribution of expression strategies for individual arguments. For a selected set of 14 verb meanings, we observed, in an LSE corpus, the expression strategies used for each argument and then identified semantic role clusters of microroles that tend to be coexpressed, i.e., that

[1] Cuxac (2000) offers a very detailed description of these forms of signed discourse from the perspective of the semiogenesis of language. He calls them "structures of great iconicity." This approach includes manual and non-manual articulators, with special attention to the function of the gaze as an iconizing resource. This semiogenesis theory situates the most iconic forms of sign languages in the focus of the attention.

[2] The term alignment refers to coexpression patterns between core arguments, i.e., which arguments use the same argument markers (flag or indexes). For example, an ergative system coexpresses S and P and uses a different marker to signal A arguments (cf. Haspelmath, 2011).

are prone to be expressed using similar strategies: independent noun, preposed or postposed to the verb, use of role shifting, classifiers, and indexing.

Our analysis and methods are inspired by the concept of "Behavioral Profile" (Divjak and Gries, 2006, 2009; Gries, 2010), a corpus-based quantitative approach to semantics, which assumes a strong correlation between semantic and distributional properties. The method consists of coding every particular corpus instance of a linguistic unit (e.g., a verb meaning) in terms of morphosyntactic, syntactic, and semantic contextual characteristics. The resulting co-occurrence table is assessed by means of a hierarchical agglomerative cluster analysis so that units with a similar distribution are grouped together. The hypothesis is that similar distributions reflect similar meanings. Our method is different in that we analyzed and clustered not only lexical meanings (in our case, a set of verb meanings) but also the participant roles of the arguments of those verbs. In addition, the morphosyntactic features on which the cluster analysis will be based are the coding strategies used for every argument. The following sections present the data, methods, and results of this approach.

MATERIALS AND METHODS

This research has been conducted on an LSE corpus entirely recorded in the region of Vigo (Galicia, Spain). It consists of 24 video files analyzed with ELAN (ELAN (version 6.2), 2021). Its total length is almost 3 h 20 min (3:19:26 precisely), and it contains 7,570 tokens. These tokens have been analyzed as 2,777 clause-like units (CLUs), i.e., units that, as it happens with clauses traditionally identified with spoken languages, consist of a predicate and its arguments (Hodge and Johnston, 2014). This corpus includes 13 elicited narrations, 5 interviews, 1 episode of a web series recorded in Galicia with 4 deaf performers, and 2 files from other genres. Their distribution by length, tokens, and CLUs is specified in **Table 1**. Concerning the signing participants, there are 7 men and 4 women. Among them, 5 are in the age group from 55 to 69 years, and the other 6 are in the group from 40 to 54. All of them have been signing for at least 20 years, and the time of their first contact with LSE varies from their birth to when they were 17 years old (in 4 cases it was before they were 5, in 6 before 12, and in 1 after 12). The age of acquisition of the performers in the web series remains unknown.

Deaf signers and sign language (SL) interpreters (see "Acknowledgments") have collaborated in the glossing process in ELAN, whereas the grammatical annotation has been carried out by the authors of this study. For every one of the 2,777 identified CLUs, the following have been annotated in different ELAN tiers:

1. ID-gloss. We follow the proposal of Johnston (2010) to consistently use the same capitalized word for all the occurrences of a sign, regardless of whether they are inflected or not. An ID-gloss, therefore, represents the lemma of a sign.
2. Categories for each lexical (noun, verb, adjective, etc.) or partly lexical unit. Partly lexical units are those that are not listed in a dictionary but are part of the signed discourse (classifiers, deictics, buoys, or gestures).[3]
3. Predicate arguments, which have been tagged as A1, A2, A3, etc., depending on the semantic structure of each verb, i.e., in terms of microroles.
4. The locus, when relevant, e.g., in indicating verbs.
5. The animacy of the referent, i.e., whether it is human, animate non-human, or inanimate.

From these annotations, it has been possible to study for every argument in every CLU the expression strategies, which are detailed below.

From the abovementioned sample, we have selected all those CLUs that include a token with one of these 14 verb meanings**: carry**, **explain**, **give**, **go**, **help**, **leave**, **look**, **say**, **search**, **sign**, **speak**, **take**, **think**, and **throw.**[4] This selection was conducted based on frequency criteria (at least 13 occurrences of that meaning in the corpus). However, some frequent verbs were excluded. In particular, the lexemes START and WANT were not included, since they occur mostly in combination with other verbs, forming verb series or periphrases. WAIT2 was also excluded due to its nature of discourse marker, which renders the analysis of its verbal character doubtful. The distribution of the selected verb meanings among the different types of discourse is specified in **Table 2**.

The methodology of selecting the data by frequency has the consequence of ignoring some classes of verbs whose predicate is usually non-verbal, as it is the case of psychological verbs whose argument structure involves an Experimenter and a Theme, such as AFRAID, NERVOUS, and ANGRY (Oomen, 2017) or feeling verbs, such as FEEL-COLD or BE-ANGRY, which are built with a single participant (Oomen, 2018, 2020). Attributive, existential, or possessive constructions are also left out, with

TABLE 1 | Corpus distribution by the type of discourse.

Types of discourse	Token no.	CLU no.
Narrations	2963	1375
Interviews	2596	897
Elicited examples	1546	306
Drama (web series)	377	163
Other	88	36
Total	7570	2777

[3]The distinction between lexical and partly-lexical units is taken from Johnston (2010, p. 125). From the perspective of the semiogenesis of language (Cuxac, 2000), other authors prefer a distinction between lexical units and "transfer units" (cf. Sallandre and García, 2019).

[4]Given that the common convention in the literature on signing languages is glossing signs or sign lemmas in upper-case letters, this article uses the boldface format to specify verb meanings. Those expressions referring to classifying predicates are written in lower-case non-boldface letters, as they are not lexemes. In the case of lexeme glosses, numbers have been used to tag different lemmas with the same meanings; if a meaning specification needs to be included, it has been added after a full stop. The annotation in the classifiers provides information on the type of classifier (cl.e, entity classifier), and the hand configuration is indicated in brackets (2f, 2 fingers; Bh, horizontal B hand). AH stands for "active hand" and PH for "passive hand." See example B in **Figure 1**. Pertinent locations have been signaled with sub-indexes: 1 for the signing person; a and b for locus in different positions of the signing space.

peculiar characteristics in sign languages (Herrero and Salazar, 2003; Zeshan and Perniss, 2008).

These verb meanings can be expressed through a single lexical form, as is the case with **help,** which is conveyed in the sign HELP. Nevertheless, in some cases, they are linked to two lexemes, such as the meaning of **go**, which has two lexemes: GO and GO2. We also have examples of a same meaning materializing through a lexical form (LEAVE) or through a classifying predicate (partly lexical form): *leave*. See **Figure 1** for examples of a lexical (A) and partly lexical (B) forms. Undoubtedly, the fact that a verbal meaning is expressed through a lexical or partly lexical unit ("transfer units" in Sallandre and García, 2019) has consequences in the distribution of its arguments, as seen in the analysis of the results. In particular, it is characteristic of descriptive constructions (partly lexical) that one of the arguments is incorporated in the classifier predicate. Note that the term "partly lexical" warns that these units are not conventional, which does not mean that they do not follow certain formative patterns.

Every verb meaning denotes a type of situation with one or more intervening participants, each of them with a specific role (microrole). In the following lines, these 14 verb meanings are presented, together with the participants involved in each event type. Microrole labels, but not numbers, are taken from ValPaL (Hartmann et al., 2013). A total of 34 different argument roles (microroles) has been observed:

- **Carry** A1: carrier—A2: carried thing—A3: carrying goal.
- **Explain** A1: explainer—A2: explained content—A3: explaining addressee.
- **Give** A1: giver—A2: gift—A3: giving recipient.
- **Go** A1: goer—A2: going goal.
- **Help** A1: helper—A2: helpee.
- **Leave** A1: leaver—A2: left place/person.
- **Look** A1: looker—A2: looked at entity—A3: looked at place.
- **Say** A1: sayer—A2: said content—A3: saying addressee.
- **Search** A1: searcher—A2: searched for thing—A3: search location.
- **Sign** A1: signer.
- **Speak** A1: speaker.
- **Take** A1: taker—A2: taken thing—A3: taking source.
- **Think** A1: thinker—A2: thought content.
- **Throw** A1: thrower—A2: thrown thing—A3: throwing goal.

TABLE 2 | Frequency of the selected verb meanings by discourse type.

Verb meaning	Drama	Elicited ex.	Interview	Narration	Other	Total
Carry	0	4	6	3	0	13
Explain	1	3	7	8	0	19
Give	0	14	4	12	0	30
Go	1	3	7	10	1	22
Help	1	9	0	10	0	20
Leave	0	1	0	39	0	40
Look	0	16	14	109	0	139
Say	1	7	11	3	7	29
Search	1	7	1	30	0	39
Sign	1	0	30	0	0	31
Speak	0	3	34	0	0	37
Take	3	12	0	77	0	92
Think	2	6	6	9	0	23
Throw	0	6	0	9	0	15
Total	11	91	120	319	8	549

The indexes A1, A2, and A3 are specific for each verb, and they are theoretically arbitrary. Therefore, there should not be anything in common between, for example, the second argument in **help** and that of **search.** Nevertheless, the indexes are motivated by the prominence and relative frequency of each argument, so that, for example, all the agents are A1 (but not all the A1 are necessarily agents). Thus, A1 is the first candidate to become a subject, whereas A2 and A3 are, in principle, candidates to become an object. However, in many languages, the subject and object syntactic functions are characterized by presenting relatively constant expression forms (order, case, agreement, etc.). As explained in the following lines, the expression forms of these arguments in LSE are quite variable. The aim of this study is to find common expression patterns between different verb arguments within our data on the assumption that their expression similarities are semantically motivated.

All the examples registered in the corpus—from the annotated files in ELAN—for these 14 verb meanings (a total of 549 CLUs) together with the properties of their arguments have been extracted. The data have been reorganized in a 1,096-row and a 10-column table, in which rows show the arguments of every CLU and columns their varying expression properties. **Table 3** summarizes the frequency of verbs and arguments. The index numbers identifying each microrole are theoretically arbitrary.

The 10 variables in the dataset are Verb_meaning, MicroRol, Genre [=type of discourse], Animacy, Independence, Order, Role-shift, Classifier, Indexation, and Indexation locus. The first two variables are the ones that are described and used as clustering criteria for the data; genre and animacy are control variables; and the rest of them describe the expression strategies for every argument.

Six variables have been studied:

1. "Independent expression (indep)": it is observed if there is an overt expression of an argument. There are three possible values: *L* (lexical element or pronoun), *0* (implicit or incorporated in the verb), or *X* (undetermined [e.g., reported speech]).
2. "Position of the independent elements (order)": depending on whether an argument is placed before or after the verb, with four values: *a* (anteposition), *p* (postposition), *s* (sandwich, between two verbs), and *NA* (non-applicable [=not independent]).
3. "Role-shift (R)": there is constructed action, and it reproduces the actions, thoughts, or locutions by the referent of a specific argument. The values are *R* (Role-shift applicable to the argument referent) and *0* (no role-shift).
4. "Classifier (cl)": the argument in question takes the form of a manual classifier, in the active hand or in the passive hand, with three values: *cld* (active hand classifier), *cli*

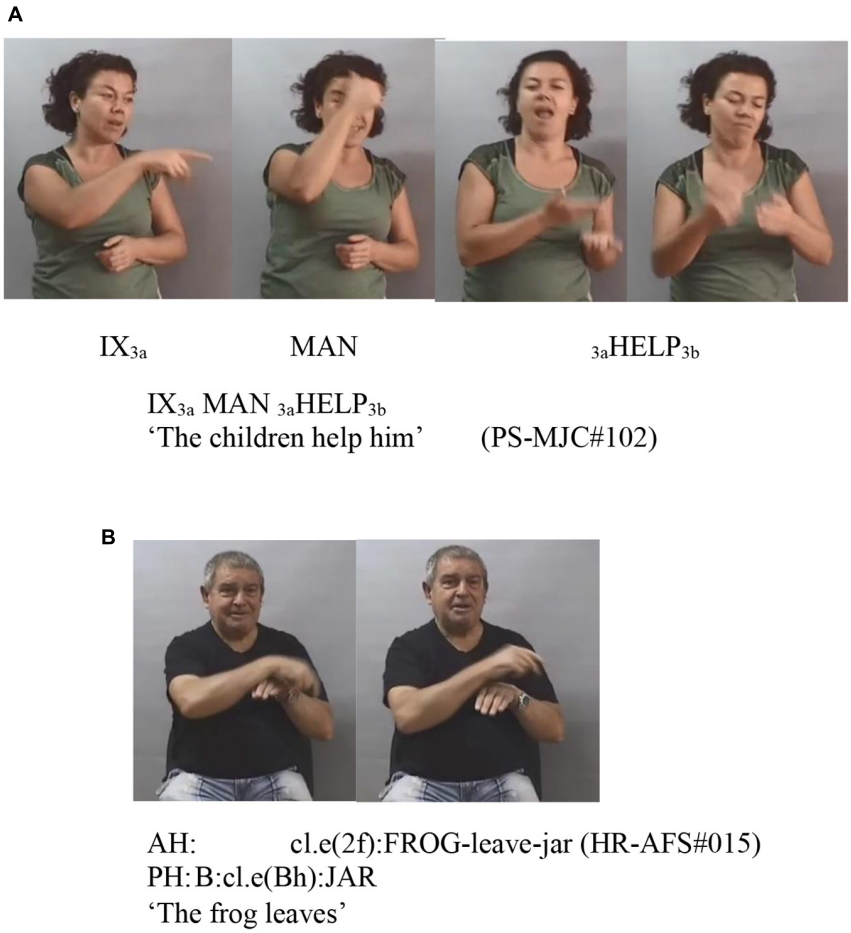


FIGURE 1 | Examples **(A,B)**.

(passive hand classifier), and *0* (no applicable classifier for this argument).

5. "Indexation (Idx)": it marks the initial or final location of the agreement verbs, with four values: *l1* (initial locus of movement), *I2* (final locus of movement), *I1/I2* (initial and final locus [reciprocal]), and *0* (no indexation, no verbal inflexion for agreement).
6. "Indexation locus (ILocus)": indexation is produced in the signer locus or in a distal location, with the values: *s* (proximal location [in the signer's body]), *n* (distal location [not in the signer's body]), and *NA* (non-applicable [no indexation]).

The value levels for each of these variables have been gathered in **Table 4**, together with their frequency.

This dataset has been analyzed using the hierarchical agglomerative cluster (HAC) analysis. This is a family of methods used to identify and represent (dis)similarity relations between different items on the basis of the variables that characterize the items. In our case, we analyze first the (dis)similarities between the 34 argument roles and, after that, the (dis)similarities between the 14 verb meanings. In both cases, the relative frequencies of each expression strategy function as the variables used to build the similarity

TABLE 3 | Frequency of verb meaning and arguments.

Verb meaning	N_CLU	A1	A2	A3	Total_args
Carry	13	13	13	10	36
Explain	19	19	15	18	52
Give	30	30	29	30	89
Go	22	22	19	0	41
Help	20	20	20	0	40
Leave	40	40	21	0	61
Look	139	139	117	22	278
Say	29	29	28	13	70
Search	39	39	32	7	78
Sign	31	31	0	0	31
Speak	37	37	0	0	37
Take	92	92	92	19	203
Think	23	23	12	0	35
Throw	15	15	15	15	45
Total	549	549	413	134	1,096

TABLE 4 | Analyzed descriptive variables and assigned values.

Variable	Values	Description	Frequency
Indep		Independent expression	
	L	Lexicon or independent pronoun	347
	0	Implicit or incorporated in the verb	702
	X	Undetermined (e.g., reported speech)	47
Order		Position of independent elements	
	a	Before the verb (anteposition)	250
	p	After the verb (postposition)	88
	s	Between verbs [sandwich constructions]	9
	NA	Non-applicable [=not independent]	749
R		Role-shift	
	R	Role-shift applicable to the argument referent	203
	0	No role-shift	893
Cl		Classifier	
	cld	Active hand classifier	117
	cli	Passive hand classifier	37
	0	No applicable classifier for this argument	942
Idx		Indexation	
	I1	Initial locus of movement	197
	I2	Final locus of movement	244
	I1/I2	Initial and final locus (reciprocal)	8
	0	No indexation	647
ILocus		Indexation locus	
	s	Proximal location (in the signer's body)	151
	n	Distal location (not in the signer's body)	298
	NA	Non-applicable [no indexation]	647

matrix. All computations were carried out using R (R Core Team, 2020) following the steps reported by Divjak and Gries (2006, 2009) and Levshina (2015, chap. 15) to analyze behavioral profiles.

RESULTS

The proportion of appearance for the descriptive variables (**Table 4**) has been calculated for every argument of every verb. There do not seem to be obligatory expression strategies. Some expression procedures are certainly never used with certain arguments, but it is extremely rare that any of them happens in 100% of the cases.

For each of the values of every descriptive variable, we can order the arguments from those using these expression strategies in (almost) every case to those never using them.

As an example, a particular argument can be overtly expressed—either through a lexical or an indexical form (pronoun). As it has already been stated in the previous section, the data come from different types of discourse. Therefore, most of the examples are contextualized. As a result, a frequent discursive elision of verb arguments has been detected. This can be observed in **Figure 2A**, where those with the highest frequency rate in being expressed independently are the A3 of **carry**, the A2 of **go**, the A3 and the A2 of **throw,** and the A2 of **give**, i.e., locations and manipulated objects. However, the most frequent scenario with the majority of the arguments is they are not overtly expressed, but deduced from context by the non-manual expression (role-shift) or expression procedures incorporated in the verb (classifiers and indexation).

Computation of Distances and Clustering of Argument Roles

In order to calculate the "behavioral profile" for every argument, a co-occurrence table was construed by using the bp function of the RLing package (Levshina, 2015), which constructs behavioral profile vectors from categorical data, resulting in numeric vectors with concatenated proportions of each value in every variable in the data frame. **Table 5** is a partial sample of behavioral profile vectors. For example, the argument *A1.carry* ("carrier") is left implicit 77% of the times (indep.0 = 0.77) and lexically expressed 23% (indep.L = 0.23), and when lexically expressed, it is always preposed to the verb (order.a = 1.0).

If the values of two rows in the behavioral profiles table were identical, then we would say that the distance between arguments equals to 0. Otherwise, we can compute the distance between each pair of arguments. The more dissimilar their vectors, the greater their distances. The distance matrix is used to amalgamate the items exhibiting the highest similarity and successively amalgamate the resulting clusters until all clusters have been amalgamated. The resulting structure is typically represented by a dendrogram, i.e., a tree with all objects as leaves or branches.

The clustering algorithm is contingent on two important settings: (1) the measure of (dis)similarity and (2) the amalgamation strategy. Distances can be computed in R with the function dist() using different methods. We have chosen the "Canberra" method, which is more sensitive to differences between small values near zero. There are also different strategies of amalgamation, and we use the method "Ward.D2," which usually produces compact and interpretable clusters (cf. Levshina, 2015, p. 306–312). **Figure 3** depicts the clustering of verbs arguments in several hierarchical levels, representing the distances between the different items and clusters.

The optimal number of clusters can be determined by the so-called average silhouette width (ASW). However, in this case, such a method does not provide clear-cut results, the highest value (ASW = 0.23) corresponding to 15 clusters. This can be interpreted as an additional clue for the continuous nature of argument expression strategies. However, the observation of the dendrogram shows four relatively consistent clusters (ASW = 0.16). These four clusters have been highlighted in **Figure 3**. The relative distances between the members of the selected four clusters can be best perceived in a scatterplot (**Figure 4**), where intersections between groups 1 and 2, on the one hand, and groups 3 and 4, on the other hand, can be observed.

The following step in cluster analysis is to identify which of the variables drive the clustering, i.e., where the differences between clusters are. For each of these four groups, we calculate which properties show higher average proportions for every cluster in contrast with the others, and we select the features where the difference between proportions is the highest.

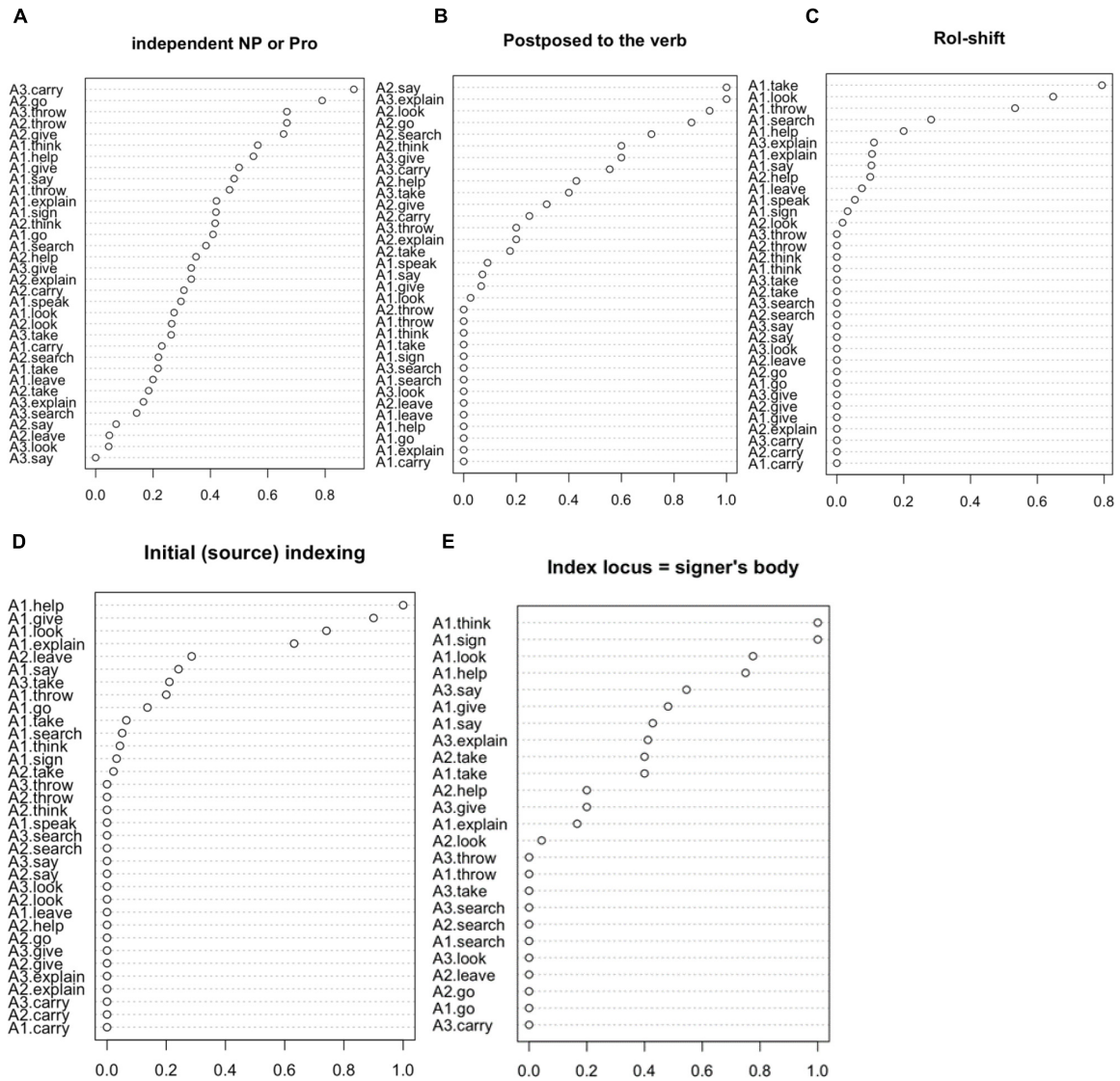


FIGURE 2 | Proportion of arguments expressed according to descriptive values.

TABLE 5 | A partial sample of the table with behavioral profiles of arguments.

	indep.0	indep.L	order.a	order.p	order.s
A1.carry	0.77	0.23	1.00	0.00	0.00
A2.carry	0.69	0.31	0.50	0.25	0.25
A3.carry	0.00	0.90	0.44	0.56	0.00
A1.explain	0.58	0.42	1.00	0.00	0.00
A2.explain	0.40	0.33	0.80	0.20	0.00

The numbers indicate proportions (between 0 and 1) of the given feature.

Cluster 1 consists of all the A1s (minus that of **leave**, which is in cluster 4). In addition, it includes the A2 of **throw**. These may be perceived as an anomaly, given the uniformity of the rest of the members of this cluster. The main features of these arguments are the following:

- Frequency of overt expression slightly above average (indep.L + 0.12)[5] and, in this case, clear preference for anteposition (order.a + 0.45).
- Initial indexation (Idx.I1 + 0.28) localized in the signer's body (ILocus.s + 0.31).
- Above-average use of role-shifting (R.R + 0.10).
- Use of classifiers less than average (cl.0 + 0.17).

Cluster 2 is composed by the A2s of **give**, **say**, **explain**, **carry,** and **think**. These are about given or carried objects and about what is said, explained, or thought. These are characterized by the following features:

[5]These abbreviations correspond to variables and values described in **Table 4**. The figures convey the difference between the average proportions of the cluster minus the average proportions of the remainder clusters.

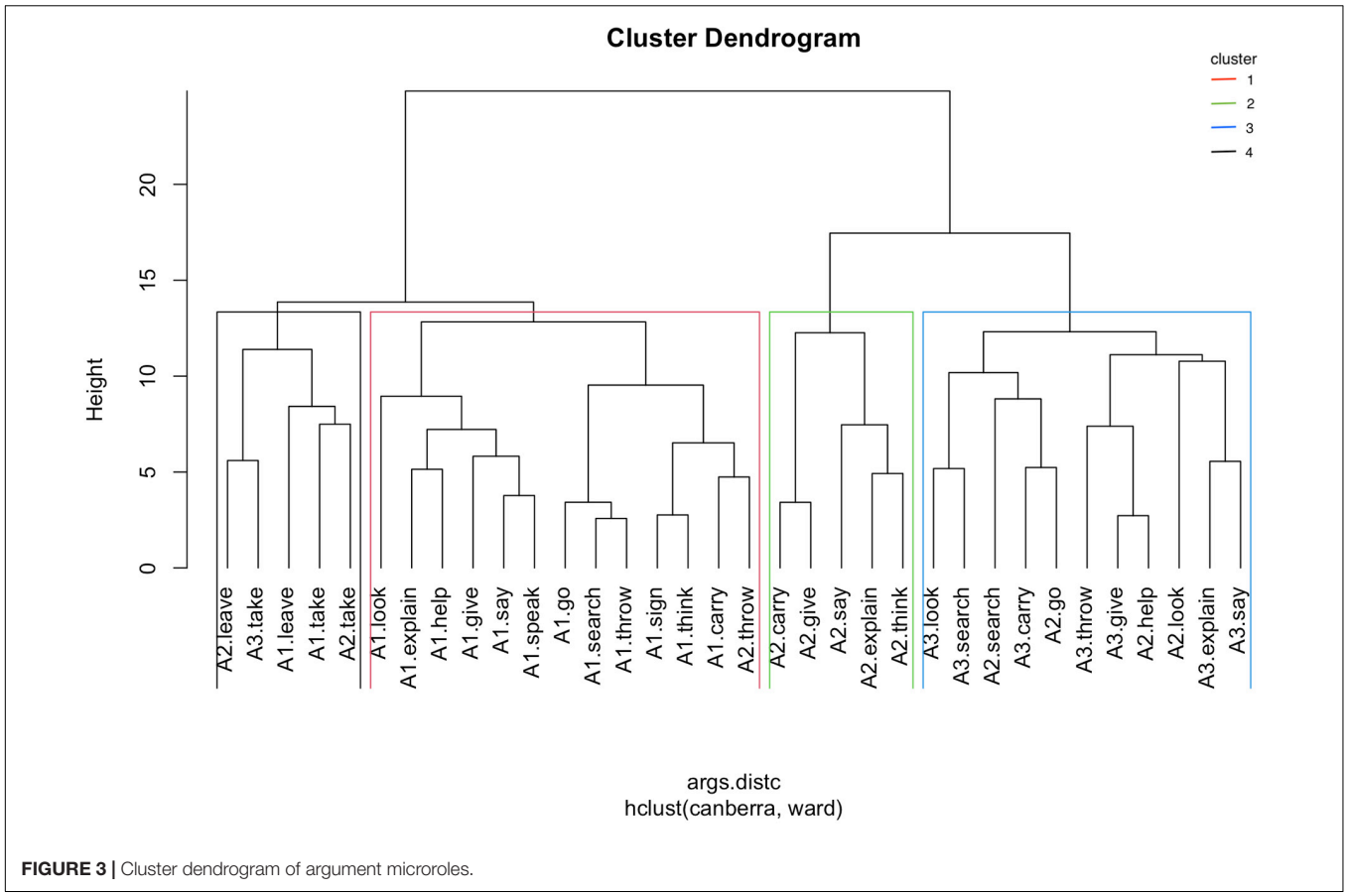


FIGURE 3 | Cluster dendrogram of argument microroles.

- These arguments are usually not indexed (Idx.0 + 0.48).
- Indeterminate order: propositions and reported speech have been analyzed as independent clauses; hence, it is difficult to specify their order as arguments of a predicate (indep.X + 0.34), but when they are lexical elements, there is preference for the post-verbal position (order.p + 0.25).
- Slightly above-average use of classifiers (cl.cld + 0.09).

Cluster 3 consists of arguments sharing the trait of being the destination of a movement (A2 of **go**, A3s of **carry** and **throw**, and A3 of **search** and **look**) or the recipient of a transfer action (A3 of **give**, **say,** and **explain**; A2s of **look** and **help**). The A2 of **search** (an object) also belongs in this group. These are characterized by the following features:

- A clear association with final indexation (Idx.I2 + 0.80) with a preference for expressing locus different from the signer's body (ILocus.n + 0.26).
- Preference for postposition (order.p + 0.39) when it is an independent expression.
- Less than average use of classifiers (cl.0 + 0.14) and role-shifting (R.0 + 0.10).

Cluster 4 gathers all the arguments of the verb meanings **leave** and **take**, which in LSE are (almost) always descriptive verbs.

- The arguments in these two verbs are expressed through classifiers (cl.d + 0.27, cl.i + 0.25, cl.0 −0.52).
- As a consequence, seldom are they expressed through lexicon (indep.0 + 0.29) or indexation (Idx.0 + 0.27).
- When they are lexically expressed, there is preference for the pre-verb position (order.a + 0.21).
- Usage of role-shifting slightly above average (R.R + 0.10), due to its use with A1 (but normally not with A2).

In the dendrogram in **Figure 3**, a hierarchically inferior level with a total of 7 clusters, subdividing three of the four main clusters, is perceived. Therefore, the so-tagged cluster 1 shows a separation between, on the one hand, the A1 of **look, help, explain, give, say,** and **speak** and, on the other hand, the A1 of **go, throw, search, think, sign,** and **carry**. At first glance, it does not seem like a consistent division.

Concerning the previous cluster 2, two types of objects it used to gather can be separated: the A2s of **give** and **carry**, on the one hand, and the A2 of **say**, **explain,** and **think**, on the other hand. These can refer to propositions or reported speech.

Regarding the previous cluster 3, there is a division, broadly speaking, between the A3 and the A2 referring to places and those acting as recipients of actions. In this case, the A3 of **throw** does not behave as expected, since it clusters with the recipients and not with the destinations.

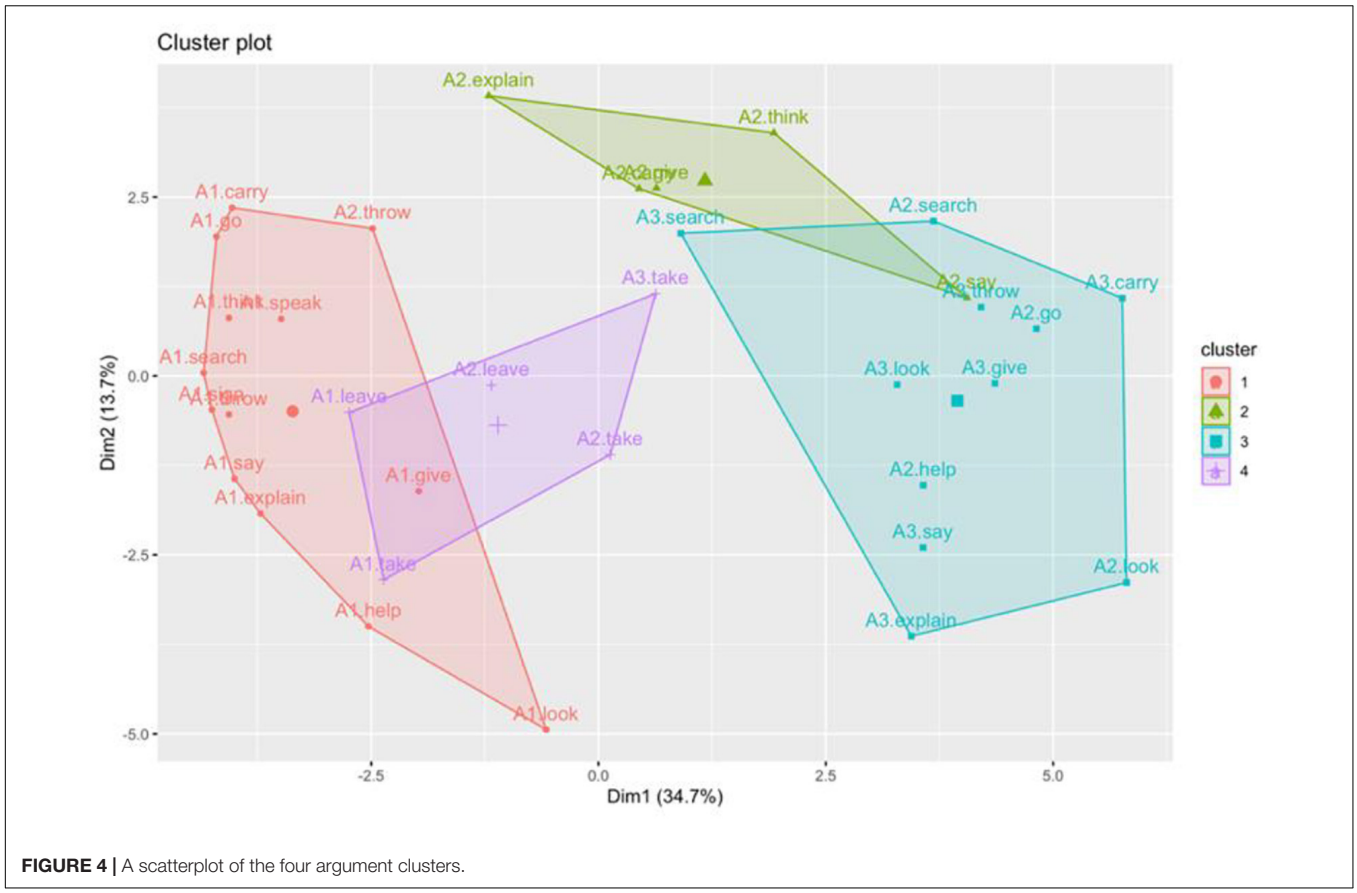


FIGURE 4 | A scatterplot of the four argument clusters.

Computation of Distances and Clustering of Verb Meanings

The same method used to obtain the argument clusters has been subsequently applied to calculate the properties and clusters of verb meanings. Given that the arguments of every verb have different frequencies (see **Table 3**), the effect will be that the most frequent will be heavier in the verb's profile and, therefore, A1 will be heavier in one-participant verb meanings than in three-participant ones. **Figure 5** is the resulting dendrogram, where three groups have been highlighted for being the division with the highest ASW (0.202). The scatter plot of verb meanings shows clear distances between groups (**Figure 6**).

All the 9 verb meanings forming the first cluster (**give, carry, throw, go, look, help, search, say,** and **explain**) use space location procedures to express an argument that can equally represent a place (**carry, throw,** and **go**) or a recipient (**give, look, help**, **say,** and **explain**). The meaning of **search** always implies a place, regardless of what is being searched, an object or a person. Within this first group, there are two subgroups: one with **carry, give, throw,** and **go**, consisting of movement predicates (literal or metaphorical). These present the following traits more often than other groups of verbs:

- Indexation oriented toward locus not equal to signer (ILocus.n + 0.35).
- Compatible with lexical expression (indep.L + 0.22), frequently in the post-verbal position (order.p + 0.16).

The other subgroup with indicating predicates (**look, help, say,** and **explain**) shows the following features:

- Initial indexation (Idx.I1 + 0.17).
- There is no use of classifiers (cl.0 + 0.16).
- Relatively frequent use of role-shift (R.R + 0.07).

The second cluster is formed by **think**, **speak,** and **sign**. What they share is they are usually realized in mono-argumental constructions (100% of the cases with **speak** and **sign**; 47.8% with **think**). From the rest of verb meanings, only **leave** shows a similar percentage of mono-argumental use (47.5%). Since they are all typically monovalent verbs, the properties of their set of arguments are those of A1:

- Rare indexation (Idx.0 + 0.40), but when it occurs, it mostly comes from the signer (ILocus.s + 0.79).
- Rare role-shifting (R.0 + 0.09).
- Overt expression slightly higher than average (indep.L + 0.05), with a preference for anteposition (order.a + 0.19).

The third cluster consists of the verb meanings of **leave** and **take**, which is consistent with the results from argument clustering. Both are expressed through lexical (LEAVE) and

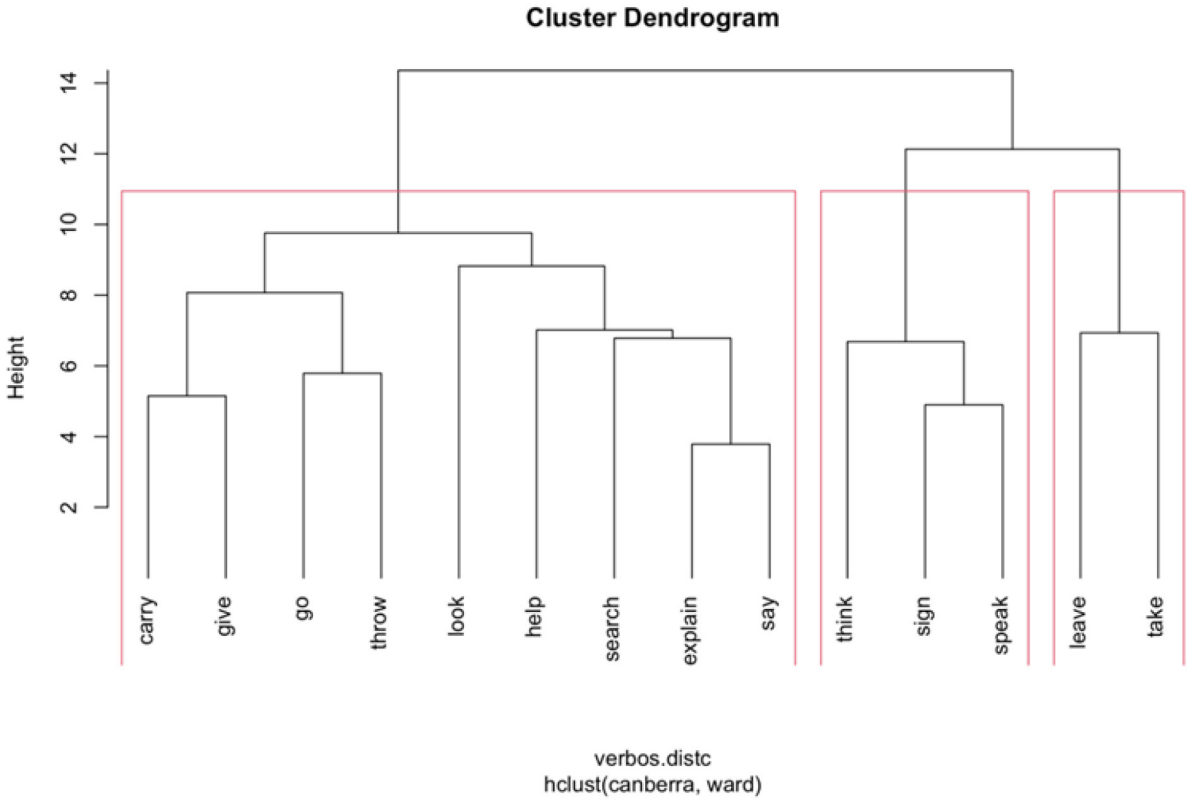


FIGURE 5 | Cluster dendrogram of verb meanings.

descriptive (*leave*) predicates. Hence, their dominant properties are:

- Expression of arguments through classifiers (cl.cld + 0.38, cl.cli + 0.14).
- Seldom are they expressed through indexation (Idx.0 + 0.27) or independent expression (indep.0 + 029).
- Role-shifting (associated with argument A1) (R.R + 0.12).

DISCUSSION

This section aims to justify the obtained results, and in particular, to contextualize the hereby presented trends. It also intends to explain the apparent anomalous data as far as possible.

Body as Subject

The arguments analyzed as A1 share the feature of referring to the most agentive participant of each verb or verbal meaning. Furthermore, in this sample, all of them are human (or, at least, animated). It can be, therefore, expected that most of them belong in the same group (**Figure 3**). The graph shows, however, a division between those A1s associated with meanings involving another participant and those which (mostly) do not indicate another argument or point a location. Among those from the first type, **talk** seems to be an anomaly, since **sign** belongs to the second group.

These results should be contrasted with the thesis by Meir et al. (2007) according to which the subject is identified with the body ("body as subject"). As it has been explained in Section 1, the authors defend the hypothesis that, in sign languages, the body is generally associated with the single argument of mono-actantial verbs and, in the case of bi- and tri-actantial verbs, it is the agent argument, or the most similar to the agent, the one expressed with reference to the body (Meir et al., 2007, §4.1). Even if this article does not discuss how the subject is expressed in sign languages (or if subject is or not an appropriate category for visuogestural languages), it can be assumed that there is a similarity between there hereby called A1 and the usual trend of the subject to be the most agentive and prominent argument. At least, it would be convenient to ask ourselves whether there is a *de facto* relationship between the A1 argument and the signer's body. The two following studied expression strategies allow the establishment of this relationship:

- The initial indexation parameter (i.e., initial locus for movement, see **Table 4**) identifies mostly A1s. Moreover, some of the highest values of these A1s coincide with those of the locus in the signer's body. This is particularly perceivable with meanings expressed through agreement verbs (**look, help, give,** and **say)** and less clear with the A1s associated with **explain** and **take.** The A1s of **think** and **sign** are those showing the clearest relation with the

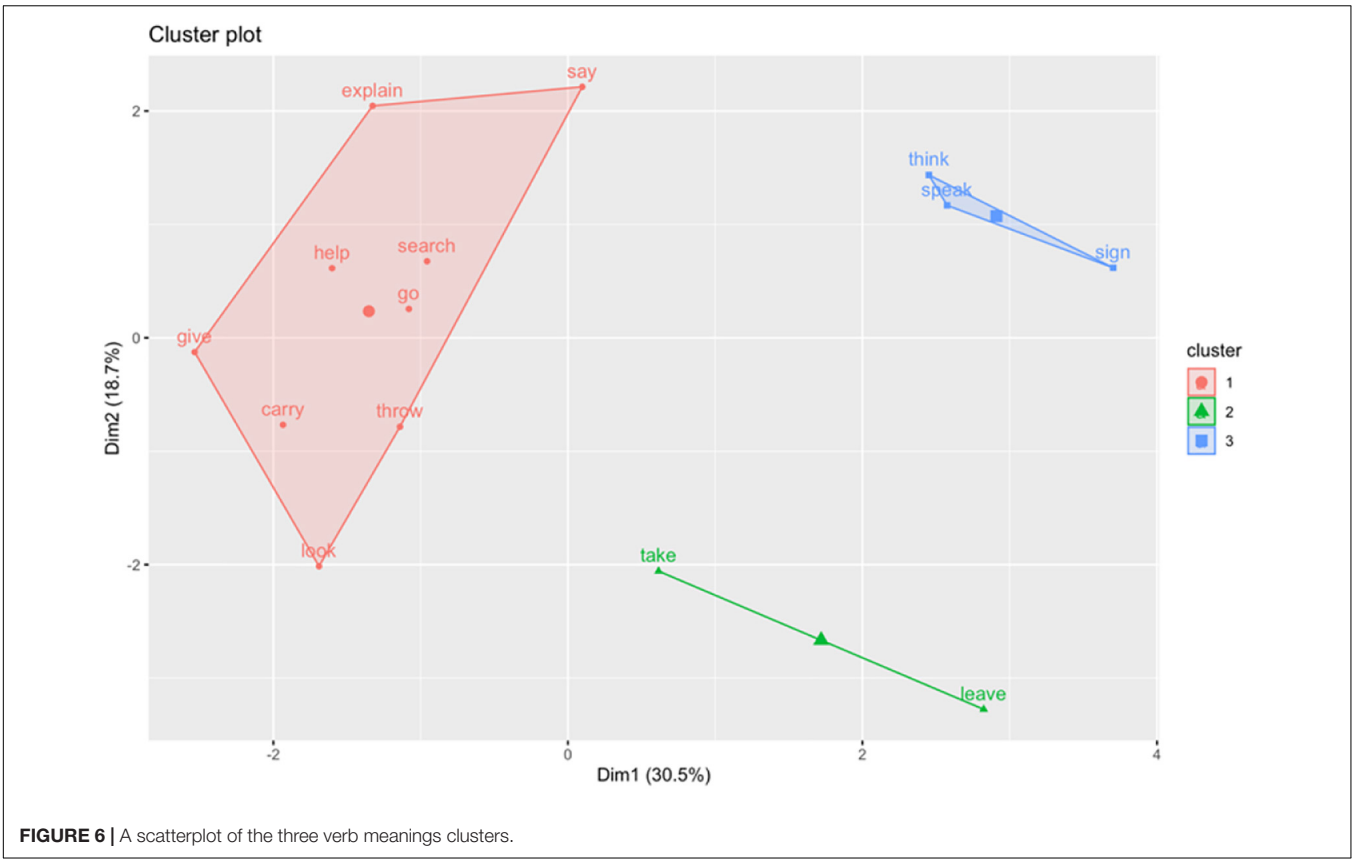


FIGURE 6 | A scatterplot of the three verb meanings clusters.

body. Among the arguments which show the movement origin, the least are the A1s of **carry, speak,** and **leave.** In the case of the first one (**carry**), the movement of the verb in its lexical form indicates a trajectory from one place to another, so that the initial index does not coincide with the body and is not similar to the A1 (e.g., **Figure 7A**). Frequently (46%, 6 examples out of 13), the A1 is a non-specified human entity, which favors a location far from the body, precisely in order to point an agent-backgrounding (Barberà and Cabredo, 2017). Regarding the A1 of **speak**, in its most frequent form, it is articulated at the height of the mouth, so it does not need such an indexation (e.g., **Figure 7B**). The A1 of **leave** is frequently expressed (26 examples out of 40) as a classifier in the active hand (never in the passive hand) so that the body indicates the origin or starting point from the distancing point. The same occurs when **leave** is expressed through a lexical form: the body of the signer represents a place from which they leave, and it is therefore not an A1 (e.g., **Figure 7C**). See also **Figure 2**: D *Initial (source) indexing* and D *Index locus = signer's body*.

- The use of the role-shift reinforces the association agent-signer, since, generally speaking, A1 is the argument taking the role. Moreover, the association of constructed action with arguments other than A1 allows interpreting the CLU with agent-backgrounding so that the non-A1 argument is in focus. Thus, in **Figure 7D**, the participant being explained (Arua, the main character in the story) has more prominence that the one explaining (the moon). The A3 of **explain** and the A2 of **help**, both animated arguments, are associated with role-shifting. There are no similar examples with the A3s of **give** and **say**, despite also being expressed through agreement. As expected, there are no examples of constructed action in the A3s of **look** or **carry**, which indicate a location (see **Figure 2C**: *Role-shift*).

As a result, the quantitative analysis through applied clustering to LSE seems to confirm the thesis that A1 prefers to identify itself with the body of the signer. Nevertheless, there is also the possibility that the body points toward a location (**leave**) or that the indexation starts in a different locus than the body, particularly in verb meanings implying object movement (**carry**).

Furthermore, both the resource of using the A1 for a locus not related to the body (as it is the case with **carry**) and the identification of a different argument from that of A1 with the role are procedures, which have been identified in the specific literature as being responsible for a loss of prominence by the subject (or, more generically, the most agentive and prominent argument) (Guitteny, 2006; Janzen, 2008; Villanueva, 2010; Barberà and Cabredo, 2017; Leeson and Saeed, 2020; Kimmelman, 2022).

Other Arguments Different From A1

When observing other arguments, the fact that those being analyzed as A2 associate participants that seem to have a limited

A



AFTER $_{x}$CARRY$_{y}$ OTHER SCHOOL BUILDING

AFTER $_{x}$CARRY$_{y}$ OTHER SCHOOL BUILDING (ET-MJC#095)
'I was later taken to another school'

B



EQUAL SPEAK TALKATIVE NO

EQUAL SPEAK TALKATIVE NO (ET-MLA#095)
'I do not speak at length'

C



NOW IX WOMAN $_{x}$LEAVE$_{y}$

NOW IX WOMAN $_{x}$LEAVE$_{y}$ (PS-JRV#068)
'(and) now the girl leaves'

D



GESTURE EXPLAIN

G:looking-astonished $_{a}$EXPLAIN$_{b}$ (BL-FRE#166)
'Arua gazed up at the moon amazed: 'Are you talking to me?'

FIGURE 7 | Examples **(A–D)**.

similarity must be highlighted. In particular, only the A2s from **give**, **carry, say, explain,** and **think** are together in **Figure 3**. Others appear in different clusters:

- With other arguments of the same verb meanings: A2s of **take** and **leave**. These verb meanings are a singular grouping, as it can be observed in the corresponding graph (**Figure 5**). They share the feature of allowing the expression through lexemes and classifying predicates. In the case of **leave,** the classifier of an entity corresponds to the person leaving (A1), and in the case of **take**, it is A2 the one expressed in a classifier. There are no similarities between the A2 of **take** (the taken object) and the A2 of **leave** (the place from where they leave).
- With A1s: A2 of **throw**, analyzed below.
- With A3s: A2s of **look, search, help,** and **go**. They all share in common that they make reference to the location of a transference or a trajectory.

Concerning the A3, it should be stressed that they express human recipients (the person being given, told or explained) or places (where something is being thrown or taken). The A3s of **look** and **search** also represent places and appear to be associated with what is being looked at or searched for (A2). Oomen (2020) studies the formal differences between a class of agreement verbs and another of spatial verbs with data from DGS. However, this configuration does not reflect the clusters hereby analyzed, since it considers GO or LEAVE as spatial verbs (in different groups in the research in this work), whereas THROW, TAKE, and SEE are in the agreement group. The difference with the methodology used in this study is that Oomen does not analyze the arguments as separate entities, but she studies the formal property of verbs (e.g., having or not a handling handshape) and constructions (the constituent order). The explanation we propose for the fact that both human entities and locations appear clustered together is that all of them refer to a transfer or movement scheme, in which iconicity is the base for the conceptualization of these processes.

The results for the A2 and the A3 of **throw** were already similar in those calculations not considering the animacy factor. The former appeared with the A1s, and the latter showed more affinities with recipients than with places. In both cases, it can be interpreted that they behave as if they were discursively more prominent than others with which they apparently have more in common (A2s of **carry** and **give**, on the one hand, and A3 of **carry**, on the other hand). The expression traits they share (and which could justify this interpretation) are their tendency to be expressed independently (in lexeme or pronoun forms) and the fact that they can appear as passive or dominated-hand classifiers (**Table 6**). The final indexation, however, shows contradictory results for the A2 and A3 arguments of **throw**.

TABLE 6 | Comparison of A2 and A3 of throw.

	Express indep.	Elided	Classif passive hand	Not classif	Final indexation
A2 of throw	66%	33%	13%	87%	0%
A3 of throw	66%	33%	20%	80%	100%

The result of combining the forms of expression with the animacy produces a relocation of the A2 of **throw** with other arguments intuitively closer, such as the A2 of **carry** and **give**.

Clustering of Verb Meanings: Some Trends

Extracting conclusions from our results and their potential correlation with morphological classes in predicates, such as those proposed by Padden (1988), was not expected given the limited number of studied verbs and verb meanings. However, there seem to be a trend toward associations between the observed clusters and some specific morphological traits.

Particularly, a singularity of the group formed by the meanings of **leave** and **take**, characterized by their high frequency in the expression through classifying predicates, was observed. In addition, **give** and **carry** admit classifiers, although not in the proportion of the former, so they are not attracted toward the same group. Concerning this, in an early stage of data observation, it seemed that there were formal indications to treat together all the verbs implying object manipulation (**take, give, carry,** and also **throw**), since their A2 show anteposition percentages equal to or above 50%. However, when treated with other properties, this trend was blurred.

The results also allow to strengthen the relevance of expression through indexing or agreement verbs, which are those making the most use of space grammatical resources, both for expressing recipients/receivers (**help**, **give**, and **explain**) and places pointed to (**go**, **throw**, and **take**). From the semantic scope, they generically refer to a transfer or movement scheme that is iconically based.

For the meanings of **think** (cognition) and **speak** and **sign** (language), a different group is created. We consider that, in this association, the valency factor bears a lot of weight, since **speak** and **sign** are clearly monovalent, and **think**, even if it admits an object, usually has a general use (to be thinking).

CONCLUSION

A quantitative approach has been applied to a corpus that—even if limited in extension—has been intensively and profusely analyzed.

The arguments of 14 verb meanings have been tagged as A1, A2, and A3, depending on their microrole structure so that A1 is the most agent-like (e.g., the giver, in the case of a giving process), A2 is the second participant implied in the process (e.g., given object), and A3, when present, is the third (e.g., given person).

The formal properties have been analyzed for every argument of every example, in order to, then, identify similarities through a clustering method.

The results can be summarized as follows: (1) tendency of A1s to cluster together, which indicates that similarities in the form imply similar patterns in conceptualization; (2) diversity of A2s, in correlation with the diversity of objects or goals selected by the different verb meanings; (3) proximity between the A3s referring to people and signaling locations, as they share

indexation procedures; and (4) singular behavior of two verb meanings that are frequently expressed through classifiers.

In spite of the reduced size of the corpus, this analysis allows supporting some theses on verb meanings and their coding in sign language. Hence, the tendency most agent-like arguments (A1) show to associate with the signer's body (as it is perceived through indexation and role-shifting) has been confirmed. Furthermore, those arguments signaling a human recipient or a destination (A3) are preferentially associated with verb meanings materialized through indexical procedures (agreement or indexing verbs). The singularity of arguments performed through classifying predicates has also been confirmed, particularly with the behavior of those arguments linked to the meanings of **take** and **leave**.

The relevance of this study for the knowledge of sign languages is demonstrated as the analyses in this study converge with previous research in sign languages (the body as a subject, the functional similarity of the indexing procedures, regardless of whether recipients or places are indicated). As far as spoken languages are concerned, the divergence of the procedures used to distinguish arguments in the clause constitutes a drawback when it comes to establishing generalizations.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors in isignos.uvigo.gal, without undue reservation.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

JMG-M designed and applied the statistical formulation and clustering method. JMG-M and MCC-P have interpreted the results and written the text. Both authors have participated in the grammatical analysis of the data constituting the base of this study.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.806526/full#supplementary-material

Supplementary Data Sheet 1 | ArgStr_dataset.csv argument microroles and variables analyzed for cluster analysis.

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The Role and Place of Sign Language in Deaf Youth's Access to Literacy: Contributions of a Cross-Review of ASL-English and LSF-French Research

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In this mini-review, we investigate the role sign language (SL) might play in the development of deaf learners' reading skills. Since Stokoe's recognition, in the 1960s, of American Sign Language (ASL) as a language in its own right, the ASL has been progressively included in the research on the development of reading in the deaf, but with different statuses. Two contrasting paradigms can thus be identified in the literature. The first considers that sign language (SL) plays an indirect role in the development of reading skills. In line with the dominant psycholinguistic model of reading acquisition in hearing children, the authors consider that deaf children must first develop phonological representations in order to learn to read, like their hearing peers. For the authors of the second paradigm, SL plays a direct and central role in deaf children's access to reading as long as an appropriate visual (rather than phonological) mediation is made between the SL and the written language. We propose to present an overview of studies in both paradigms, in the American and French contexts. Then, we defend the idea of a "deaf norm", operating both in SL structuring and in information processing in general, justifying the central position that SL must have in any learning by deaf people. We will conclude by outlining some promising avenues for teaching reading to deaf learners.

Keywords: sign language, literacy acquisition, deaf children, phonological awareness, visual methods, deaf norm

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INTRODUCTION

The importance of a sign language (SL) for a true social inclusion of deaf people is now well recognized in major international texts[1]. However, the interest of using SL in the schooling of young deaf people and in particular for teaching them writing and reading is strongly discussed. Can SLs, as visual-gestural and multilinear languages, provide access to an alphabetic type written language, which is based on the matching of graphic and phonetic units?[2]

[1]International Classification of Functioning, Disability and Health, or ICF for short (WHO); Convention on the Rights of Persons with Disabilities (UN).

[2]the issue is different for other graphic systems, like Chinese (see for instance Gabrielle Jones' Ph.D. dissertation: http://hdl.handle.net/2142/44319).

Many authors consider deaf students' phonological skills in spoken language to be a prerequisite to their access to literacy, thus minimizing the role of SL in this process. In contrast, some other authors have shown that SL skills would be a stronger predictor of literacy skills (e.g., Goldin-Meadow and Mayberry, 2001; Mayberry et al., 2011; Humphries, 2013). The key question, then, is whether deaf people learn to read in the same way as hearing people. Should "mainstream" models of learning to read be a single standard, to which all learners, regardless of who they are, must conform? Or should specific models be proposed to best account for deaf-specific pathways to reading? The place given to SLs in models of learning to read among the deaf is indicative of this dichotomy between following or breaking away from a majority model. It should be noted here that for us, learning to read does not stop at identifying words; we prefer the concept of literacy which include, according to Barré-de Miniac et al. (2004), not only reading and writing, but also their function and use in multiple contexts.

After an overview of recent representative American and French studies on this issue, we highlight recent lines of inquiry supporting our hypothesis of a deaf norm, i.e., a specific cognitive processing of information related to deafness (Garcia and Perini, 2010; Perini, 2013), which could contribute to the recognition of SLs as a key vehicle for deaf access to writing.

HIGHLY CONTRASTING ENGLISH-LANGUAGE STUDIES

Research on the acquisition of written English by deaf children has led to very divergent theoretical models. A first and dominant approach consists in considering that deaf children follow the same acquisition paths as hearing children. For both, mastery of phonological skills in English is the main prerequisite for the development of literacy skills. The difficulties of the deaf are therefore attributed to their more fragile access to spoken language phonology. The Simple View of Reading (SVR) is a model that describes the process of reading development in most learners (Gough and Tunmer, 1986; Kilpatrick, 2015) and provides an explanation for some reading difficulties such as dyslexia. In this model, reading comprehension (R) results from the interaction of two components: word recognition or decoding (D) and language comprehension (C). These two components are absolutely necessary: the deficiency of one element leads to the deficiency of the outcome (R). Trezek and Mayer (2019) consider the SVR formula ($R = D^*C$) to be a strong hypothesis for explaining reading development in the deaf, based on the premise that deaf people differ from hearing people only in the hearing ability. Depending on their level of face-to-face English proficiency, deaf children may show deficits in either the two components or in D alone. For them, SL plays no role. Another model designed specifically for the deaf, the QSH (Qualitative Similarity Hypothesis: see Paul, 2009; Paul et al., 2013; Andrews and Wang, 2015), also considers that deaf and hearing learners go through qualitatively similar processes, while acknowledging that skill development may be quantitatively delayed in the deaf. According to both models, while SL is considered beneficial in cognitive terms for deaf children due to its visual-gestural modality, it is not considered to contribute in any way to learning to read, as it does not provide access to phonological skills in the spoken language.

A part of the American research argue on the contrary in favor of deaf-specific literacy pathways. Some authors, while convinced of the importance of phonological skills in learning to read, temper the QSH hypothesis, arguing that these essential phonological skills are not necessarily linked to the auditory modality (Allen et al., 2014). Good abilities in ASL phonology may be sufficient, as argued by McQuarrie and Parrila (2014)—finding a positive correlation between phonological skills in ASL and reading proficiency in Deaf children. Few teaching programs have been proposed to exploit this hypothesis, including the noteworthy Cripps (2008) and Supalla (2017) on the reading of ASL as a transitional means to access the reading of English. Others, like Mayberry et al. (2011) and Miller and Clark (2011), suggest that deaf people's difficulties are due to a lack of early access to a SL (see also Cummins, 2007). Allen and Morere (2020), in a study involving deaf signing children aged 3–6, show that these children's identification of words and letters is better when they have had early access to ASL, even if they do not have deaf parents. That's why, for Caldwell-Harris (2021), ASL must be sufficiently established by the time the child begins formal reading instruction. Indeed, without a fluent language of instruction, the written language cannot be finely explained to the deaf student. Hoffmeister and Caldwell-Harris (2014), Hoffmeister et al. (2022) similarly propose a model describing the learning of written English in three stages: the deaf child initially relies heavily on word-sign connections, gradually breaks away from this strategy and implements new ones to acquire increasingly complex written structures. The experience of communication and discourse in ASL is therefore fundamental to understanding increasingly long texts. Kuntze et al. (2014) propose a model based on the observation of strategies employed by deaf parents and teachers and on the natural tendency of deaf people to learn in a visual mode. Their "visual model" has five components: ASL acquisition and visual engagement, emergent literacy, adult mediation *via* written English, knowledge of Deaf culture, and finally support of visual media such as video. Rooted in a sociocultural view of literacy, their concept of "Multiliteracy" allows them to take into account the role of deaf children's multilingual and multicultural skills in learning to read and write. Recalling that the deaf child, in learning written English, is learning a new language, the authors aim to take into account developmental factors that contribute to reading acquisition, such as the early linguistic and literary skills that emerge as early as birth. They show how these early skills can be acquired through the five components identified above.

French studies give to LSF (French Sign Language) more or less importance in the teaching of writing to deaf children, strongly depending on the field.

A PART OF FRENCH RESEARCH: MINIMIZING THE ROLE OF SL IN ACCESS TO LITERACY

SVR is the dominant model adopted in the majority of French studies in cognitive psychology. They presuppose a common development in hearing and deaf people and have a restricted conception of reading, which consists mainly of converting graphemes into phonemes. The experiments aim to demonstrate the major role of phonological awareness in the acquisition of efficient written word recognition processes (Colin, 2004; Colin et al., 2007, 2013). For this purpose, the authors emphasize visual strategies for accessing the phonological structure of spoken language (lip reading, Cued Speech), as a means of compensating for the auditory deficit (Leybaert et al., 2018), which they call "Visual (or amodal) Phonology". These authors, who have so far overlooked any possible link between SL and written language (the D and C components of the SVR formula only play their role with a spoken language), have recently been considering the interest of using SL at two levels. On the one hand, because it allows for the natural development of the C component (Colin, 2004); on the other hand, because of the complementary role it can play for the R component, alongside Cued speech and lip reading. Indeed, according to Leybaert et al. (2018), (p. 90), SL allows "the exercise of segmentation, categorization and regularity detection skills". It is then mainly mentioned for the possibilities SL would offer to establish formal correspondences between its units and those of the written language. However, SL and spoken language being quite different, these correspondences are limited to the configurations of the initialized signs and the dactylological units. It is noteworthy to note that (Courtin Cyril, 2005) is the only French psycholinguist to recognize the potential of SLs to support the development of good writing skills, with or without oral parallel education.

Some French researchers, however, take into account SL in the educational curriculum of the deaf, but through the perspective of bimodal bilingualism. In a similar vein as Swanwick (2016), (Mugnier, 2016, 2021) defined bimodal bilingualism as the simultaneous use of all linguistic resources available to deaf children (signs, spoken and written language). This approach wants to be as close as possible to the linguistic reality of deaf students, who in fact come mostly from hearing families, in which communication is mainly vocal. She thus insists on the importance of the use of signs and speech at the same time in the classroom, as a pragmatic solution to the linguistic variety of deaf students. Indeed, (Esteve, 2011) proposes a "reasoned pedagogy of code switching" which lets bimodal interactions develop freely. Nonetheless, for now, no well-defined proposals are made concerning bimodal teaching strategies for reading and writing French. As a matter of fact, "there is no real agreement in the international literature regarding what comprises a bimodal bilingual teaching approach and so it is difficult to compare and contrast strategies or draw firm conclusions about efficacy" (Swanwick, 2016, p. 42). Furthermore, considering the bimodal bilingualism propositions, some professionals seem to fear the risk of relegating the SL to a simple communication tool and to further weaken an already minority language (Swanwick, 2016).

In these two fields of French research, which admittedly have different perspectives, the fact that the majority of deaf children are born to hearing parents seems to justify not giving a central role to SL in access to literacy. The importance of early access to SL is little discussed, whereas it is well documented in the American literature presented above. The reference to the hearing norm is omnipresent in these works as well as in the SVR and QSH models. However, we believe to be essential to explore the hypothesis that the predominance of the visual in the deaf could influence their learning to read. This question is important in that a better understanding of deaf "functioning" could lead to a more appropriate written language instruction.

A DEAF NORM HYPOTHESIS AND ITS IMPLICATIONS

North American studies on proficient deaf sign readers/writers have recently revealed specific cognitive functioning and strategies for deaf people. The study of eye movement during reading in proficient deaf adult readers and young deaf children aged 6–12 (Bélanger et al., 2012, 2018; Bélanger and Rayner, 2015) showed that all of them have a more developed visual span than hearing readers, allowing them to process more visual information within a single fixation (when reading, the reader moves his eyes alternating short saccades and longer fixations). They also perform fewer re-fixations and backtracking when reading a text. No evidence of phonological procedures was found in the panel of deaf readers, suggesting that word identification in deaf readers is more likely based on visual recognition of whole words or word fragments. This hypothesis of a global word identification process is supported by analysis of the early writing of deaf preschoolers who are ASL or LSF signers: these "invented spellings" demonstrate a variety of visual strategies, which, it should be noted, rely heavily on the SL (Cripps, 2008; Herbold, 2008; Williams and Mayer, 2015; Beaujard and Garcia, 2020).

Other studies, this time from the social sciences, have also revealed cognitive specificities in deaf people and confirm, in a completely different way, the hypothesis of a global grasp of words in reading, and this, *via* a SL. Interviews with expert deaf readers were conducted and analyzed with a qualitative method, whose interest is to provide a holistic view of the processes of literacy acquisition in deaf people, and also to take into account the different contexts of acquisition. Adults interviewed by Silvestri and Wang (2018), and Mounty et al. (2014) report visual thinking "like a movie", reading strategies that directly link signs and written words, and understanding texts as "a whole, like a picture". In the panel studied by Silvestri and Wang (2018), as in the French panel of Garcia et al. (2007), the criterion distinguishing the most successful readers was the use of SL, at home and then at school. The most proficient were also the ones

who most readily recalled the teaching activities performed in the classroom. Caldwell-Harris (2021) explains this through the presence of ASL in teaching allowing for a full understanding of the learning. Other interviews with deaf signers show a clear link between good reading skills and early access to a SL (Morere et al., 2012; Wang et al., 2016).

The analysis of deaf writing provides yet another perspective on acquisition strategies that are thought to be unique to the deaf. Charrow and Fletcher (1974) were the first to suggest that the written language of American deaf people would be partly comparable to that of L2 learners (see also more recently Stokoe, 1960; Koulidobrova et al., 2018; Howerton-Fox and Falk, 2019). However, work on Quebec deaf written French conducted by the *Groupe de recherche sur la LSQ et le français sourd* at UQAM has revealed a number of particularities encountered only in deaf written productions. These include a disruption of syntax aiming at organizing utterances according to a visual logic (e.g., "la chambre du lit de l'oreiller", instead of "l'oreiller du lit de la chambre"). With her panel of deaf adults, Perini (2013) highlights specific details that deaf people use to mention in their text. For example, for the action of hanging a picture on the wall, Deaf people often describe the tools used and the actions performed, compared to hearing people: avec un clou frappe marteau pour crochet (Simon); Il a tapé la pointe sur le mur avec le marteau (Charles). The fact that these particularities are found in both deaf signers and non-signers suggests a processing of information specific to deafness prior to the linguistic processing in either language.

Based on these distinct studies with regards to both discipline and methodology, it appears that deaf people access literacy through specific pathways. The innovative hypothesis of a deaf norm as proposed by Garcia and Perini (2010) and Perini (2013) emerges, evoking the "cognitive common core" mentioned by Cuxac (2000) as the basis of any SL. Such a cognitive common core could indeed, to a lesser extent, be at work in deaf writing. Research on emergent SLs (e.g., Fusellier Souza, 2006, 2012; Martinod, 2019), conducted within the framework of the Semiological Approach (e.g., Garcia and Sallandre, 2014, 2020) has indeed shown the relevance of deafness in the structuring of sign languages. This would imply that SLs, as deaf creations, would best reflect the deaf-specific cognitive processing of information and would for this reason be the most likely to support successful cognitive development of the deaf child, whether he has deaf or hearing parents. We therefore hypothesize that SL is the best metalanguage for deaf access to literacy.

SOME PROMISING AVENUES

None of the studies presented proposes a specific method of teaching written language through SL. This is, more broadly, one of the major gaps in the work on written language acquisition in the deaf population (Hoffmeister and Caldwell-Harris, 2014). Nevertheless, the studies presented in this section allow us to identify a number of avenues that could guide the formalization of more effective pedagogical approaches. They show indeed that it is possible to learn to read and write *via* a SL. This simply requires early exposure of deaf children to a SL in the family, and then formalization of its learning in schools, so that it becomes a rich and fluid language for the child. Considering the written language of the deaf as a second language also makes it possible to specify the status of SL in access to literacy: a first language, that is to say a face-to-face language capable of playing the role of reference language in all school acquisitions.

Another important avenue, which goes beyond the question of the choice of first language for the deaf child, concerns the way in which written words are identified. In the majority model for hearing people, word identification is done through a phonological process. However, it seems that for deaf people this identification is done in a visual way, i.e., by global recognition of the word. Several authors exploit the idea of morphological awareness instead of phonological awareness (Gaustad, 2000; Clark et al., 2011; Perini, 2013; Beaujard, 2015). The study of orthographic regularities and word formation (radicals, lexical and grammatical affixes) would allow deaf people to improve word identification and extract meaning more easily. Some feedback from pedagogical experiments with adults (Marçot, L., and Perini, M., Marçot, L., and Perini, M.) and children (e.g., Duhayer, 2005; Kellerhals, 2005) describes the process by which deaf teachers and learners use SL to construct meaning in written language (see also Humphries and MacDougall, 1999). However, the processes by which deaf children acquire written language using SL as a metalanguage still need to be described in more detail in order to understand the cognitive strategies that are put in place and to exploit them for teaching.

CONCLUSION

The inclusion of all people in society requires a rethinking of what is traditionally understood as part of the norm. Every human being is now considered normal, not in spite of their differences but with their differences. If states adhere to this concept of inclusion, through the ratification of major international texts, schools must also welcome all ways of being in the world, including language. We consider that there are different paths to literacy and that the hearing majority model alone does not explain how it works.

The differences between "assimilative" approaches and approaches that deviate from a dominant model are very profound, touching on the way in which the written word and the deaf public themselves are viewed. Researchers adopting the assimilative view have a reductionist approach to writing, which is primarily understood in terms of its smallest units and how they are combined (Perini and Garcia, 2022). Most of these authors rely on experimental research based on the comparison of performance between deaf and hearing people. This both presupposes and reinforces a vision of the deaf public as being deficient, inevitably lagging behind hearing people in terms of

the quality of phonological representations. The only foreseen solution is then to reduce the gap with the supposed norm (improve hearing) and to compensate for it with visual tools (cued speech for example). Researchers calling for a move from the mainstream model take a broader and more qualitative view of literacy, encompassing its linguistic, cognitive, sociological and cultural dimensions. They conduct more general studies of good deaf writers to identify success factors. This broader and less prescriptive view allows access to writing to be seen as a complex and multifactorial process and to consider the deaf public in all its diversity. Although no generalizable pedagogical solution has been proposed to date, the studies presented here, even though still essentially descriptive and partly programmatic, allow us nevertheless to highlight avenues for teaching writing to the deaf that meet their specific cognitive and attentional needs.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Time Is Ripe to Make Interactional Moves: Bringing Evidence From Four Languages Across Modalities

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Sign language linguistics has largely focused on lexical, phonological, and morpho-syntactic structures of sign languages, leaving the facets of interaction overlooked. One reason underlying the study of smaller units in the initial stages of development of the field was a pressing concern to ground sign languages as linguistic. The interactive domain has been sidestepped in gesture studies, too, where one dominant approach has been rooted in psycholinguistic models arguing for gesture's tight relationship with speech as part of language. While these approaches to analyzing sign and gesture have been fruitful, they can lead to a view of language as abstracted from its natural habitat: face-to-face interaction. Such an understanding of how language manifests itself—one that takes for granted the conversational exchange—cannot account for the interactional practices deployed by deaf and hearing individuals within and across various ecological niches. This paper reviews linguistic research on spoken and sign languages, their approaches to gesture that have tended to posit a divide between what is linguistic vs. non-linguistic and sign vs. gesture. Rather than opposing the two, this paper argues for seeing the dynamics between gesture and sign as intimately intertwined both intra- and inter-personally. To ground this claim, we bring evidence from four languages: ASL—American English and French Belgian Sign Language (LSFB)-Belgian French across modalities (signed and spoken) to offer a view of language as situated, dynamic and multimodal. Based on qualitative corpus analyses of signers' and speakers' face-to-face interactional discourses of two communicative actions, viz. palm-up and index pointing, it is exemplified how deaf ASL-LSFB and American English-Belgian French hearing individuals mobilize their hands to continuously contribute to both linguistic meaning and the management of their social actions with addressees. Ultimately, exploring the interactional synergies arising within and across different communicative ecologies enables scholars interested in the fields of gesture and sign language research to gain a better understanding of the social, heterogeneous nature of language, and as to what it means for spoken and sign languages to be embodied languages.

Keywords: sign language, gesture, palm-up, conversation analysis (CA), interaction

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1 INTRODUCTION

One of the essential questions in linguistics that scholars seek to understand is how individuals, within and across diverse ecological niches, communicate with each other (Ferrara and Hodge, 2018). This question, however, has historically been addressed in linguistics through a particular lens, primarily derived from the investigation of Indo-European (spoken) languages and as just speech or text (Vigliocco et al., 2014; Perniss, 2018). Furthermore, the nature of these traditional linguistic theories was "mostly occupied with aspects of language that denote [d] things arbitrarily and categorically" (Özyürek and Woll, 2019, p. 68), a view inherited from the duality expressed in Saussure's *signe*. In turn, such a conception has firmly impacted the field of linguistics where the empirical emphasis has been laid on certain structures of language, such as the lexicon and morphosyntax while defocusing others mainly connected with interactional-pragmatic aspects of language use.

Although these traditional linguistic views have been fruitful in terms of producing knowledge about the building blocks of individual utterances, some scholars' current perspective on what constitutes language and how it works in human communication has tremendously expanded since these initial conceptions of language. It has been reckoned with in the fields of gesture studies (Kendon, 2008; Müller, 2018) and sign language (hereafter, SL) linguistics (e.g., Ferrara and Hodge, 2018; Perniss, 2018) that these theories tend to depict a narrow picture of language and its properties because they offer "a distilled abstraction of how language really manifests" (Murgiano et al., 2020, p. 3) in a given communicative context.

In fact, the arena where humans' language ability manifests itself in the here and now is deeply rooted in human sociality (Holler and Levinson, 2019), which directly converges with what Schegloff (1996) once called the home habitat of language itself, that is, face-to-face interaction. After all, it is in this context that the human ability for language has emerged phylogenetically, is learnt by children, and is mostly used in everyday conversations (Perniss, 2018). When communicating face-to-face, people draw on a wide range of interwoven multi-semiotic practices to create and interpret meaningful composite utterances (Enfield, 2009).

Shifting the construal of language as a structured, symbolic system to an inherently multimodal and situated social practice (Ferrara and Hodge, 2018; Murgiano et al., 2020) requires the analyst to account for semiotic moves of the entire body as it is situated in the physical environment (Streeck, 2009; Mondada, 2019). As such, the body is reconceived as a locus for meaning making where all sorts of visible bodily actions (Kendon, 2004) are available for speakers' and signers' interpretation. These embodied visible units of meaning, referred to as *gestures*, as we shall argue, are deeply integrated with language, whether in its signed or spoken manifestation. In this paper, we follow Andrén's (2014) framework of "the upper and lower limit of gesture" (p. 153), to consider any visible bodily action as potentially communicative in the context of its production while remaining a visibly recognizable resource available at all times for interpretation, even if it is not "necessarily intentional" (Bolly and Boutet, 2018, p. 2).

But *how* the body (specifically, manual and non-manual articulators) of language users is implicated in spoken and signed interaction has not—yet—reached consensus thus far in the SL linguistics and gesture communities. The actual perceptible differences between gestural phenomena and the signing stream have influenced how scholars treat visual imagery in SLs. As it stands, there are two competing views of gesture - one that affiliates gesture with sign, and another that differentiates gesture from language - but these views, as will be argued here, need not be mutually exclusive.

At the crossroad of gesture and sign, this paper offers unique insights into the topic of language in interaction across modalities, insights that we believe have far-reaching ramifications not only for how we come to describe the presence of gestural instantiations in signed and spoken discourses, but for language theory itself. This kind of opening on language pushes us to rethink the traditional dichotomy that distinguishes between what is linguistic and non-linguistic, what is part of language and what is viewed as outside of it (Kendon, 2008, 2014). In the same vein, it forces us to put into perspective what is considered a foundational property of language and what is considered marginal "or even a negligible attribute" (Murgiano et al., 2020, p. 4). Ultimately, such an approach will offer a more thorough understanding of the rich heterogeneity of the human language ability.

In **Section 2**, we first review literature conducted on gesture from a cognitive and psycholinguistic perspective (2.1). We discuss their main limitations with respect to analyzing gestural phenomena. Next, we consider the other side of the coin, language as a multimodal, situated social practice (2.2) by presenting an overview of the interactional meanings of gesture in signers' and speakers' conversations to further ground that language does not only emerge inside people's minds but shapes and is shaped by people's activities in interaction. After laying out the data in **Section 3**, evidence is brought together from four languages across modalities, namely, ASL/American English and LSFB/Belgian French (**Section 4**), to show how signers and speakers use gestural phenomena to create meaningful utterances and regulate the flow of their conversational exchanges. Lastly, the implications of applying this kind of approach to language are discussed in **Section 5**.

2 SETTING THE STAGE FOR GESTURAL INSTANTIATIONS IN SIGNING AND IN SPEAKING

2.1 Gesture in Cognitive-Psychological Accounts

The ways gestural aspects have received attention in SLs have been influenced by models inherited from the prevailing structuralist approach to language, primarily devoted to the linguistic analysis of spoken language (SpL, hereafter) structures (see Kendon, 2008 for a thorough discussion of the

influences of Saussurean and Chomskyan approaches to language on (SL) linguistics). However, other events have reinforced the barrier standing between gesture and sign, which is also the result of a strongly advocated model that situates gesture within the realm of a cognitive-psychological view of the term, which emerged in the latter half of the 20th century.

These accounts of gesture in signing are found in earlier works on the subject (Emmorey, 1999; Sandler, 2009; Schembri and others, 2005) as well as more recent work (Goldin-Meadow and Brentari, 2017) where gesture is defined in terms of a psychologically driven model of language. Following McNeill (1992), they argue for a binary separation between what is embedded in the sign (for SLs) as discrete and categorical from more gradient aspects that they consider paralinguistic.

McNeill (1992, 2005) ideas about gesture are primarily concerned with the microgenesis of utterance formation, the 'Growth Point', as it unfolds in a speaker's mind; gestural production *in situ*, then, acts as a window into the mind. In particular, McNeill's interest in gesture lies in gesticulation (McNeill, 1992), which includes the most idiosyncratic units depicting imagery, the deictic and the iconic forms of language. These forms are treated as unique to SpL—their very definition requires their co-expression with speech. SLs are conceived of as standing in direct opposition to gesticulation leaving them outside the bounds of human communication. McNeill's aim to account for gesture in a single theoretical system, one that sees "the whole person as a theoretical entity" (1992, p.11) leaves out deaf signing people. While it is indisputable that (parts of) SLs bear resemblance to conventionalized gestures (i.e., emblems), we still cannot claim that SL users integrate gradient, imagistic expressions with conventionalized forms differently than SpL users when the fundamental question is one of definition (i.e., what body movements are considered 'gesture' or 'sign'). Rather than emphasizing continuities, as it was presumably intended to do, this continuum has exacerbated categorical differences between bodily actions expressed by hearing speakers and deaf signers. If 'gesture' is a theoretical notion that humans have both imagistic, idiosyncratic aspects of thought combined with linguistic expressions, then it should follow that deaf signing humans, too, have similar mental constructs. The outward expressions (viz. signing) should also be analyzable from the same framework or else the framework is flawed (Shaw, 2019). We see this shortcoming as an unintentional byproduct of approaching the analysis of gesture solely from this "inside looking out" perspective (McNeill, 2018), as deeply rooted in the inner cognitive and psychological functioning of the human mind (McNeill, 1992, 2005), where gesture is distanced from the environment in which it ordinarily unfolds and to whom it is addressed, that is, in language as used by speakers and signers with co-present addressees.

McNeill's approach to SLs influenced early treatments of gesture in SL. Emmorey's (1999) study of ASL narratives asks whether signers also gesture. Applying the principle of co-expression with speech as the litmus test, she finds signers do not produce spontaneous idiosyncratic manual gestures that co-occur simultaneously with signing as speakers produce gestures concurrent with their speech. Rather, signers might interject manual gestures in between conventionalized signs or gesture with one hand while signing with the other. Emmorey reveals the shortcomings of applying the McNeillian sense of gesture to SLs. Defining gesture as gesticulation implies that only (manual) spontaneous, idiosyncratic gestures that are capable of revealing the imagistic nature of thought are considered unique to SpLs. It will be examined further, however, how such a position impedes the full treatment of visible bodily actions in SpL and SLs.

Another example of a McNeillian view of gesture in sign is found in Sandler's (2009) work on Israeli Sign Language (ISL). In ISL, signers use their mouth to express the gestural aspects of certain discourse parts, and these mouth actions are analogous to the representational hand gestures found in speakers' discourse. Sandler suggests that the gestural content, expressed by the mouth, co-occurs with the linguistic content conveyed by the hands, just as is the case in speakers' use of co-speech gestures but in reverse. *Gesture*, here, is still situated outside of language, as reflected in Goldin-Meadow and Brentari's quote on Sandler's (2009) study: These mouth gestures are seen "to embellish [emphasis added] the linguistic descriptions they g [i]ve with their hands" (2017, p. 12). What the mouth reveals here is the imagistic, instantaneous and idiosyncratic aspect of gesture usually attributed to the hands in SpLs. Moreover, Goldin-Meadow and Brentari's (2017) aforementioned words portray mouth gestures as purely paralinguistic that provide ancillary support, as if they were ornaments that only assist the hands. Such a view reduces the scope of gesture's role and position in SL discourse.

Some scholars have put forth alternate interpretations of other ways that signers ordinarily express themselves, shedding light on possible modality-independent characteristics that included, for instance, the use of space in pronouns and indicating verbs (Liddell, 2003), or depicting constructions (Schembri et al., 2005). The latter, for instance, raised questions about whether these constructions could be analyzed as mixed forms, incorporating both linguistic and gestural elements. Schembri et al. (2005) have explored the use of classifier constructions by signers for expressing motion events in three historically unrelated SLs, namely, ASL, TSL, and Australian SL (Auslan), and their comparison with the gestures performed by hearing English non-signers describing the same motion events. An important detail about the design of their study is that speakers were constrained to using their hands without being allowed to speak, which impacts the kinds of gestures produced.

Analyzing the handshape, motion, and place of articulation, the authors found that not only all signers across the three unrelated languages used motion and place of articulation in a similar fashion, but they were also the same in the silent gestures articulated by the hearing non-signing speakers. In contrast, the handshapes were similar among signers within the same SL but different from the other SLs and from the silent gestures as well. In other words, hearing speakers, when prevented from speaking, produced gestures that resembled the signs that signers performed regarding motion and location parameters, but not handshape. Thus, while motion and location units for the

description of events displayed systematicity, variability in handshape was established for different SpLs and SLs. According to the authors, their findings add evidence with respect to the status of classifier constructions as "blends of gestural and linguistic elements" (p. 287), which concur with other results (e.g., Liddell, (2003) study, reporting that classifier handshapes were categorical in nature (viz., linguistic)).

Resulting from these methodological designs and theoretical paradigms, only a limited set of discourse features are considered as eligible gestural instantiations in signing, "mainly depicting constructions, constructed action, and referential use of space" (Shaw 2019, p. 4). This view limits the range of other visible bodily actions that deaf people employ in their discourse, including the interactive forms. The same holds true in the study of gesture in relation to speech where only the most imagistic side of gesture is considered gesture proper.

The hybridity of embodied expressions is enticing as an analytic starting point. There are a few shortcomings to these studies that we consider here. To begin, the studies conducted under these research paradigms mainly draw on data collected under experimental conditions with a predominant focus on task-oriented narrations from a single speaker, and either neglect the face-to-face context or take it for granted. Second, some push forward the notion that gestural expressions might be channel-specific (where linguistic status follows the articulator through which the bodily action is expressed). SLs have already shown that the hands, especially, but also the eyebrows, mouth and even torso, can be used conventionally. What we stand to gain by comparing signed and spoken discourses is a theory that does not automatically presume a priori that a bodily action belongs to one category or another. Instead, we describe what the bodily actions accomplish semiotically in interaction and consider separately whether the forms are conventionally shared. The benefit of this approach is that we have greater latitude to account for how people express themselves through their bodies in all sorts of modalities (be it speech, sign, tactile/pro-tactile sign, and so on). Should we find similar patterns cross-linguistically we might advance the argument for a theory that embraces both "language" and "action" as an integrated system.

Lastly, although silent gestures (also called "spontaneous signs", Goldin-Meadow and Brentari, 2017, p. 9) have been explored alongside conventional SLs and homesign systems as regards their roles in language emergence and evolution (see Goldin-Meadow, 2015 and Özçalışkan et al., 2016), we argue that these silent gestures are not reflective of how bodies engage in real-life contexts. Put differently, silent gestures are not spontaneous, idiosyncratic gestures created on the spot but rather, they are the result of some sort of convention established within that specific constricted usage, as discussed by Müller (2018). Hence, they fail to resemble language because they are not like language, at least as it materializes in natural contexts with various conversational partners. The meanings and forms of these silent gestures cannot be generalized either to a larger audience of users, or for more complex communicative purposes, nor across various naturalistic contexts (outside their restricted settings), which make the claim of silent gestures as evidence for a divide between gesture and sign relatively weak (Müller, 2018).

Yet, if we adopt Kendon's definition of gesture as "visible actions as utterance" and Andrén's framework where the upper and lower limits of gesture allow for the potential for gradience in any form, *gesture* is kaleidoscopic. In interaction, language users of SLs and SpLs resort to a broad range of bodily behaviors to pragmatically manage their interaction while negotiating the moment-by-moment relationship with addressee(s). Hence, only focusing on the imagistic side of gestural expression in signing and in speaking, as if gestures were only a product of inner thoughts, brings to light an incomplete picture of multiple minds (and bodies) interacting. By shifting attention to language in situated interactions, intersubjectivity comes into play (Schiffrin, 1990) and it becomes immediately apparent that some bodily moves are responses to the moves of the other person. The growth of ideas, then, also occurs in concert with another mind.

While it is true that McNeill's (1992, 2005) theory remains a strong influence on the examination of gesture in SpLs and SLs, several scholars have begun to embrace language proper as inherently multimodal and primarily dialogic (e.g., Kendon, 2004; Goodwin, 2007; Enfield, 2009; Streeck, 2009) and examine gesture as part of people's social activities (e.g., Bavelas, 1994; Gerwing & Bavelas, 2013).

The present paper builds on current and previous work that views the pragmatic and interactional meanings "ever present in human interaction" (Ferrara, 2020, p. 2). The next section surveys key studies whose work has demonstrated how language users—deaf and hearing—deploy their body to regulate their interaction rather than to express propositional meaning *stricto sensu*.

2.2 Gesture in Usage-Based, Interactional Accounts

When we turn our analytic eye to an interaction as a unit of analysis, certain bodily actions come to the fore. Gestures that appear seemingly meaningless in terms of propositional content serve central roles to addressees assessing utterances as they unfold online. In face-to-face conversation, not all gestures align with the propositional content of spoken utterances but rather play a role in the management of the social context in which they take place. Like navigational markers, these gestural forms guide conversational partners, turn-by-turn, through the production and interpretation of informational and social meaning. These gestures have received many different labels such as "speech handling" (Streeck, 2009), "pragmatic" (Kendon, 2004) and "interactive" (Bavelas et al., 1992). The latter is used to refer to this specific class of gesture as Bavelas and others' 1995) functional typology is used in the present paper.

Bavelas and others conducted several research experiments (1992, 1994, 2008) in which they concluded that not only visibility (the fact of interacting with a visible addressee, 1992) but also the dialogue situation itself (the fact of having both parties to be able to express themselves spontaneously and freely, 1994) acted as independent influences on the emergence of interactive gestures (Bavelas et al., 2008). In

addition, the degree of knowledge shared between interactants also influenced the use of interactive gesture (Holler & Bavelas, 2017). In other words, social context and information states were the two main drivers behind the emergence of the forms.

These findings shed light on this particular class of gesture that does not seem to serve directly the propositional content but rather to point to diverse aspects of interaction itself and the interpersonal management of the speaker/signer-addressee relationship. Now, the ways those gestures involve the addressee in the interaction are multifaceted. Bavelas and others 1995) have highlighted four major functions, namely, regulating turns in conversation as well as delivering, citing, and seeking information. These functions serve as the basis for the evidence provided in **Section 4**. It is worth noting that Bavelas and others' functional typology has gained traction recently and has been applied on spoken and signed language data (e.g., Holler, 2010; Shaw, 2019; Ferrara, 2020; Gabarró-López, 2020; Lepeut, In press). In what follows, each main interactive function is explained with additional literature in SL and SpL studies supporting the claim for the inter-personal roles that the body entails in language.

First, regulating gestures maintain the flow of conversation with respect to turns-at-talk (Bavelas et al., 1992, p. 473). These include backchannels made by addressees to show agreement, following and/or attention. In SL research, the turn-taking engine is a facet of signed discourse that has received the most attention, particularly in the following areas: how signers take, maintain, or yield the turn (Baker, 1977; McIlvenny, 1995; Coates & Sutton-Spence, 2001; McCleary and de Arantes Leite, 2013; Girard-Groeber, 2015), how conversational repair (e.g., self-initiated repair, other-initiated repair, and so on) is undertaken (Dively, 1998; Dingemanse et al., 2015; Manrique, 2016; Skedsmo, 2020), and how overlap in signing occurs (Baker & van den Bogaerde, 2012; Coates & Sutton-Spence, 2001; de Vos et al., 2015; Groeber & Pochon-Berger, 2014; McCleary and de Arantes Leite, 2013). Even studies on tactile SLs have described the functioning of turn-taking patterns, such as conversational repair practices and backchannels (e.g., Mesch, 2001). The same is true for studies that have adopted a multimodal perspective on turn-taking and the role of gesture in the management of such turns (e.g., Deppermann 2013; Mondada, 2007; Van Herreweghe 2002).

A second interactive category consists of delivery gestures whose role is to mark the content of the information transmitted (as new or shared) to the addressee, including digression and elliptical gestures. Shared delivery gestures correspond to the notion of common ground defined as the "knowledge, beliefs, and assumptions that interlocutors" (Holler and Bavelas, 2017, p. 218) share prior to or develop during conversation. Common ground is another interactive accomplishment that gesture marks and has received important attention in both spoken (Holler, 2010; Gerwing and Bavelas, 2013) and signed conversation (Shaw, 2019; Ferrara, 2020). By contrast, the delivery of new information to addressees (Kendon, 2004; Müller, 2004; Streeck, 2009; Ferré, 2012) has been reported and seems more frequent in spoken than signed discourse (Ferrara, 2020).

Seeking gestures aim to elicit addressees' responses. In conversation, participants do not only monitor their own actions and states of mind but also those of their conversational partners (Clark & Krych, 2004). These interactive gestures are used to seek understanding, following, attention, and agreement from addressees with the ongoing conversation and even help during word search activities (Goodwin & Goodwin, 1986).

Finally, citing gestures refer to previous contributions made by the other interactant in the conversation and acknowledge a point being made by the addressee (Bavelas, 1994). Citing functions of gestural phenomena have been reported for the index pointing, for instance, in ASL (Shaw, 2019) and NTS (Ferrara, 2020) and spoken conversation (Bavelas, 1994).

Interactive gestures are only recently gaining attention among SL researchers but they seem to be patterning in similar ways across modality. Given the sparse research on SL interaction, this brief survey reveals that some properties of SL interaction remain largely overlooked, leaving a gap in our understanding of SL functioning. Yet, it remains fundamental to be able to describe signers' practices—just like those of speakers—to obtain a more comprehensive picture of how language works beyond speech. These studies pinpoint crucial implications for the integration of interactive gesture in language use. The scholars exploring their interactional meaning align with a view that considers gesture and sign hand-in-hand as found in Müller's (2018) and Kendon's (2008, 2014) approaches, among others. Müller (2018) argues that the meanings of gesture are rooted in "embodied experiences that are dynamic and intersubjective, and not at all like images" (p. 12). As for Kendon (2008), he highlights the importance of setting aside the gulf between gesture and sign in favor of viewing the two side-by-side through historical, functional, and material arguments:

> it would be better if we undertook comparative studies of the different ways in which visible bodily action is used in the construction of utterances [. . .]. Such an approach would reveal the diverse ways in which utterance contributing visible bodily actions can be fashioned and the diverse ways in which they can function from a semiotic point of view (Kendon, 2008, p. 358)

Many scholars have recently embraced this view in both gesture research and SL linguistics (e.g., Ferrara & Hodge, 2018; Müller, 2018; Puupponen, 2019; Ferrara, 2020). Yet, the fact remains that only a handful of studies have put theory into practice by adopting a direct comparative approach between different SpLs and SLs while relying on directly comparable interactional corpus data.

2.3 The Current Approach

This work aims at advancing the comparative study of visible bodily action in sign and speech. More particularly, the current paper adopts Kendon's (2008) framework and offers a unique

perspective not only on language use across languages (ASL-AmEng/LSFB-BF) and modalities (signed/spoken) but also on the similarities that emerge when gesture and sign are explored side-by-side in different contexts (dyads/triads) and settings (at home/in the lab). To illustrate a potentially fruitful area for cross-linguistic analysis, we have selected the palm-up (PU hereafter) and pointing actions as a point of departure. These manual forms are particularly well-suited for cross-linguistic analysis because of their physical resemblance with each other and the frequency with which they emerge in face-to-face encounters. Accounting for their patterning in signed and spoken interactions should contribute to the discussion of how gesture is defined and how language is analyzed. This study demonstrates how ASL and LSFB signers along with American and Belgian French speakers draw on similar methods of communication to express diverse interactional meanings through these two gestural practices. These two gestures are analyzed and discussed when conveying interactional meanings as reviewed in 2.2. The data used to discuss the PU and Index pointing interactional meanings are described next.

3 METHOD AND DATA

In this study, we adopt a comparative approach between languages (cross-linguistically and cross-modally) and also step out from experimental settings and narrative tasks to demonstrate the synergies that arise from face-to-face interactions where signers and speakers are "free" to communicate about any topic.

The research draws from data collected in the United Stated and Belgium, and includes four languages, namely, ASL and American English (AmEng), and LSFB and Belgian French (BF). The data present a novel approach in the fields of gesture studies and SL linguistics in that the films (ASL-AmEng on the one hand and LSFB-BF, on the other) have been collected under the same methodological conditions so that direct comparisons of signers and speakers' communicative practices can be made.

We focus on two manual forms that emerged throughout the interactions by applying a conversational analytic framework that is informed by interactional sociolinguistics (an approach also used in Shaw, 2019 and Lepeut, In press). The premise of this sort of analysis starts with discourse that is as naturalistic as possible so the analyst can examine the ways in which interlocutors draw on their communicative repertoires naturally. Conversation Analysis (CA), originally conceived by Sacks, Schegloff and Jefferson (1974), is a technique that looks at discourse as structured in sequences of turns where interlocutors design their talk (speech, sign) on-site. Utterances are analyzed as linked contingently where a contribution by one interlocutor can be seen as prompting an utterance by another. Within these sequences, people iteratively reveal their orientations to each other and to the content about which they talk.

For the purposes of this paper, four films were selected and viewed multiple times in their entirety before the researchers identified four segments during which several PU and pointing actions emerged. One to 5 minutes (depending on the excerpt) were then closely reviewed turn by turn in ELAN. Following in the tradition of Streeck (2009) and Goodwin (2007), each PU and pointing token was analyzed for co-occurring nonmanual behaviors and their relationship to the prior—and subsequent—turns to situate them within the broader interactive context. After identifying the forms, Bavelas et al. (1995) functional typology was used to attribute the interactive functions, an approach also applied quantitatively in previous work (see Ferrara 2020 for index pointing in NTS, Gabarró-López, 2020 for PU in LSFB and LSC and Lepeut, 2020 for PU and pointing in LSFB and BF). All in all, examining both the form and the function in this way led to conclusions about their interactional meanings in context.

3.1 LSFB and Belgian French

The data for LSFB and BF are drawn from two multimodal corpora: 1) the LSFB Corpus (Meurant 2015); and 2) the FRAPé Corpus (Meurant et al. subm.), the ambient spoken counterpart of LSFB. The LSFB Corpus is the open-access reference corpus for LSFB (https://www.corpus-lsfb.be/). It is composed of data produced by a total of 100 signers (male and female, aged between 18 and 83 years old, and from diverse regions in Belgium). The data collection process in the FRAPé Corpus - ongoing - applies the same methodological process as that of the LSFB Corpus. The FRAPé Corpus is comparable to LSFB in terms of genres, participants and recording environment, so that direct comparisons between both corpora can be conducted when individuals are tested under the same conditions. Only some minor adjustments were done (e.g., task where speakers discuss cultural differences between Walloon and Flemish people in Belgium instead of hearing-deaf culture).

Sessions were guided by a deaf moderator for LSFB and a hearing moderator for FRAPé who guided the different conversational exchanges between the participants through different tasks. For this study, one pair of female LSFB signers and one pair of female BF speakers were selected. LSFB signers talked about the differences between deaf and hearing cultural habits while BF speakers discussed the differences between the Walloon and the Flemish. Although the discussions are semi-directed, participants are free to talk and jump in the conversation any time they want, reflecting the dialogic character of spontaneous conversation (Bavelas et al., 2008).

The video samples were transcribed and annotated using the ELAN software. The ID-gloss technique based on Johnston, (2015) annotation guide was used for LSFB. All transcriptions for speech follow Valibel's transcription conventions (see Bachy et al., 2007). The left and right hands were annotated on two separate tiers. The functions based on Bavelas et al. (1995) typology for interactive gesture as described in section 2.2 was used to annotate the interactive PU and pointing in the data.

3.2 ASL and American English

This section of the paper draws on data collected as part of another comparative study of signed and spoken discourses in the U.S. (Shaw, 2019). The ASL and American English interactions were filmed following sociolinguistic techniques of collecting language data in naturalistic settings (Labov, 1972; Schiffrin, 1987, 1990). Two groups of four people were filmed for just over 1 hour each: one group consisted of four deaf friends using ASL, the other consisted of four hearing friends using American English. The participants already knew each other, and the social

gatherings were not unlike ones they ordinarily had with each other. To provide some structure to both groups, the participants were asked to play the game *Guesstures* and were not instructed to act in a certain way as part of their encounter other than to play the game. Each filming session took place in one of the participant's homes.

Both films were imported into ELAN. Spoken utterances for each hearing participant were broadly transcribed with basic prosodic features (rising/falling pitch, marked emphatic stress, vowel lengthening, speed of production). Manual gestures for each participant were transcribed on separate tiers. Glosses for the manual components and descriptions of non-manual markers of the signed utterances were transcribed in separate tiers for the ASL data.

3.3 Selection of Interactional Gestures in Signing and in Speaking

The selection of the PU and the index pointing as relevant cases for this paper is motivated by two main factors. First, both forms are conducive to examine aspects of the human language ability in achieving specific interactional goals in the social context since they appear to operate as pragmatic. As Cooperrider et al. (2018) highlight for the PU: "[i] f researchers agree on anything, it is that palm-ups are interactional in nature" (p. 5). Ferrara (2020) has also demonstrated that index pointing actions are not solely used for referential purposes but also interactional ones in Norwegian signed conversation and the same holds true for SpLs (see Mondada 2007; Jokinen, 2010). Yet, corpus-based analyses of these two forms from an interactional point of view is lacking and has remained overlooked in gesture and SL research. Secondly, to be able to compare systematically gesture in signing and in speaking, the investigation of identical gestural phenomena occurring in both languages is necessary. Therefore, these two tokens constitute a strong baseline for the current study.

In this paper, PU is defined as resulting from a rotation of the wrist(s) that brings the palm(s) into an upward position, displaying a flat hand with the fingers more or less extended. However, next to this conventional representation, other, less canonical versions of the form may occur and are also considered. The wrist rotation, for example, may be absent if the preceding gesture/sign has already put the hand(s) in this orientation. The same holds true if the hands are already resting on the lap. As a result, the person only needs to bring the hand(s) into the conventional position in space and with the conventional configuration to produce the PU. Similarly, more reduced forms of PU can be performed, without completing the entire 180° rotation but displaying the intention of movement of the wrist(s). These reduced forms have been reported in previous research (e.g., Mesch, 2016; Gabarró-López, 2020) and are defined by Mesch (2016) as a movement when the participant "slightly rotate [s] the wrist so that the palm forms a smaller angle than 90° with the floor" (p. 177). The partial or full rotation of the wrist(s) is of importance here, which also distinguishes it from a mere pointing action of the hand.

While the mere act of pointing may seem trivial at first sight, it remains a multifarious tool (Cooperrider and Mesh, 2022). We follow the definition of Cooperrider and Mesh who define pointing as a meaningful "bodily "movement toward a target—someone, something, somewhere—with the intention of reorienting attention to it" (p. 22), with a focus on points with the extended index only.

In the following sections, evidence drawn from the four languages across modalities is provided. PU and index pointing cases are qualitatively detailed, first in LSFB/BF and next in ASL/AmEng. These instantiations demonstrate how language users from different ecological niches activate their whole body, using similar communicative practices, to regulate the dialogic flow and engage with their addressees in interaction. These examples show the importance and the relevance for integrating these conversational moves within the broader context of language theory, regardless of the modality in which language manifests itself.

4 EVIDENCE FROM FOUR LANGUAGES ACROSS MODALITIES

4.1 Palm-Up and Index Pointing in LSFB and BF Conversations

4.1.1 LSFB

The sequence below illustrates a series of interactive PU and pointing actions in LSFB drawn from a conversation with two female deaf signers, S001 and S002, who discuss differences between hearing and deaf culture. The conversation deviates on the topic of cochlear implants and hearing aids. The example in **Figure 1** begins with the primary signer (S001) explaining that when she visited a school for the Deaf, she noticed a lot of implanted children.

S001, when mentioning there were a lot of implanted children, introduces this content by metaphorically handing over the new information to her addressee, S002 with a PU carrying a delivery function. This PU marks the content of information as new and/or relevant to the main point to S002. In other words, the new content is delivered on the palms of her hands for S002's to inspect. By signaling to the addressee the status of the information, the signer "helps coordinate the understanding of meaning between [signer and addressee]" (Bavelas et al., 1995, p. 395), which is corroborated by the fact that S002 promptly responds to the PU by giving non-manual feedback (a head nod together with an open mouth). By responding to this two-handed PU, S002 signals on a moment-by-moment basis that she has understood the new information. Upon receiving this finely tuned response, S001 directly resumes signing to give her opinion on the matter (in **Figure 1**. "I prefer hearing aids . . . ").

The next two-handed PU by S001 comes right after she expresses her opinion signing "BETTER HEARING. AID IMPLANT NOT AGREE PT:PRO1 IMPLANT PALM-UP" ("I prefer hearing aids . . . I am against cochlear implants you know"). PU can be produced to seek information from others in conversation, therefore serving a seeking function whose aim is to seek agreement, following, or check for understanding and/or attention from the addressee. Here, S001 is seeking evidence of agreement with what she has just uttered, and the meaning expressed in the PU is analogous to "don't you agree with the point I just made?" (Bavelas et al., 1995). In response to the PU, S002 provides immediate feedback with the lexical sign "YES" ("I agree with you"). It is worth mentioning that S001's PU is co-produced with a shoulder shrug, a repeated headshake and down cornered lips that all participate in the meaning-making process. These non-manual features add an epistemic dimension to the PU being performed reflecting the signer's stance on the event talked

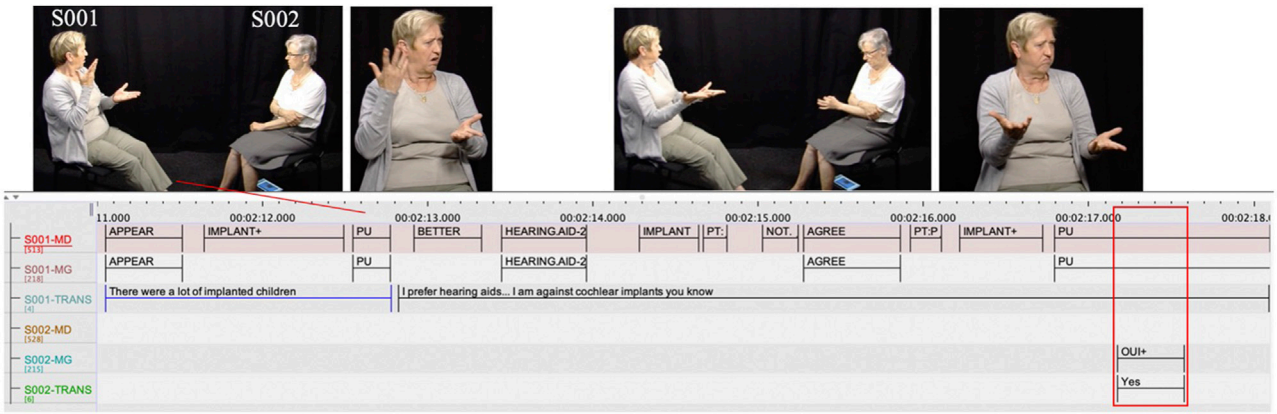


FIGURE 1 | Delivery PU followed by a seeking PU by S001 (LSFB Corpus, 02:11.050-02:18.099).

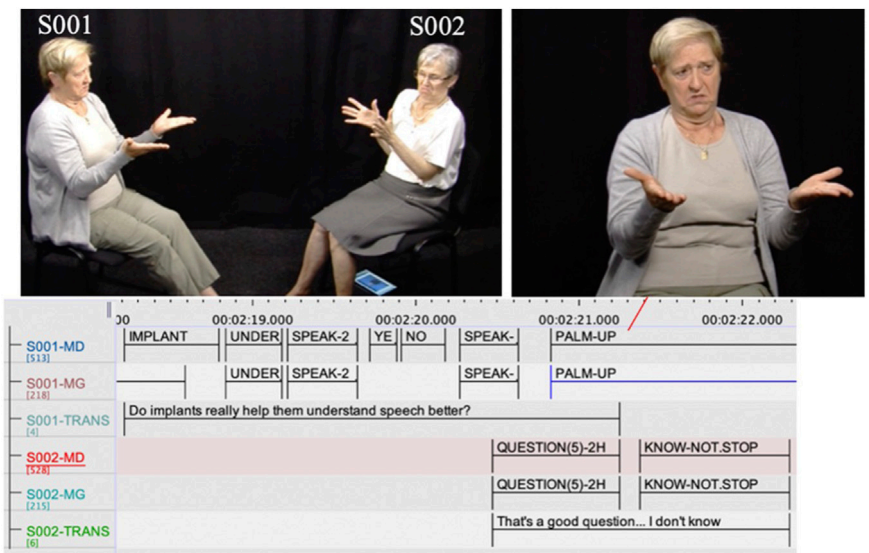


FIGURE 2 | Turn-Yielding PU by S001 (LSFB Corpus, 02:18.212-02:22.287).



FIGURE 3 | Repeated backchanneling pointing by S001 (LSFB Corpus, 02:22.463-02:28.469).

about. The combination of the manual and non-manual aspects illustrates how the signer activates her whole body to convey the intended meaning to her addressee in the interaction.

After producing the seeking agreement PU in **Figure 1**, S001 asks a follow-up question to S002: whether implants help understand speech better (**Figure 2**). She ends her question with a two-handed PU and S002 replies that she has absolutely no idea (QUESTION KNOW-NOT STOP).

In the first part, S001's PU acts as a turn-yielding signal. This token takes place in final position of a yes/no question. As shown in previous SL studies, PU can function as a question particle in yes/no and *wh*-questions (e.g., NZSL; Mckee and Wallingford, 2011). Yet, the change in speakership does not occur instantly as S002 does not have a straight answer to S001's question: "that's a good question. I don't know". As a result, S001 does not bring her hands back to rest. Instead, she keeps them in the exact location, handshape, and orientation characteristic of the PU for more than 5 s (5343 ms) along with a sustained gaze, overlapping with S002's utterance, who introduces a related but new topic in the discussion: "at home my granddaughter is hard of hearing" (**Figure 3**). As S002 elaborates on the topic, which marks a turn transition between both signers and during which other interactional cues emerge in the interaction (viz., S001's two interactional index points as S002 performs PUs in **Figure 3**).

The example in **Figure 3** begins as S002 ends her utterance with a post-stroke hold on the sign "HEARING.BAD" for 407 ms to seek S001's understanding/following. To show her acknowledgement, S001 produces a one-handed index point on her dominant hand (S001-RH) while her non-dominant hand (S001-LH) remains held in the shape of the previous PU. In this case, S001's pointing does not carry referential meaning on its own but it also expresses feedback, highlighting the active role of the addressee in the exchange (Ferrara, 2020). Upon receiving direct confirmation with S001's first index point, S002 produces next a two-handed PU to punctuate her discourse ("Well"), directly followed by a short hesitation hold (368 ms) during which, S001 reproduces the exact same pointing as if to reiterate her backchannel response in case S002 has not received it:

The two instances of interactional pointing contrast with the seeking function observed in **Figure 1**, with the PU as here they do not aim at monitoring the other in the conversation but instead show agreement and/or following. As Ferrara (2020) highlights on pointing in Norwegian SL (NTS), "these showing following/ agreement finger points tell another signer 'ah, I see' or 'yes, I agree with what you are saying,' and thus are examples of conversational feedback or backchanneling" (p. 15).

Alternatively, it is revealing to observe that both PUs in **Figure 1**, and in **Figure 2** occur at the end of S001's utterance. However, the PU in **Figure 1**, aims at getting a feeback response from S002, while in **Figure 2**, S001 ends with her palms facing upwards at the end of her question, offering S002 the floor and leaving room for her reply on the implant question. This echoes previous results on the relevance of addressing specific interactional strategies in the management of SL discourse (Groeber & Pochon Berger, 2014; Lepeut, In press). S001 releases her hold with her hands going back to rest only when the next turn has officially been taken by S002, signaled with S002's PU *mais* ('but'). It has been argued by Groeber and Pochon-Berger (2014) that these subtle actions are non-arbitrary as "the timing of the release is based upon the current speaker's meticulous on-line analysis of the co-participants conduct" (p. 9), which the authors pursue further, the "hold release is key to understanding the interactional job that the hold performs" (p. 10). In this instance, the hold release does not occur until S001 has visibly acknowledged and recognized S002's actions, that is, S002's start of a new turn and upon which S001 finally brings her hands back to rest.

4.1.2 Belgian French

In the following cases, a description of the interactional meanings of PU and pointing in the spoken Belgian French dataset, the FRAPé Corpus, is introduced.

In **Figures 4**–**6**, L001 and L002 talk about the special linguistic situation that characterizes Belgium between the Walloon and the Flemish, and how far this situation goes back in time. Both sit in silence (.) and the example begins with L001 telling her addressee, L002, that Flemish people living in the French-speaking part used to be trialed in French and that her dad used to act as their interpreter. As L001 utters the words "and so <PU> daddy used to . . . " (02:52.559), L002 simultaneously raises her hands from rest position in the shape of a PU (02:52.967) to take the turn, which results in speech and gestural overlaps between L001 and L002's utterances (picture 1, on the left). L002's intervention into the main line of L001's action results in pushing the primary speaker to suspend her speakership to enable L002's intervention. L001 leaves her hands up in midair position as she had not finished speaking but since L002 continues with her utterance, she finally brings them back to rest and L002 takes over (**Figure 4**, picture 2 on the right).

The PU initially performed by L001 is held briefly in midair position as L002 intervenes in the main line of action. L001 is going to bring her hands to rest position, which "leaves the floor to the next speaker and makes the speaker transition effective" (Groeber and Pochon-Berger, 2014, p. 14). This kind of finely-tuned coordination of the co-participants' actions on a moment-by-moment basis, in turn, displays "turn boundaries as flexible, interactionally achieved and unfolding across a certain timespan rather than fixed points in time" in conversations (2014, p 14). How this kind of activity is systematically achieved within and across signed and spoken language interaction awaits future research.

Then, in **Figure 5**, L002 elaborates upon L001's previous turn mentioning that the same situation is still happening today: if people are Walloon but living in the Flemish side - although close to the French linguistic border - they receive all the paperwork in Flemish and not in French. As she is uttering those words, L001 provides feedback to show her agreement with that statement in the form of another PU concurrently reflected in her speech as she says "ah yes" (03:02.632). As both speakers are telling each other that this linguistic situation is not new, a brief silence takes place in the conversation with both of their hands lying in rest position.

In **Figure 6**, L001 is going to produce another PU (03:42.099) to deliver new, relevant information content to L002 by mentioning that the university in Gent, a Flemish city, was French speaking at the time and she holds that PU to obtain some feedback from L002, which she does in the form of a head nod.

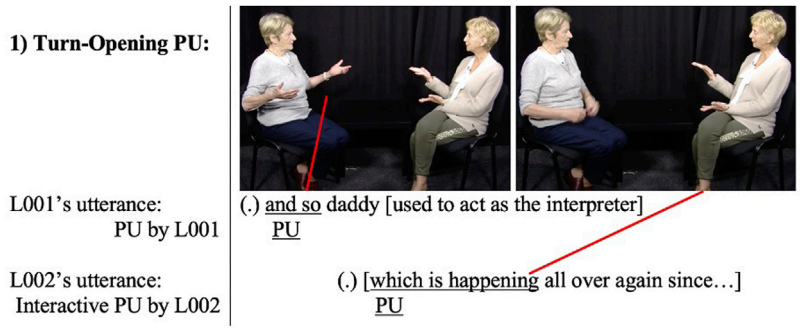


FIGURE 4 | Turn-Opening PU by L002 (FRAPé Corpus, 02:52.999-02:56.276).

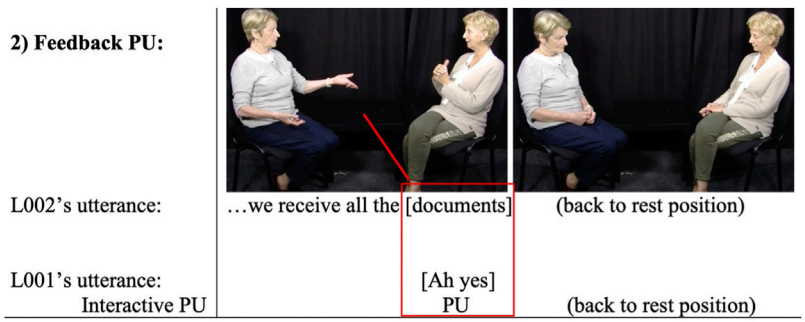


FIGURE 5 | Feedback backchannel PU by L001 (FRAPé Corpus, 03:01.414-03:03.587).

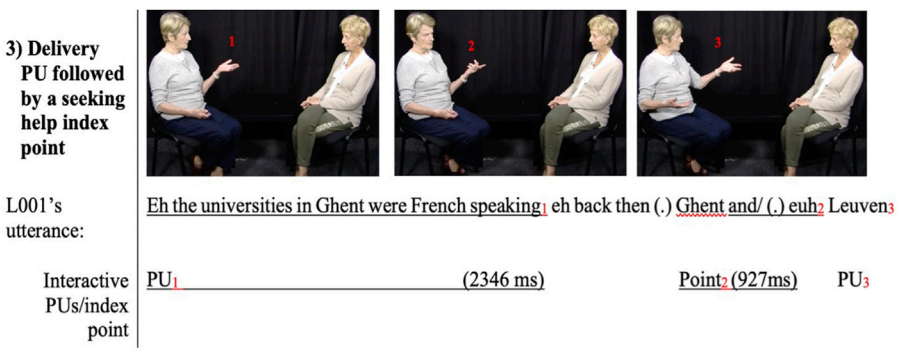


FIGURE 6 | Delivery PU and seeking help index by L001 (FRAPé Corpus, 03:42.099-03:48.827).

As L001 mentions Ghent University, she remembers that there was another Flemish university for which it was similar. Yet she cannot find the name and changes her PU into an index pointing (03:45.688) that she holds for 927 ms, combined with a floating gaze and frowned eyebrows, to seek L001's help during that word search activity. Through the pointing gesture and the hold, together with the hesitation in her speech "and/" and the non-manual activity, she makes a direct reference to her addressee, asking to help with the missing information. But L001 recovers the university name by herself and delivers the missing piece on the palm of her hand to L002 one more time with a PU (03:48.189). The sequence resumes with L001 keeping the floor and elaborating her claim about Flemish universities being French speaking at the time.

4.2 Palm-Up in ASL and American English Conversations

4.2.1 ASL

We turn now to examine the interactive PU in ASL during a 1 min exchange between a wife (P001), husband (P002), and

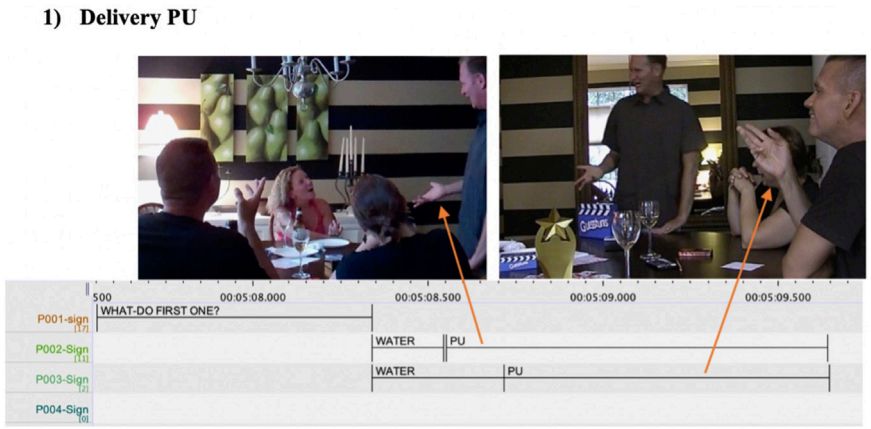


FIGURE 7 | Delivery PU by ASL signers (P002, P003).

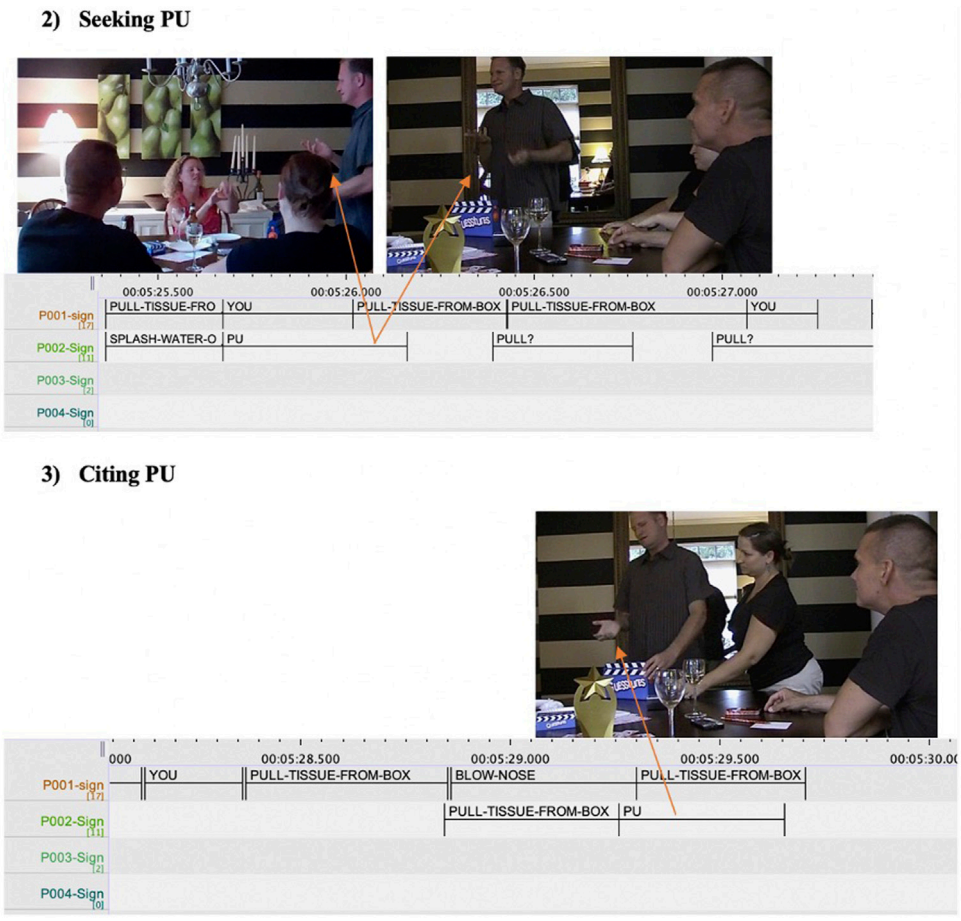


FIGURE 8 | Seeking and citing PU in ASL.

another friend (P003). No pointing actions emerged in this segment (for more details on pointing actions in ASL, see Shaw, 2019). Just prior to the moment of focus here, P002 (standing in **Figure 7**) gestured four clues to P001, two of which, "Water" and "Tissue", she missed. They began their post-turn debrief here when P001 asked "what was the first

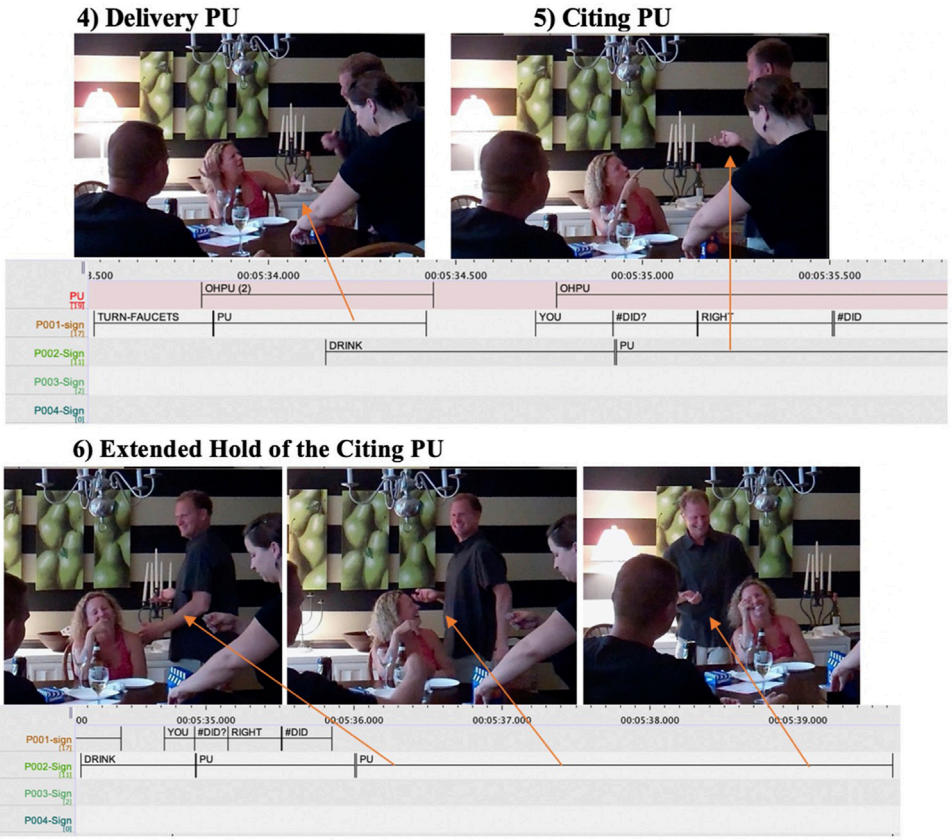


FIGURE 9 | Delivery and citing PU in ASL.

clue?". The participants who knew the correct answer (P002 and P003) both replied "WATER! PU (hold)" (**Figure 7**, 1).

In this example, P002 holds the PU relatively low with respect to his torso—the fingers index toward P001. P003's reduced PU, in contrast, is positioned 90° close to his own face given that he is resting his elbow on the table. Holding the PU in these instances has the effect of delivering new information (i.e., the clue was "water") but the move also implies a sort of judgment of P001 especially by her teammate. The PU presents the clue as obvious, right in front of her, *in the hand*, and hits on two dimensions of the exchange: the interactive and knowledge sharing dimensions. Her response is mild disbelief, her mouth is agape then she purses her lips, blinks her eyes and looks down at the table bashfully for a moment.

Her teammate then informs her of the other incorrect guess ("Tissue") and re-enacts the moves he performed. He then quickly shifts to repeat those he performed for "Water". In **Figure 8** P002 has just acted as if splashing water on his face then produces a PU form. This PU differs from the earlier one in a few important ways. First, the hand is held much closer to the signer's torso and it comes just after a self-initiated turn. If we consider one interactive function of the PU as a vehicle for passing judgment on something, the physical proximity of the form to the signer visibly signals personal evaluation. In this example, his performance of "Water" is the object of evaluation. His turn initiation disambiguates the PU as evaluating his own talk and not that of his interlocutors.

Notice, while P002 presents his performance of "Water", P001 simultaneously enacts her ideas for "Tissue". She begins by acting as if pulling a tissue out of a box. P002 does not understand what is meant by this action—given that his immediately prior utterance concerned his choices for gesturing the clue "Water". We see evidence of his confusion when he repeats the pulling action with lowered brows. When P001 clarifies that she was gesturing "Tissue", P002 repeats the pulling action followed by PU with his head tilted slightly (**Figure 8**, 3). Here, the PU is produced lower in space than the one in example 2) but, importantly, not as low as in the first example (**Figure 7**). Also, P002's gaze is now at his own hand. What can be made of these differences? Given that he just repeated the action that P001 produced, we conclude that this PU cites the information just provided by his interlocutor to the discourse but it also marks his uptake of the information as well as an assessment of the

content. He then asks P001 what he should have done to gesture "Water". P001 replies by acting as if she is taking a long drink from a cup and then turning off faucets.

After P001 provides this suggestion, she produces two PUs with lowered brows, effectively delivering the information and also assessing it as common sense (**Figure 9**, 4 and 5).

In (4), P001's right hand PU is close to her head which is unsurprising given that her elbow is on the table. Her left PU is situated between the interlocutors though. This has the effect of both delivering information and also citing it while her face expresses the evaluation of it. This move essentially ranks her suggestion as common sense (again, *in the hand*) and her teammate's performance as unsatisfactory. The slight is taken up by P002 in his very next turn when he repeats the gestured actions (drinking dramatically from a cup), the ones he had indeed performed during the game. He then flips his wrist into a PU (**Figure 9**, 5) and holds it in place, sustaining gaze with his teammate. P001 immediately realizes her mistake, signing "YOU #DID? RIGHT #DID" ("You gestured that? That's right, you did"). Her teammate does not let her get away with it that easily, though, and holds this PU for a full 4 seconds as he walks behind her, taps her shoulder and makes eye contact with their audience, P003 (**Figure 9**, 6).

This final PU is unlike the others that were held because the signer also physically moves away from where he was standing. Instead of dropping his hand, this hold becomes performative—a metaphorical carrying of the content of his prior turn as if a prize marking that he was right. The semiotic transformation, then, from delivery of information to citing said information while also regulating turns by holding claim to the floor is signaled by the movement of the wrist, eye gaze, non-manual markers as well as the physical positioning of his body. The interactive subtext is that "I was right, you were wrong" in the playful context of healthy competition. The release of the hold (cf. Groeber and Pochon-Berger, 2014; Lepeut, In press) occurs right when he takes his seat and gives his teammate a high five.

4.2.2 American English

Now we turn to a short sequence from the American English data. A series of PU and pointing forms that emerged between four friends (P005, P006, P007, and P008) while they figured out how to play the game. The primary speaker (P005) in this exchange is seated on the far left and holds the instructions as she shifts between reading and informing the group of the rules. This 1 min exchange begins when she reads aloud, "Two teams . . . " while producing a PU (**Figure 10**, 1).

The speaker rotates her left hand to PU and holds it there for a full 5 seconds despite the fact that her speech trails off after uttering "Two teams". Holding the PU serves multiple functions here. It begins as a classic delivery gesture where the content, "two teams," is metaphorically relayed to the group, just as her hand rotates to supine position. But when coupled with her eye gaze which is directed, not at her interlocutors, but the instructions, the form takes on a turn-regulating function as well, signaling to the group that she is not done reading and still holds at least partial claim to the floor. The woman sitting next to her on the couch, P006, reinforces this by whispering to P008 (seated on the floor opposite her) "You wanna sit here?" This turn prompts P005 to look up at the addressed but not relinquish the held PU (**Figure 10**, 2).

Just after this moment, the primary speaker returns her gaze to the instructions and briefly closes her fingers of the left hand saying, "So does anybody have any preference for teams?" Upon uttering 'teams', she extends her fingers into a fully opened PU (**Figure 11**, 3).

This repetition of "teams" is embedded in a request for preferences of teammates. She also repeats the PU but this time holds it fully open for 4 seconds. Her couch neighbor takes up the second position, replying, "Well, tell us what we need to do first" at which point P008 starts to wave an open PU toward P005 (**Figure 11**, 4). The movement catches P005's eye and she briefly looks up at P008 just as she retracts the PU (not pictured). What is worth noting in this instance is that when she moves the PU in P005's direction, P008 has not verbally said anything; P006 has. After P008 signals the PU toward P005, P008 simply says "Yeah", taking up P006's suggestion while also reinforcing P005's role as holding the knowledge contained in the instructions. All this time, P005's PU is held in space, retaining a visible trace of her prior turn and also sustaining her claim to the floor. The question becomes how to interpret P008's PU form—whose talk is it citing? Is she trying to initiate a turn? It is not entirely clear until she utters "Yeah" agreeing with P006's suggestion that P005 relay the instructions first.

The next series of turns involves deciphering who is supposed to pull a card out of the game box when a clue is correctly guessed. P005 retracts her PU and at the same time the other participants weigh in on possibilities—how do the cards drop into the box? Does the guesser or the gesturer pick out the card when a guess is correct? P005 continues to read silently and then finds out that it is the gesturer who is responsible for grabbing the card. She begins by saying "Ohhhh" marking new information (Schiffrin, 1987), then reads aloud "you have a few seconds to get your team to guess the word and grab the card . . . before it drops out of sight and out of reach." This information prompts P007 and P008 to echo "Ohhhh" with the same rising-falling intonation that P005 uttered. New information has been introduced and P007 playfully adds "Guess and grab. Guess and grab." It is this last contribution that prompts P005 to edit by responding, "Well, guess, con*firm* and grab." During this utterance, she produces a quick sequence of gestured forms that cite prior talk while adding epistemic judgments about it.

First, she produces a pointing action directed toward P007, citing P007's prior utterance ("Guess and grab") (**Figure 12**, 5) but, in concert with the speech, also signals that what she is about to say contrasts with the prior turn. P005 quickly flexes

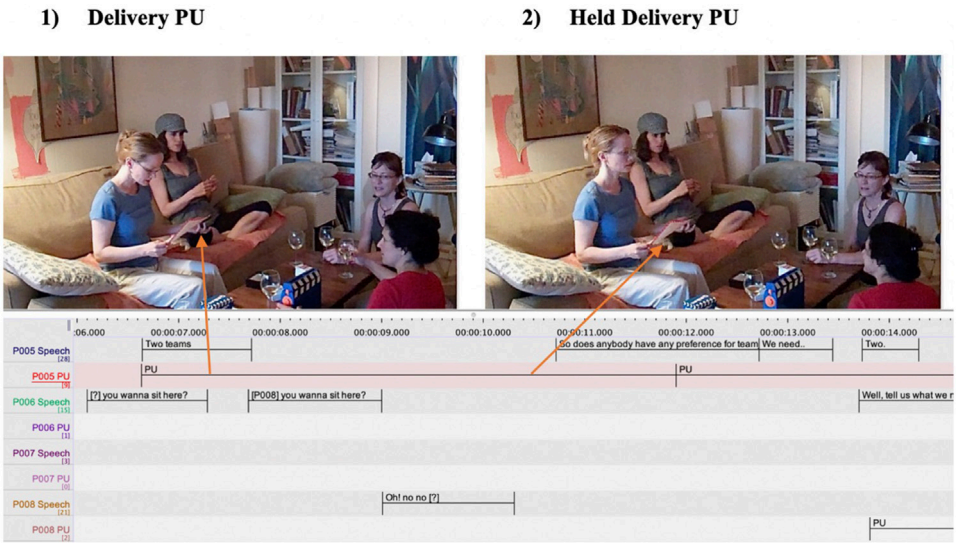


FIGURE 10 | Delivery PU in American English.

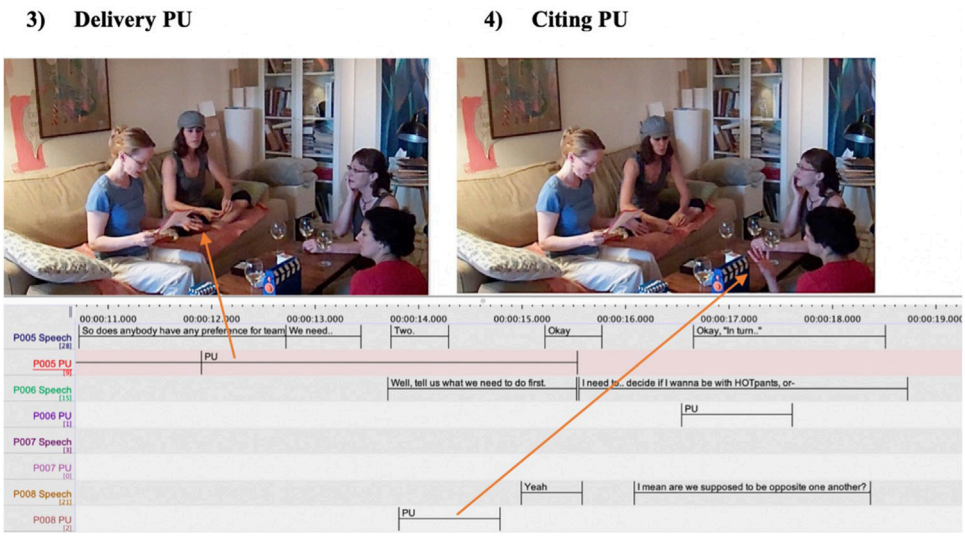


FIGURE 11 | Delivery and citing PU in American English.

her wrist on the first syllable of "confirm" which results in the point being oriented in an opposite direction (not pictured). Then she tosses a PU toward P007 on "grab" (**Figure 12**, 6) effectively delivering the edited utterance back to the primary author of the original turn.

The manual actions are produced quickly but they accomplish a few interactive and knowledge sharing tasks. The initial point coheres P005's contribution to P007's prior talk while signaling something unexpected is to come (cf. the discourse marker *well*, Schiffrin, 1987). The second point could be said to symbolically illustrate contrast to P007's talk (that the player does not just guess and grab the card but also has to confirm that it was correct) by pointing in the opposite direction. After staking this claim and delivering it back to P007, P005 ends up hedging by saying "I guess". She opens a PU while shrugging slightly and drawing down the corners of her mouth (**Figure 12**, 7).

5 DISCUSSION AND CONCLUSION

This paper reported cases of the PU and index pointing action in different signing and speaking contexts from an interactional perspective. These forms accomplish an array of pragmatic

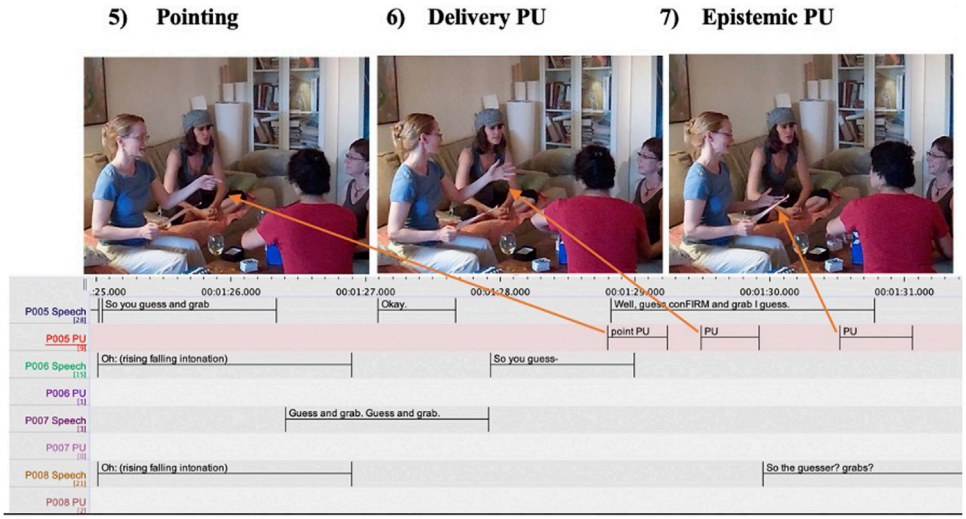


FIGURE 12 | Pointing, delivery PU, and epistemic PU in American English.

moves—citing, seeking, delivering information and regulating turns. How do interlocutors discern the differences? It appears that several co-occurring bodily expressions are key to disambiguating the meanings. First, location in space and movement—the extension of the hand near or far from the torso as well as the movement of the hands toward an interlocutor helped to distinguish its meaning. Second, eye gaze—whether the participant looks at their interlocutor or elsewhere seems to make a difference in the function of the form. Third, facial expression—the PU, in its simple form allows other articulators like the face, torso and head, to take central stage and indeed the co-participants respond in kind. And finally, prior utterances - whether the PU is produced inter- or intra-signer/speaker plays a part in the form's interactive meaning.

While language conveys propositional information, it also conveys social meaning. This latter dimension of language use (including how interlocutors discern the meaning of the moves), has received short shrift in linguistic theories. These data show that when there is an open floor, interlocutors negotiate turns as well as knowledge-sharing all at once. The turn-taking mechanism triggers sensitivities to all the social relationships between them. But when they are also negotiating common ground, they mark epistemicity too, which shifts dynamically as time unfolds. People are adept at expressing and interpreting these micro-moves on-line, but the coordination takes work—work that is made evident through their bodies.

What do these forms tell us, then, about each of these aspects (relational and informational) of interaction? We can look at the moment-by-moment unfolding of the interaction to uncover what the form means (or, stated differently, what it accomplishes). Linguists interested in interaction often describe conversations as jointly constructed. This perspective calls into question who 'owns' the ideas expressed in the turns. When people meet face-to-face, the meeting of the minds can be seen through the participants' bodies. The raised PU and pointing actions between two interlocutors activate the space between them—they do not contribute substantive content, there are no images per se that could be abstracted from them. Rather, they signal attunement, a visible presentation of intersubjective intentions. And they emerge systematically across at least four distinct ecological niches.

The overlaying of social with linguistic moves allows the researcher to account for these seemingly impromptu forms that challenge theoretical boundaries between gesture and sign. It is high time to go beyond the inner, cognitively driven models of gesture to include a more socially regulated conception of it. Gesture is not exclusively an *intra*-personal phenomenon revealing the imagistic side of language (as advocated by McNeill, 1992 and Goldin-Meadow and Brentari, 2017), but it is also highly *inter*-personal, assisting the dialogic process of interaction by regulating the dynamics of the speaker-addressee relationship and managing aspects of interaction itself. We push forward the claim that both signers and speakers' bodily expressions are cut from the same cloth (Kendon, 2004, pp. 307–325). Therefore, more gradient-gestural expressions should not be seen as outside language in any modality. On the contrary, when communicating, all individuals draw on diverse resources from their available semiotic repertoires in the here-and-now (Ferrara and Hodge, 2018). These resources can be interpreted as linguistic, in the sense of belonging to the realm of language as a system but also part of the multimodal components, including these more gradient-gestural phenomena. These two sides are not mutually exclusive, and they need to be considered as equal components of language, as both sides of the same coin.

To account for this social, interactive nature of gesture in language, the diametric opposition between sign and gesture, the linguistic vs the non-linguistic, needs to be left behind in favor of a more encompassing and integrative definition of language as a system and as a situated practice (Murgiano et al., 2020). The acknowledgement of interactive mechanisms in signers' discourse that are typically not considered part of the signing stream, part of language, but that resemble those deployed by speakers in SpLs, allows scholars to contend that humans use their bodies in parallel and meaningful ways.

DATA AVAILABILITY STATEMENT

Videoclips have been made available through OSF at: https://osf.io/dkr6w/. Further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

Both AL and ES conceptualized the study and analyzed their data (LSFB/French: AL and ES: ASL/AmEng) and wrote 50% of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2022.780124/full#supplementary-material

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MINI REVIEW
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French Sign Language/French Translation Studies in France: A Mini Review

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In this mini review, we present an overview of existing research in French sign language (LSF)/French translation studies in France. The practice of LSF/French interpreting is ancient, since traces of it can be found in the High Middle Ages, but its professionalization is more recent (it dates from the Deaf Revival of 1975–1995). The profession of French to LSF translator is even more recent: it dates from about 10 years ago. Following this professionalization, translation studies research emerged about 30 years ago. It has been developing particularly over the last 20 years, driven by university programs (MA in LSF/French interpretation and translation). This research is multifaceted and is not confined to a single discipline. Indeed, translation studies are inherently multidisciplinary, and we can find references to translation and interpretation in historic, linguistic, sociologic, or computer science studies, among others. Moreover, translation studies are also part of different schools of thought, which can be explained historically. In this paper, we present an overview of translation research concerning LSF/French interpretation and translation (practiced by both deaf and hearing people) in France. We also address the prospects for further developments, related to the emergence of new practices, and the question of the didactic applications of these different researches in the field of interpreters and translators training within 5 universities in France.

Keywords: French sign language, LSF, French, interpretation, translation, translation studies

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INTRODUCTION

There are several definitions of translation studies, ranging from a very narrow focus on interpretative techniques to a very broad multidisciplinary perspective[1]. In this article, which concerns LSF/French translation studies[2], we consider translation studies to be the scientific study of translation/interpretation and all that is related to it, both in theoretical and practical terms, in a Deaf Studies vein. Because of the size limitation of this article, we do not intend to present an exhaustive list of translational research in France today. Instead, we have chosen to present a general overview of this issue, historically contextualized, and the links with education and ongoing or planned research.

[1]This text was translated into English with the help of Madeleine Papiernik.
[2]In both ways: from French to LSF and from LSF to French.

A CONTEXTUALIZED RESEARCH

Translation studies research in France is historically linked to the emergence of the interpreting and translating professions and is based on linguistic and translation models but it is also based on ideas developed within the training courses. It is the importance of these complementarity fields that we wish to highlight.

History of LSF/French Interpretation and Translation

The oldest traces of interpretation in France between sign language (SL) and French date back to the High Middle Ages (Cantin, 2021, p. 17–30). This shows us that this practice is very old. The interpreters mentioned in the sources were not paid professionals at that time. They were hearing people, close to and in contact with deaf people: friends, family, neighbors, or monks when the deaf person lived in a Catholic order, who were called upon to act as interpreters when necessary. From the eighteenth century onwards, the deaf began to be more educated, thanks to the creation of a school by the Abbé Charles-Michel de l'Epée (1712–1789). From the end of the eighteenth century to the end of the nineteenth century, the sources mention interpretations made by deaf people themselves (senior students or teachers), who had the best mastering of written French and who could use this medium to interpret to less educated deaf people. Their interpretation was accepted by the courts, then the town halls and other jurisdictions (Encrevé, 2012: 58, p. 149–152). Linguistic and translation research as we understand it today did not exist at that time. However, there were reflections and actions, such as those of Auguste Bébian (1789–1839, for linguistic description) or those of Ferdinand Berthier (1803–1886). Berthier was a deaf teacher at the National Institution for the Deaf and Mutes in Paris, he was an interpreter, writer and famous activist for the rights of the deaf to use SL in all fields via competent (deaf) interpreters. Unfortunately, the Congress of Milan of 1880 was followed very strictly in France, which resulted in the banning of SL from deaf schools (Encrevé, 2012, p. 297–322). As a result, schools for the deaf could no longer provide interpreters: deaf teachers were dismissed and hearing teachers were no longer taught SL. Therefore it was once again the relatives of the deaf who served as interpreters. The following decades, with two world wars and economic crisis, did not bring about any major changes for deaf people or SL and interpreters (Bernard et al., 2007).

Everything changed with the Deaf Revival, a deaf protest movement that started in 1975 (Cantin et al., 2019, p. 148–151). Deaf people and hearing people who supported them (academics, artists, speech therapists, teachers, interpreters and parents of deaf children) asked for the right to use SL (renamed LSF in 1978) in all fields, including education. LSF began to be taught to hearing people, thus opening the door to future generations of interpreters with no close ties to the deaf. The interpreting profession also began to structure itself (Encrevé, 2014, p. 9–11): the interpreters' association was created in 1978, under the name "National Association of Interpreters for the Hearing Impaired". It is now called the "French Association of Sign Language Interpreters and Translators" (AFILS). This semantic evolution is significant: the interpreters who created the association were still close to deaf people, motivated by the idea of helping the disabled, not yet aware of the linguistic value of SL (like many deaf people themselves), trying to bring SL closer to the standard of written French (Séro-Guillaume, 1994, p. 40), and working on a voluntary basis. Today's interpreters are paid and trained professionals who work between two languages and two cultures. As a sign of this evolution, in 1988 the association adopted a code of ethics which still governs professional practice today. The first interpreter training courses were created in the 1980s and today there are five universities that each deliver a master's degree in LSF/French interpretation: Lille, Paris 3 (ESIT), Paris 8, Rouen and Toulouse (Encrevé, 2014, p. 13). The profession of translator has emerged even more recently, thanks to the opening of a dedicated training course at the University of Toulouse in 2005 (essentially for translators into LSF, i.e., deaf people) and it has since been supplemented by a training course at the University of Paris 8 since 2020 (which provides training in both languages but which wishes to develop translation into French). The profession of translating has grown simultaneously with the development of analogical then digital video, providing a new medium in which SL could be "written" (Gache, 2014). Today, despite the lack of official data, we estimate that there are around 600 qualified interpreters and 10 trained translators.

Translation Studies Research and Its Relevant Theoretical Models

Because of this recent professionalization, translation studies research emerged mainly since the year 2000. For historical reasons, universities training courses for interpreters are offered both in specialized interpretation and translation centers (D-TIM at the University of Toulouse-Jean Jaurès, ESIT at the University of Paris 3) and in linguistics studies departments (Universities of Paris 8, Rouen and Lille; Encrevé, 2014; Garcia and Burgat, 2016). Therefore, they are driven on the one hand by linguistic models of LSF and on the other hand by translation models of all languages. In France, Christian Cuxac and his collaborators are developing, at the University of Paris 8, the semiological approach, which occupies a central position in the LSF linguistics (Garcia and Sallandre, 2020). Cuxac progressively built his approach from the study of the deaf community, its language and the education of deaf children (Cuxac, 1983, 2000), then he proposed a complete SL description model. This approach aims at explaining the structural functioning of SL and demonstrating the linguistic value of iconicity. It supposes that iconicity is a core system but is also a view of the world based on a practical perception of reality. Indeed, it shows that deaf people, because of their deafness, apprehend the world only via the visual-gestural channel rather than the audio-phonatory channel, which impacts the linguistic structures of the language. The semiological approach is a linguistics analysis, based on a corpus of deaf people's spontaneous production, which has developed its own tools to update the linguistic categories of this language. It is the opposite of previous linguistics works which aimed to try to describe the SL through the framework of spoken languages, by excluding their specificities, especially iconicity (Stokoe, 1960).

The semiological approach is followed by three university courses for interpreters out of the five existing in France: Paris 8, Rouen and Toulouse, and is complemented by a multidisciplinary approach to deaf studies: history, sociolinguistics, didactics, etc.

The other training programs follow different models. University of Lille is in line with international research on SLs in cognitive linguistics, based on the syntactic studies developed by Risler (2000) and based on Anglo-Saxon works (e.g., Liddell, 2003). The singularity of the training offered by ESIT at the University of Paris 3 is that it is not based on a particular linguistic model. It uniquely adopts the translational theories of speech languages, trying to show how LSF can fit into the same framework (Pointurier-Pournin, 2014). Concerning translation models, the various training courses consider that the heart of the translating activity is the meaning. They all refer to the interpretive theory of translation (Seleskovitch and Lederer, 1984), which invites the interpreter and the translator to understand (deverbalize) and then re-express (Burgat, 2014). They all rely on Gile's (1995) model of efforts to train on simultaneous interpretation. This model has been reworked for SL interpreting to define "6 stages of interpreting mechanisms," used by the training courses of Lille, Paris 8, Rouen and Toulouse (Bernard et al., 2007, p. 86–87). The Paris 8 and Toulouse courses also follow Katharina Reiss' theory on text types, combined with Hans Vermeer's *skopos* theory (Reiss and Vermeer, 1984). While the Paris 3 (ESIT) course prefers Philippe Séro-Guillaume's principles (Séro-Guillaume, 1994) combined with the *skopos* theory. It should be noted that the translator courses at the universities of Toulouse (opened in 2005 and becoming a master's degree in 2021) and Paris 8 (opened as a master's degree in 2020) follow the same linguistic and translational models as the associated interpreter courses (Leroy et al., 2019).

Research-Training Links

Because research on LSF has promoted deaf language and understood its profoundly iconic nature, most training programs encourage young interpreters to produce their interpretations in the most iconic LSF variant possible, rather than in a version closer to French (Burgat and Encrevé, 2015; Burgat, 2021). For all of them, interpreting in signed French is not acceptable, and students need to move away from linear SL and train to express themselves in the most spatial, iconic, and expressive SL as possible. Variations exist depending on the linguistic models favored. In spite of their differences, all these training courses ensure a similar way of interpreting practices and define the identity of the interpreting profession. Deaf speakers are considered as speakers of a language in its own right (with the same linguistic value as a vocal language), considered as equal as hearing speakers and not as people with deficits. This results in a specific positioning of the French/LSF interpreters taught in training: they are professional interpreters, who are not helpers, nor teachers for the deaf, nor social workers. The interpreters' professional practice contributes to allow deaf people to fully take their place in the interaction. By respecting their autonomy rather than by doing things in their place, deaf people are viewed as equal to hearing people.

Today, the number of researchers in LSF translation studies (many of whom are certified interpreters) is still low in France, but it is increasing. With this in view, research by teachers and students should be seen as complementary, as many masters' thesis complements professional research in French translation studies. Approximately 40 dissertations are written each year by interpreters and translators' students. We have explored about a hundred student master's thesis over the last 20 years, in all universities. There are a large number of dissertations on the different fields of intervention of French/LSF interpreters (medical, legal, social, health...), on specializations (VRI, tactile LSF...) or on specific audiences (migrants, deaf people with associated disorders...). Other subjects which are widely studied are focused on professional aspects, such as the evolution of the interpreter's profession from an historical point of view, working conditions, professional illnesses, the economy of the interpreter's profession, professional retraining, but also legal, ethical and deontological, and technical aspects (deverbalization, schematization, cognitive functioning of the interpreter...). We can also see that students are concerned about deaf and hearing users by the number of dissertations in sociolinguistics (language variants and registers in interpreting, language contacts, diglossia, etc.). There are not many dissertations on the structural functioning of the LSF. Three of the five interpreters' master's degrees are integrated into linguistics programs. But because the master's degrees are accessible with a bachelor's degree not necessarily in linguistics, dissertations on linguistics and interpreting are in the minority overall (they tend to focus on lexical units: terminology, lexical creation, etc.). Finally, there are very few dissertations which deal with pragmatics (interpretation and implicit or stereotyped language/ambiguous speak and interpretation...). Of course, this list is not exhaustive. These master's thesis are creating new avenues of research, to be explored deeply, and to be valued and promoted in the scientific community. These new and diverse subjects show an ever-growing change within the profession and the research around it.

DISCUSSION AND POTENTIAL FUTURE DEVELOPMENTS

Research in LSF/French translation studies is constantly being enriched by new fields; we present two of the most polemic subjects at the moment.

The first field is research in automatic SL processing between French and LSF, regarding translation and interpretation, which is mainly conducted by the M&TALS[3] team in the LISN[4] laboratory from the Paris Saclay University. It began with Annelies Braffort PhD thesis in 1996 (Braffort, 1996) whose aim was to recognize and try to understand gestures from LSF. Almost 25 years later, the thesis of Segouat (2010) was about translating from French to LSF using a virtual signer (i.e., a virtual character

[3]Modélisation et traitement automatique des langues des signes, https://tals.limsi.fr/ (06/07/21).

[4]Laboratoire interdisciplinaire des sciences du numérique, https://www.lisn.upsaclay.fr/ (06/07/21).

performing SL) for the french railway transportation system. The aim of the thesis was to build a system parallel to the vocal one, that would use small pieces of pre-animated SL (instead of vocal ones) to give the information in SL thanks to a virtual character. For this system to be producing a quite natural language, the author focused on the study of the coarticulation phenomena, which is the ability of linking pre-recorded pieces of language and rendering them in the most natural way. Therefore, these pieces may have to be modified to be linked together, and the modification differs depending which piece you link to another. This was not really a translation system, but it was a first study of how LSF could be generated automatically and naturally from pre-built animations.

Nowadays, the M&TALS team is focusing on translation systems in different ways. Firstly, thanks to a specific corpus analysis,[5] they have identified several production rules. These rules allow one to juxtapose signed units. They also have described how these rules could be used as a system to model an entire utterance in LSF, fully respecting the simultaneity of the language. Members of the team[6] also worked on providing tools to help translators' work, in the field of computer aided translation (CAT). They started from identifying the necessary steps in the text-to-sign translation process: they filmed translators (both deaf professionals and hearing interpreters) in their work, from reading text for the first time to the delivery of a translated result. Several tasks were identified, and some did not fit the process proposed in existing CAT systems, such as the principle of linearity, which is the fact that one text translated to another can be segmented into parts that will be in the same order in both texts, the translated one and the translation. It appeared that a big step of the process consisted of re-organizing ideas from the text so that the SL version was no longer alignable with the original source. They also suggest adapting a concordancer to SL to serve as a translation archive, meaning that when the translator has finished their translation work, they need to link translated parts of their work and store them in a database. Afterwards, they and other translators can access this database to query and re-use these translations. The same authors also conducted a study on how the interface of a CAT designed to be used with SL should looks like.[7] They provide within their designed interface a way to re-organize ideas from the text to the SL version. Their idea is to use blocks which users can manipulate visually and can put text, picture, maps and manual drawing. The blocks can be used as a prompter while the translator if filming themself for the final product. Moreover, the interface would also provide an encyclopedic assistance for lexical searches, such as looking-up definition, map search, picture search, and encyclopedic searches for context. Their first prototype is currently under development and is about to be available online for professionals to test. Kaczmarek and Filhol set up the concordancer and made it available online[8], it is said to be potentially useful in teaching LSF but also in teaching translation and interpretation methods by displaying lists of examples and counterexamples of translations, as it shows aligned parts in French text and LSF. The M&TALS team is also involved in various research projects, such as Rosetta[9] and EASIER[10]. Both of these projects have no results nor publications yet.

The second field is the position of deaf interpreters in France. The development of the interpreting and translating professions history, shows that the three main functions performed by one deaf interpreter in the Anglo-Saxon world are practiced by two to three different people in France. These three professions are: translation into LSF (a profession in its own right, master's degree), international sign/LSF interpreting (a function for the time being performed by translators or not, with no diploma at this time), and intermediation (a profession in its own right, master's degree). This separation between these functions works well and there is a good relationship between hearing interpreters, deaf translators, and interpreters. For a few months now, two translators (trained in co-interpretation at the World Association of Sign Language Interpreters via the technique known as "feeding" in the Anglo-Saxon world), have been experimenting with live and recorded interpreting in pairs with hearing interpreters. The practice is still being debated and needs to be better defined but its use is being developed. Master's thesis and research articles are being written on this issue (Cantin and Encrevé, 2022, in press), which is why we cannot go into further detail.

CONCLUSION

To conclude, we have attempted in a reduced format to present an overview of LSF/French translation studies research in France, which is a growing discipline. Thanks to the increasing number of deaf students, leading to potentially more deaf researchers, we can hope that research related to SL in France will lead to a better recognition of deaf people, their language and the professions of translator and interpreter.

AUTHOR CONTRIBUTIONS

SB, FE, and JS make substantial contributions to the conception. All authors contributed to the article and approved the submitted version.

[5]See Mohamed Hadjadj, Michael Filhol, Annelies Braffort. Modeling French Sign Language: a proposal for a semantically compositional system. International Conference on Language Resources and Eval-uation, ELRA, May 2018, Miyazaki, Japan: https://hal.archives-ouvertes.fr/hal-01848986/document (06/07/21).

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[8]https://platform.postlab.fr (06/07/2021).

[9]https://rosettaccess.fr/ (06/07/2021).

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Predictive Processing in Sign Languages: A Systematic Review

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The objective of this article was to review existing research to assess the evidence for predictive processing (PP) in sign language, the conditions under which it occurs, and the effects of language mastery (sign language as a first language, sign language as a second language, bimodal bilingualism) on the neural bases of PP. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. We searched peer-reviewed electronic databases (SCOPUS, Web of Science, PubMed, ScienceDirect, and EBSCO host) and gray literature (dissertations in ProQuest). We also searched the reference lists of records selected for the review and forward citations to identify all relevant publications. We searched for records based on five criteria (original work, peer-reviewed, published in English, research topic related to PP or neural entrainment, and human sign language processing). To reduce the risk of bias, the remaining two authors with expertise in sign language processing and a variety of research methods reviewed the results. Disagreements were resolved through extensive discussion. In the final review, 7 records were included, of which 5 were published articles and 2 were dissertations. The reviewed records provide evidence for PP in signing populations, although the underlying mechanism in the visual modality is not clear. The reviewed studies addressed the motor simulation proposals, neural basis of PP, as well as the development of PP. All studies used dynamic sign stimuli. Most of the studies focused on semantic prediction. The question of the mechanism for the interaction between one's sign language competence (L1 vs. L2 vs. bimodal bilingual) and PP in the manual-visual modality remains unclear, primarily due to the scarcity of participants with varying degrees of language dominance. There is a paucity of evidence for PP in sign languages, especially for frequency-based, phonetic (articulatory), and syntactic prediction. However, studies published to date indicate that Deaf native/native-like L1 signers predict linguistic information during sign language processing, suggesting that PP is an amodal property of language processing.

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PREDICTIVE BRAIN

Our understanding of the human brain as a source of cognition has historically focused on the brain as generating a response to external stimuli. Recently, there has been a paradigm shift in the field of cognitive neuroscience. The traditional concept of the brain as a passive, bottom-up receiver of external information has been replaced by the notion of the brain as an active predictor of the environment, generally termed as predictive processing (PP). The main idea behind the PP is that "the brain is a sophisticated hypothesis-testing mechanism, which is constantly involved in minimizing the error of its predictions of the sensory input it receives from the world" (Hohwy, 2013, p. 1).

In the last decade, the notion of PP has gained wide recognition as a model of cognitive processing applied to a variety of brain functions (Friston, 2010; Clark, 2013; Hohwy, 2013; Chanes and Barrett, 2020; Ficco et al., 2021; Perrinet, 2021), including language production and comprehension (Federmeier, 2007; Altmann and Mirković, 2009; Huettig, 2015; Lewis and Bastiaansen, 2015; Kuperberg and Jaeger, 2016; Ferreira and Qiu, 2021). Several aspects of the mechanism of PP have attracted the attention of researchers seeking to specify the model in more detail. These include the modality-dependent structure of hierarchical predictions and the interplay between prediction errors at various levels of linguistic processing (e.g., syntax vs. semantics).

Predictive Processing and Language

Most studies that addressed PP in language comprehension used the visual modality (i.e., reading) to assess PP in spoken language processing (e.g., Szewczyk and Schriefers, 2013; Bonhage et al., 2015; Wlotko and Federmeier, 2015; Rommers et al., 2017). In general, they report that prediction facilitates language comprehension. In the auditory modality for speech, multiple electrophysiological indicators in time- and frequency domains characterize automatic predictive processing at a range of scales (see Bendixen et al., 2012, for a review). Moreover, studies using simulation/modeling approaches to speech perception (Donhauser and Baillet, 2020) have shown that distinct types of PP (e.g., based on uncertainty vs. surprise metrics for phoneme sequences) elicit responses at different frequencies. This suggests that in human speech signal, PP concurrently proceeds at multiple scales.

The studies that have investigated scale-specific PP in human language from the point of view of specific levels of language structure consistently uncovered predictive processes at the levels of the language studied, e.g., phonology (Donhauser and Baillet, 2020), form and meaning (Freunberger and Roehm, 2016; Ito et al., 2016), or syntax (Yoshida et al., 2013; Bonhage et al., 2015; Droge et al., 2016). Studies at the interface between syntax and semantics, e.g., studies on disambiguation of garden-path sentences (reduced subject and object relative clauses in English), have shown that prediction errors are detected and further predictions refined at the earliest when critical linguistic information (either syntactic or semantic) is available for the language in question. For example, a magnetoencephalographic (MEG) study of Dutch language processing (Lewis et al., 2016) has shown that the difference between subject and object cognates affects neural processing at the position of the auxiliary indicating the grammatical number. Studies on the contribution of verb and noun semantics to the disambiguation of relative clauses in English (Malaia et al., 2009, 2012, 2013; Malaia and Newman, 2015) have shown that participants consistently relied on prior linguistic information (e.g., noun animacy, verbal telicity) when interpreting incoming words in complex sentences. However, participants quickly revised their predictions when they received either new semantic or new syntactic information, depending on what had previously occurred in a given sentence. This group of studies provided important supporting information for rapid error correction across linguistic interfaces.

Models of Predictive Processing

The concept of PP is not a unitary concept; among the multiple models developed, some aim to describe and predict cognition or decision-making processes in general; others focus on the mechanisms underlying linguistic prediction. The core mechanisms involved in PP, which appear across multiple models, and have been confirmed across multiple experimental studies, include top-down processing, statistical estimation, hierarchical processing, prediction, prediction error minimization, Bayesian inference, and predictive control (for a detailed review see Wiese and Metzinger, 2017). Huettig (2015) proposed a taxonomy of PP models based on (1) the type of data the models aim to explain and predict, and (2) the mechanisms (cognitive or neural) purported for the model, arriving at four broad groups.

The first group of models (Kuperberg, 2007; Kahneman, 2011) with general domain of application (cognition or language) assumes two different mechanisms (systems) involved. The first system ("thinking fast") relies on rapid re-activation of prior knowledge based on incoming information; the second system relies on conscious allocation of cognitive resources optimized for the task at hand (i.e., "thinking slow") (Kuperberg, 2007; Kahneman, 2011). Secondly, there is a group of models that claim that both linguistic and non-linguistic PP rely on the same predictive mechanisms (Altmann and Mirković, 2009), and that linguistic prediction relies on event knowledge (Metusalem et al., 2012).

Another group of PP models is grounded in production-based approaches to predictive processing. For example, Pickering and Garrod (2007, 2013) suggest that production systems facilitate language comprehension via forward models. Specifically, they argue that the comprehender performs a covert imitation, which is realized as a motor simulation of the speaker's utterances. Dogge et al. (2019) proposed Hybrid Prediction Model that, in addition to motor forward modeling, includes predictive coding that does not rely on efference copies of the motor simulation. Another production-based model of PP is the PARLO (Production Affects Reception in Left Only) framework proposed by Federmeier (2007). According to PARLO model, the left hemisphere is more prone to top-down processing; and, since the areas for language comprehension and production are predominantly found in the left hemisphere, this results in strong feedback connectivity in support of PP.

Huettig (2015) also proposes a multiple-mechanism model for linguistic PP, named PACS (production-, association-, combinatorial-, simulation-based prediction). Huettig suggests that, given the complexity of the PP phenomenon, multiple mechanisms may be involved in predictive processing, depending on the task and/or user experience in specific context and interact with each other. For example, comprehenders might use fully specified production representations for producing a predictive model or refine the model using simple associative mechanisms. The combinatorial component of the model emphasizes the interaction of multiple linguistic constraints that influence linguistic prediction. Lastly, Huettig (2015) suggests event simulation as a possible, but not necessary, element of PP.

Another model involving multiple mechanisms is the Multiscale Information Transfer framework (MSIT, Blumenthal-Dramé and Malaia, 2019). This model assumes parallel processing of incoming linear signal at multiple temporal scales (and thus, by multiple mechanisms). As the incoming sensory-linguistic signal is parsed into units at multiple scales (e.g., as syllables, words, and clauses), each level of linguistic processing (phonotactic, semantic, syntactic, pragmatic) quickly provides and discards predictions based on sequence probabilities (syntagmatic) and linguistic structure availability (paradigmatic), under the top-down guidance of the processor's sentence- and discourse-level predictions, thus allowing for both feed-forward and feedback effects.

Most of the linguistic models for PP mentioned above are based on research in spoken languages, with a focus on auditory modality, and, computationally, dealing with one-dimensional timeseries data. The study of sign languages (SLs), thus, can be informative for PP for several reasons. First, SLs are natural languages realized in the visual modality, i.e., reliant on 3D or 2D (video-type) processing. Therefore, SLs provide a unique opportunity to shed light on the underlying interplay of vision and cognitive processes in relation to the temporal structure of linguistic prediction. Second, examination of how linguistic PP unfolds temporally in the visual domain (as opposed to reading printed text, which is visible all the time) can contribute to refining existing PP models by identifying at which linguistic levels and/or interfaces PP occurs. Third, by examining PP in SLs as compared to PP in spoken languages modality-specific effects on PP can be isolated from modality-independent components of PP. The latter would emphasize linguistic and cognitive universals across sign and spoken languages with respect to PP.

Our goal in this work is to systematically assess the evidence for PP in SLs, the task and stimulus conditions under which it has been documented, the effects of individual differences in predictive processing (e.g., SL competence or age of SL acquisition) on the neural bases of PP, and identify the gaps in research which would allow for best possible contribution to modeling PP in human languages. We also aim to evaluate the effects of the physical and linguistic parameters of SL(s) on the PP phenomenon and to set the stage for careful experimental work in the future.

METHODS

Systematic Review Protocol

This systematic review was conducted in compliance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Page et al., 2021). It was pre-registered in the PROSPERO registry (Radošević et al., 2021; registration number CRD42021238911) to reduce the risk of bias that might occur during the review process. We defined our search and eligibility criteria according to the PICOS model (populations, interventions, comparators, outcomes, and study design).

Populations

In terms of participant-related variables, we defined the following inclusion criteria: studies on SL processing of all linguistic proficiency profiles given the probability of different processing mechanisms (see Krebs et al., 2021): proficiency in SL as a first language (L1) in Deaf signers or Children of Deaf Adults (CODAs), or SL as a second language (L2), i.e., L2 learners across age ranges. To select only research that focused on PP in SLs, we applied the following exclusion criteria: Studies of SL processing that focused exclusively on non-signers; non-human sign language processing (artificial intelligence and machine learning studies or brain-computer interface), and animal models.

Intervention

Our review focuses on SL processing at any linguistic level. Since defining language processing at a particular level does not add value to the search, we omitted it from our queries.

Comparison

With respect to studies of SL processing, comparators would be other visual processing (non-sign-language-based) or differences in processing within linguistic levels. Because one of the two controls is certain to be present in each SL study, Addition of any terms for comparisons did not add value to the search.

Outcomes

In our review, outcome is defined as evidence of predictive processing or entrainment during SL processing. As such, it was included in the search.

Study Design

Our goal was to search for any and all research-based evidence of PP in SLs. Therefore, defining the study design would not add value to the search. However, the record had to be original research, i.e., review articles were not included. As for the status of the records, they had to have been published in a peer-reviewed outlet. Therefore, only articles published in peer-reviewed journals, conference proceedings, doctoral dissertations published in digital repositories, and book chapters were considered. Finally, the record had to be written in English.

Data Sources and Search Strategy

We searched the Scopus, Web of Science, ScienceDirect, and ProQuest databases. In addition, the database APA PsycInfo was

searched through the EBSCOhost platform and the MEDLINE database was searched through PubMed. The search strings we used for the search can be seen in **Appendix 1**. All sources were searched regardless of the year of publication. We conducted the initial search in March 2021, followed by several re-runs, with the final one in July 2021. In addition, we performed a citation search of studies selected to include in the review after full-text examination (see PRISMA flow diagram, **Figure 1**). Based on the final number of records, we performed a backward citation search, i.e., we screened all references cited in studies that had passed the full-text eligibility assessment. To ensure that no recent, potentially relevant studies were missed in the database search, we also performed a forward search. We searched Scopus, Web of Science, and ProQuest in July 2021 for new studies citing the same studies that had passed the full-text eligibility assessment.

Study Selection and Data Extraction

At the identification level, the first author searched for records in databases and screened the retrieved records at the title and abstract level. Subsequently, all three authors independently reviewed the full texts. Disagreements were resolved in a detailed discussion. The first author then performed the backward and forward citation search, as described in section "Data Sources and Search Strategy," analyzed each record selected for systematic review and recorded the targeted data in a Microsoft Excel spreadsheet, based on the variables from section "Systematic Review Protocol."

Four groups of variables to seek for were established: type of stimuli, task, target language in the experiment, and participants' SL dominance. First, the type of stimuli aims to distinguish between dynamic and static SL stimuli, or in the case of spoken language stimuli—printed words on the screen or auditory presented stimuli for hearing participants. Second, the type of task refers to the paradigm used, from which the tasks are derived. Third, the target language in the experiments aims to separate SL, spoken language and written language. Finally, participants' SL dominance refers to SL as L1, L2, or whether participants were bimodal bilinguals, either Deaf or hearing.

Although this review is not clinical, we have identified a bias in the selection. Namely, only records in which findings were discussed from the perspective of PP were included. Given the wealth of evidence for PP in language, we assume that some previous studies may have PP underlying their results. However, because they were not discussed from this perspective, they did not meet the inclusion criteria.

RESULTS

Study Selection and Characteristics

The first author retrieved and screened 220 records to exclude those that did not meet the inclusion criteria. After duplicates were removed, 188 records were screened at the title and abstract level (see PRISMA flow diagram, **Figure 1**). After excluding 180 records (artificial intelligence studies, brain-computer interface, spoken language studies, etc.), 8 full-text records were assessed for eligibility. During the review of the full texts, a further 2 records were excluded as they did not meet the inclusion criteria. Namely, they were not related to linguistic prediction. At this stage, the results were independently reviewed by the remaining two authors. There was no disagreement.

Backward citation screening yielded 422 references (309 after duplicates were removed). Forward citation screening yielded 137 references as follows: in SCOPUS Brookshire et al. (2017) were cited 15 times, but these studies were not related to PP in SLs. In Web of Science, they were cited in 18 articles but had no reference to PP in SLs, the same with 4 citations in ProQuest. Citations of Brookshire (2018) were not found in Scopus, Web of Science, or ProQuest. Brozdowski and Emmorey (2020) were cited once in Scopus and once in Web of Science, but this work was not related to PP in SLs. Brozdowski (2018) was not cited in Scopus, Web of Science, or ProQuest. Hosemann et al. (2013) was cited 32 times in Scopus, 28 times in Web of Science, and 22 times in ProQuest. No new references were relevant to this review. Lieberman et al. (2018) were cited 8 times in Web of Science and 8 times in Scopus. Only one paper from Scopus met the inclusion criteria, Wienholz and Lieberman (2019).

Records that appeared to meet the criteria, but were excluded after full-text evaluation are Bosworth et al. (2019) and Kubicek and Quandt (2019). Bosworth et al. (2019) passed the screening on the title and abstract level because they examined the visual properties of American Sign Language (ASL) and there was a possibility that they discussed these visual cues in the context of prediction. However, after the full-text evaluation, it turned out this was not the case. On the other hand, Kubicek and Quandt (2019) investigated the activation of sensorimotor systems, i.e., the action observation network, while Deaf signers and hearing non-signers perceived one-handed or two-handed signs. Compared to Deaf signers, hearing non-signers showed greater activation of the sensorimotor cortex as measured by EEG desynchronization. They also found that the sensorimotor cortex was sensitive to one-handed and two-handed signs in both groups, but they activated the mirror system only in the Deaf group. However, these results were not related to (production accounts of) linguistic prediction (cf. Pickering and Garrod, 2007; Pickering and Gambi, 2018), so this work was excluded from further review. Thus, a total of 7 publications were included in the final review, of which 5 were published articles and 2 were doctoral dissertations.

The small number of records remaining may be due to several reasons. First, SL sentences have only been used in processing experiments in the last decade (first by Capek et al., 2009, followed by Hosemann et al., 2013; Hänel-Faulhaber et al., 2014, etc.). However, the degree to which these sentences were natural is questionable given that the persons recording the stimuli were advised to reduce non-manual markings (Hosemann et al., 2013; Hänel-Faulhaber et al., 2014). This is important because transitional movements between signs that have been removed (e.g., Neville et al., 1997) play an important role in providing cues for PP. Second, in general psycholinguistic research on SLs, i.e., not only in the context of PP, it is important to control for psycholinguistic variables such as word frequency, cloze probability, and neighborhood density. These metrics are derived

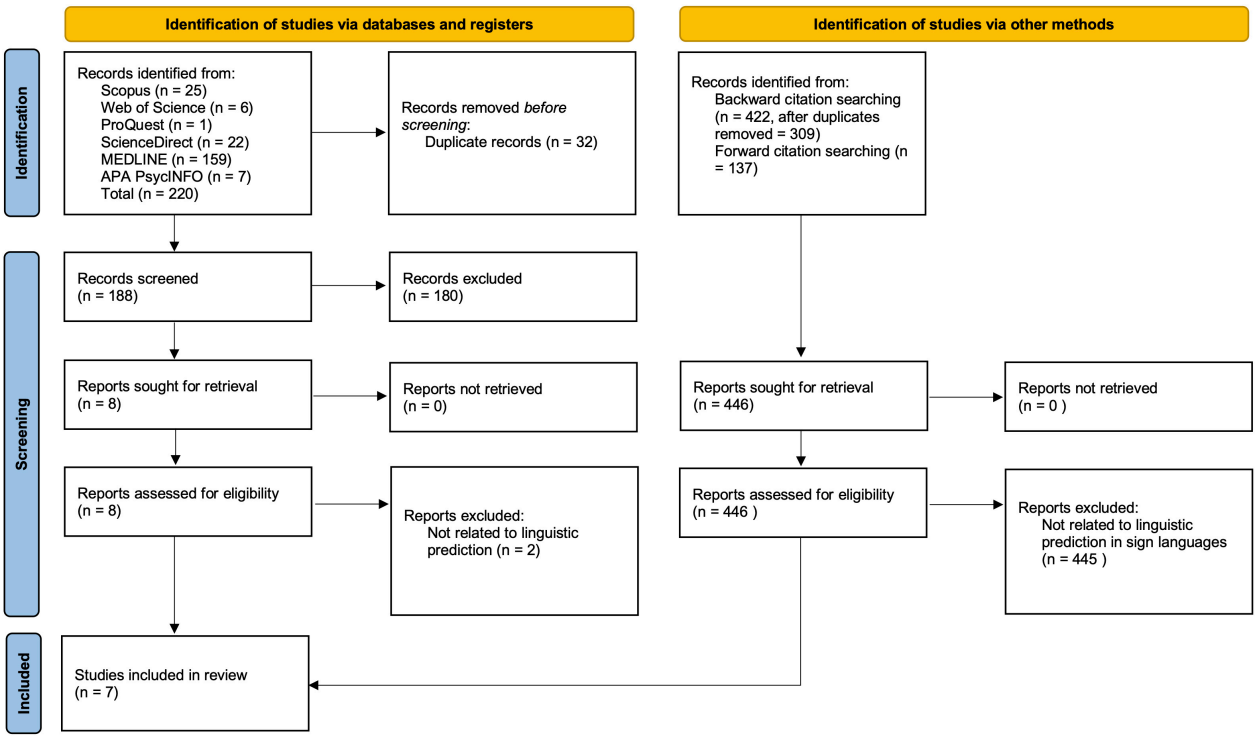


FIGURE 1 | PRISMA 2020 flow diagram (adapted from Page et al., 2021).

from corpora that are still being developed for SLs, which may be the reason for the smaller number of PP studies. Currently, such information exists only for ASL (ASL-LEX 2.0, Sehyr et al., 2021). Third, as stated in section "Study Selection and Data Extraction," there is a possibility of a selection bias. Namely, we assume there might be studies that do have PP underlying their findings. However, if the authors did not focus on PP directly, this study could not meet the inclusion criteria and was probably not retrieved using our search queries.

Synthesized Findings

The key characteristics of each study included in the final review are presented in **Table 1**. In the following sections, we summarize the records included in the final review by type of research method.

Eye-Tracking Research

An eye-tracking study of ASL found evidence of semantic prediction (Lieberman et al., 2018). Using the visual world paradigm, they investigated whether linguistic predictions modulate signers' (adults' and children's) focus on linguistic or non-linguistic information in the visual modality. They found that under semantically constrained conditions (e.g., a constraining verb at the beginning of a sentence), both children and adults shift their gaze from the ASL video (linguistic information) to the target image (non-linguistic information). Importantly, these gazes were anticipatory in both groups, i.e., they appeared before the target noun, thus suggesting PP.

Their work was extended by another study (Wienholz and Lieberman, 2019) that investigated how signers (adults and children) allocate their gaze in the visual world paradigm consisting of linguistic and non-linguistic information in ambiguous contexts. Both groups looked anticipatively at the target image when it was possible to disambiguate it. Moreover, both groups made more fixations to the target in adjective-noun sentences than in noun-adjective sentences. However, this occurred earlier in the sentence for the adults and later for the children. This suggests that PP is already developed in the children from this study between the ages of 4:1 and 8:1. However, the temporal distribution of their eye-gaze suggests that they are more influenced by competing linguistic distractors during processing than adults who have fully acquired the language, although ASL was L1 in both groups.

Behavioral Research

In addition to the studies that focus on language comprehension, there is also work that focuses on the interface of language production and motor production. Brozdowski (2018) investigated prediction at the phonological level, i.e., linguistic and non-linguistic prediction via forward models, in a total of four experiments. Experiment 1 and 2 are discussed further, while Experiment 3 and 4 were excluded as being out of the scope of this review. Forward models suggest that humans covertly simulate language production as they comprehend the incoming linguistic input. In Experiment 1, also published as Brozdowski and Emmorey (2020), he used shadowing as a proxy to covert

TABLE 1 | Key characteristics of the studies inluded in the final review.

Study	Type of study and task	Deaf/Hearing	SL dominance and age of acquisition	Type of language stimuli	Target language	Results
Brookshire (2018) Study 1 and Brookshire et al. (2017)	EEG/watching ASL storytelling	(1) Deaf, (2) Hearing	(1) L1, < 5 (mean 1.1 years); (2) non-signers	Dynamic (Sentences)	ASL	EEG coherence to visual oscillations in sign language in signers (0.4–5Hz; frontal and occipital channels) and non-signers (0.8–3.5Hz; central and occipital channels).
Brozdowski (2018) Experiment 1 and Brozdowski and Emmorey (2020)	Behavioral/manual shadowing	(1) Deaf, (2) Hearing	(1) L1, < 6 (early or native SL exposure); (2) non-signers	Dynamic [Videos of (a) pseudosigns, (b) grooming gestures]	ASL	Evidence of egocentric bias (a proxy to motor simulation) only in non-signers shadowing grooming gestures; no facilitatory effect of familiarity in signers; signers' productions had more consistent lag times than non-signers' productions.
Brozdowski (2018) Experiment 2	Behavioral/recognition task	(1) Deaf, (2) Hearing	(1) L1, < 6 (early or native SL exposure); (2) non-signers	Dynamic [Videos of (a) pseudosigns, (b) grooming gestures]	ASL	Signers had significantly slower RTs for shadowing blurred pseudosign handshapes
Hosemann et al. (2013)	EEG/semantic mismatch; acceptability and evaluation judgment	Deaf	L1, native or < 3 years	Dynamic (Sentences)	DGS	Unexpected signs elicited a biphasic N400-late positivity effect. Moreover, N400 onset began during the transitional phase, i.e., before the onset of the critical sign.
Lieberman et al. (2018)	Eye-tracking/visual world; adults clicked on the target, children pointed to it	Deaf	Adults: L1, 9 native, 8 non-native (but L1 for at least 19 years); children: L1, 17 at least 1 Deaf parent, 3 had hearing parents but were exposed to ASL by the age of 2:6	Dynamic (Sentences)	ASL	In semantically constraining sentences both groups made anticipatory gaze to the target picture, appearing before the target noun.
Wienholz and Lieberman (2019)	Eye-tracking/visual world; adults clicked on the target, children pointed to it	Deaf	Adults: L1, 9 native, 9 non-native (but L1 for at least 19 years); children: L1, 17 at least 1 Deaf parent, remaining 3 had hearing parents but were exposed to ASL by the age of 2:6	Dynamic (Sentences)	ASL	Anticipatory looks to a target picture were observed in both groups; the adults made target fixations earlier in the sentence and preferred the adjective-noun order, unlike the children.

imitation, a proposed mechanism underlying motor simulation in forward models. Deaf signers and hearing non-signers had to shadow either pre-recorded videos of themselves, a friend, or a stranger. The shadowed stimuli were either pseudosigns (phonologically plausible in ASL, but semantically empty units, therefore still considered linguistic) or grooming gestures (non-linguistic stimuli). Moreover, pseudosigns and grooming gestures could be either one-handed or two-handed. In this way, egocentric bias and visual familiarity effects could be controlled for, as they may facilitate PP. Controlling for handedness was also important, as suppression of the non-dominant hand may have resulted in longer lag times for one-handed signs. However, only non-signers showed the effect of egocentric bias, but only for the grooming-gesture condition, which is understandable given that they are non-signers and cannot predict ASL phonology from the pseudosign condition. Moreover, signers had slower shadowing production for one-handed signs than for two-handed signs. Based on this data Brozdowski (2018) and Brozdowski and Emmorey (2020) conclude that the results do not provide strong evidence for motor simulation accounts of PP.

In Experiment 2, Brozdowski aimed to further investigate phonologically based prediction during the transitional phases between pseudosigns and grooming gestures. Deaf signers and hearing non-signers were asked to monitor for a specific item while reaction times (RTs) were measured. Stimuli were presented either normally or with blurred handshape in the

transition phase, or only the still frame of the last frame before the transition movement was shown. As in Experiment 1, the stimuli were either pseudosigns or one- or two-handed grooming gestures. Only signers had significantly slower RTs for blurred handshapes, and only in the pseudosign condition, suggesting that signers made predictions about upcoming phonological representations. However, one-handed stimuli were easier to predict, which contrasts with the expected suppression of the non-dominant hand during motor simulation in forward models. In sum, given the partially opposite findings, the authors conclude that there is not enough evidence that it is precisely the motor simulation that underlies PP in ASL.

EEG Research

A study of German Sign Language (*Deutsche Gebärdensprache*, DGS) also found evidence of semantic prediction. Hosemann et al. (2013) investigated whether production-based forward models of language processing (cf. Pickering and Garrod, 2007) are applicable to the visual modality, namely to DGS. The study used a semantic expectancy mismatch design in which the sentence-final verb in the stimuli sentences could be either an expected or unexpected. EEG was recorded while Deaf native signers watched natural DGS sentences. Analysis of event-related potentials (ERPs) indicates that unexpected signs triggered a biphasic N400 effect with late positivity. Moreover, the N400 onset started during the transition phase between two signs, i.e., before the onset of the critical lexical sign. Hosemann et al. (2013) argue that signers made predictions about upcoming linguistic information via forward models, as they relied on the transitional movements seen before the lexical sign. This work aligns with findings from eye-tracking studies on semantic predictions made by ASL signers (Lieberman et al., 2018; Wienholz and Lieberman, 2019) by confirming the existence of semantic prediction in another SL unrelated to ASL.

Unlike aforementioned studies, which focused more on the content of predictions (i.e., what is predicted), Brookshire (2018) used electroencephalography (EEG) to investigate the temporal aspects of prediction (at what point PP is observed) in two studies. The first study (published as Brookshire et al., 2017) aimed to evaluate whether neural oscillations in the human brain entrain to linguistic input in the visual modality—ASL. Brookshire et al. (2017) quantified the change in visual signal using an Instantaneous Visual Change (IVC) metric that measures the relative pixel value change from frame to frame in stimulus videos, reducing the spatial dimensions in 2D video to a single scalar value in time. This way of calculating the metric acts as a spatial frequency filter whose properties change from frame to frame, depending on the colors and contrast within the scene. For example, a gross motion of a signer's arm will affect a large number of pixels, resulting in a large IVC value, while rapid complex finger motion will affect a small number of pixels, resulting in a low IVC value. Thus, the IVC metric might contain a small portion of the information inherent in the sign language signal (see Borneman et al., 2018); however, given the spatial nature of sign language, the majority of the information contained in the sign language video recording is lost. Based on this crude metric of visual input, Brookshire et al. (2017) found that signers showed higher coherence in the frequency range of 0.4–5 Hz, peaking at 1 Hz, over frontal and occipital electrodes compared to non-signers exposed to the same stimuli. The group concluded that in signers, increased coherence to gross changes in visual input over the frontal electrodes likely indicates top-down control. Non-signers also showed coherence to the visual input (which was also ASL—no control stimuli were used) in the 0.8–3.5 Hz range over the central and occipital sites. Based on these findings, Brookshire et al. (2017) argued that entrainment to gross (i.e., low-frequency in both temporal and spatial dimensions) variability in the visual signal may be an amodal property of the brain aiming to synchronize to a perceptually prominent modality. However, these conclusions are limited by the confounds in experimental design: lack of control stimuli (i.e., stimuli other than SL) and the crudeness of the visual metric, which does not evaluate information-bearing spatiotemporal frequencies in the sign language signal.

Effects of Stimuli, Sign Language Proficiency of Participants, and Task Types

All studies included in the final synthesis used dynamic sign stimuli, i.e., videos, for the stimuli under which PP was observed. However, task conditions under which PP was observed varied substantially. Brookshire et al. (2017) and Brookshire (2018), asked Deaf signers and hearing non-signers to watch ASL videos while EEG was recorded, with no explicit behavioral task reported (i.e., in a sense, without a comprehension control). Hosemann et al. (2013) used a semantic mismatch paradigm, recording EEG while Deaf signers looked at signed sentences. After viewing a sentence, participants had to determine whether the sentence was correct or incorrect (acceptability task) and then rate how confident they were in their answer (confidence rating). Brozdowski and Emmorey (2020), as well as Experiment 1 by Brozdowski (2018) used the manual shadowing task, in which Deaf signers and hearing non-signers were asked to repeat pseudosigns and gestures as they watched them. Experiment 2 (Brozdowski, 2018), engaged Deaf signers and hearing non-signers in a recognition task, in which participants had to press a key once they recognized a target from a set of pseudosigns or grooming gestures. The remaining two studies used eye-tracking to examine gaze distribution of Deaf adults and children in the visual world paradigm (Lieberman et al., 2018; Wienholz and Lieberman, 2019). In both studies, adults were asked to click on the target picture, while children pointed with a finger and the experimenter then clicked on the target.

Examined studies did not provide information on whether cross-modal prediction occurred for bilinguals, as almost all studies focused predominantly on ASL, with one study on DGS. Regarding the influence of population parameters such as SL dominance and age of acquisition, the results are less conclusive as the only two groups recruited were either Deaf native or native-like L1 signers or hearing non-signers. However, the developmental course of PP has been investigated by Lieberman et al. (2018) and Wienholz and Lieberman (2019) by examining how adults and children distribute eye-gaze in the visual world

paradigm. Their studies suggest that basic semantic prediction is developed in children as young as 4–8 years of age.

DISCUSSION

Nowadays, predictive processing is recognized as a model of cognitive processing applicable to multiple cognitive domains, such as visual processing (Eisenberg et al., 2018), meaning extraction in the visual domain (Strickland et al., 2015), and language (Malaia et al., 2021). Here, we ask whether there is primary research evidence for prediction in sign language processing in signing populations. After a systematic review grounded in PRISMA and PICOS frameworks, we identified studies that provided evidence for PP in signing populations across two linguistic levels (semantic, phonological) in multiple experimental paradigms, such as anticipatory eye gaze in the visual world paradigm (Lieberman et al., 2018; Wienholz and Lieberman, 2019) or N400 amplitude modulation in the semantic mismatch paradigm (Hosemann et al., 2013). However, investigations of motor simulation, hypothesized on the basis of predictive processing framework (Brozdowski, 2018; Brozdowski and Emmorey, 2020) found no evidence of motor simulation underlying PP in proficient signers. This does not, by itself, imply that no predictive processing takes place—rather, it indicates that predictive models do not appear to propagate to the level of motor simulation.

Semantic Predictive Processing in Sign Languages

Our results indicate that semantic prediction has been the most researched so far. The reported studies provide evidence for the prediction of semantic information during continuous signing stream (Hosemann et al., 2013; Lieberman et al., 2018; Wienholz and Lieberman, 2019), as they did not use visually manipulated material (for the importance of naturalistic SL stimuli, see section "Relations Between Other Variables and Predictive Processing"). Findings that semantically constraining contexts enable semantic prediction in SLs align well with extensively studied spoken languages (Federmeier, 2007; Huettig, 2015; Kuperberg and Jaeger, 2016; Bornkessel-Schlesewsky and Schlesewsky, 2019).

Other Types of Linguistic Predictive Processing

Brozdowski (2018) and Brozdowski and Emmorey (2020) investigated whether or not signers rely on the transitional movements between signs, hence whether they exploit phonological information to enable prediction, based on the motor simulation in forward models. However, they found no strong evidence for motor simulation. This suggests that PP does exist in sign language, as would be expected for all languages, but that motor simulation as a production account of PP, does not provide the best explanation for its underlying mechanism. Furthermore, Hosemann et al. (2013) employed a semantic violation paradigm, but they analyzed EEG data from different time points between the previous sign and the following critical sign. Thus, although they examined prediction in semantically constraining sentences, they were actually looking for phonological cues that could inform prediction by placing triggers in transitional movements. This aligns well with the Multiscale Information Transfer framework (Blumenthal-Dramé and Malaia, 2019), which emphasizes the interplay of multiple scales in SL processing.

As for other language-based variables that might affect PP, such as phonetic (articulatory) complexity, syntax, or frequency-based prediction, we did not find any research that addressed them. However, psycholinguistic properties of signs such as iconicity, frequency, or concreteness have been found to elicit distinct neurophysiological responses (Emmorey et al., 2020), suggesting differential processing. Thus, it would be worthwhile to explore the relationship between these psycholinguistic properties and PP in future studies.

Relations Between Other Variables and Predictive Processing

Type of Stimuli

The stimuli from all the records included in the final synthesis were dynamic, which is not surprising given the nature of the dynamic, continuous sign language stream. This has become something of a standard in recent SL experimental research, compared to older studies. They used a sign-by-sign presentation due to the technical limitations of the time (e.g., Neville et al., 1997) or trimmed transitional movements between the critical sign and the rest of the sentence to avoid possible coarticulation effects and differences between conditions (Grosvald et al., 2012; Gutierrez et al., 2012). Nevertheless, it is important to have non-manipulated, naturalistic SL stimuli because there is experimental evidence for the role of transitional movements in semantic prediction (Hosemann et al., 2013) as well as in the resolution of ambiguous argument structures (Krebs et al., 2018), at least in sentential contexts. On the other hand, single-sign priming studies using clipped sign stimuli (i.e., videos were clipped to the onset of the sign, thus not showing transitional movements -cf. Gutierrez et al., 2012; Meade et al., 2018; Lee et al., 2019; Emmorey et al., 2022) report N400 as indicative of priming effects prior to the onset of the critical sign. However, due to the nature of the priming paradigm and the use of isolated signs, it is possible that the transitional movements did not turn out to be important for this very reason. Indeed, there is theoretical and experimental evidence for their importance at the sentence level. Namely, SLs are multilayered and signers process the visual properties of motion at multiple levels (Blumenthal-Dramé and Malaia, 2019). Moreover, transitional movements inform language comprehension, as noted above (Hosemann et al., 2013; Krebs et al., 2018).

Type of Task

In the studies by Brozdowski and Emmorey (2020), Experiment 1 and 2 by Brozdowski (2018), Study 1 by Brookshire et al. (2017) and Brookshire (2018), both Deaf signing and hearing non-signing participants performed the same task. This is understandable from the perspective of controlling for the

effects of sign language dominance or the effects of long-term experience in the visual domain. Nevertheless, the nature of the task does not affect Deaf signers and hearing non-signers equally. For example, signers have enhanced spatial processing abilities (Emmorey, 2002; Pyers et al., 2010; Malaia and Wilbur, 2014), suggesting that these abilities might affect performance in the experiment and should be controlled for. In addition, signers imitate manual signs better than non-signers (for a review, see Rudner, 2018). Finally, hearing non-signers show different activation patterns in the sensorimotor cortex when perceiving signs than Deaf fluent signers (Kubicek and Quandt, 2019). Consequently, because hearing participants are unfamiliar with sign language and the perception of such complex visual stimuli, these results could be influenced by the increased cognitive load of observing such stimuli. The studies reviewed, involving both Deaf signing and hearing non-signing participants, did not report any measures of visual-spatial abilities or verbal working memory, with the exception of Brozdowski and Emmorey (2020), who developed a new test of motor memory. Nevertheless, they have not addressed the issue of different verbal working memory spans for spoken and sign language stimuli (Rudner, 2018; Malaia and Wilbur, 2019), although they acknowledge that motor memory and working memory are separate (Wu and Coulson, 2014). Overall, it is currently unclear whether other cognitive abilities had an impact on the performance of the non-signers from the above studies, and if so, to what extent.

Sign Language Competence

The data extracted for the target languages show that only unimodal language prediction was studied. Therefore, we cannot determine whether or not cross-modal prediction effects could be observed for bimodal bilinguals. This question should be addressed for three reasons. First, signers have been found to co-activate signs while reading (Morford et al., 2011; Meade et al., 2017; Villwock et al., 2021) as well as to co-activate written/spoken words while comprehending sign pairs (Lee et al., 2019) and sentences (Hosemann et al., 2020) and in the production of signs (Gimeno-Martínez et al., 2021). Second, there is evidence for cross-modal prediction for spoken languages (Sánchez-García et al., 2011, 2013). Third, the cross-modal prediction has also been found for other non-linguistic cognitive domains, such as perception of emotions (Jessen and Kotz, 2013) and music (Dercksen et al., 2021). Given this evidence for cross-modal interactions in both linguistic and non-linguistic domains, further studies might investigate whether bimodal bilinguals make cross-modal linguistic predictions.

Regarding the population parameters, all studies used either Deaf native/native-like L1 signers or hearing non-signers. Therefore, it is not clear at this moment whether different levels of SL dominance (such as L1 vs. L2 vs. bimodal bilingual) interact with the neural bases of prediction. However, it is reasonable to expect such differences in the manual-visual modality for two reasons. First, these effects have been found in studies of PP for spoken languages in cases of L1 vs. L2 groups (Martin et al., 2013; Kaan, 2014; Hopp and Lemmerth, 2018; Chun and Kaan, 2019; Schlenter, 2019; Henry et al., 2020). Second, differences in SL processing in other linguistic domains have been found to be a function of the SL age of acquisition (Malaia et al., 2020; Krebs et al., 2021).

Suitability of Predictive Processing Models to Sign Language Data

Various models have been developed that attempt to explain linguistic prediction. As mentioned in section "Models of Predictive Processing," most of them have been developed based on spoken language, with the exception of the Multiscale Information Transfer framework (Blumenthal-Dramé and Malaia, 2019), which specifically considers sign languages. However, from the studies we included in our systematic review, it appears that only production-based models have been tested so far, more specifically Pickering and Garrod's (2007, 2013) prediction-by-production account. Hosemann et al. (2013) interpreted their findings in the context of a forward model. Based on the N400 amplitude modulation that started during the transitional movement before the critical lexical sign, they argue that signers recruited their forward models. Similarly, Brozdowski (2018) and Brozdowski and Emmorey (2020) originally hypothesized that signers engage in motor simulation, a mechanism thought to underlie linguistic prediction via production systems, but found insufficient evidence to support this model. However, as they note, it is possible that fluent signers do not use production systems for predictions during simple tasks. As suggested earlier in section "Sign Language Competence," future studies should include signers with different levels of proficiency to elicit a variety of qualitative mechanism(s) for predictive processing (cf. Schlenter, 2019, for a similar treatment of proficiency in spoken languages, and underlying qualitative differences in predictive processing). Other studies eligible for this review reported that both children and adults made anticipatory gaze to the target item (Lieberman et al., 2018; Wienholz and Lieberman, 2019), but the authors did not discuss their findings in the context of a specific model of PP.

CONCLUSION

In this paper, we have presented the results of the systematic review of studies on predictive processing (PP) in sign languages. We have also investigated the conditions under which it occurs. Our results show that most of the reviewed studies focused on semantic prediction. On the other hand, more recent studies have focused on the phonological basis of prediction during transitional movements between signs. However, there is currently no evidence for PP in other linguistic domains, such as frequency-based, phonetic (articulatory), and syntactic prediction. Regarding the conditions under which PP occurred, we found that semantic prediction has been studied mainly in adults and to a lesser extent in children (aged 4–8 years). Currently, the neural bases of PP in signing populations are inconclusive, as only three studies used EEG and no neuroimaging studies were found. The question of the mechanism of interaction between one's sign language dominance (L1 vs. L2 vs. bimodal bilingual) and PP in the

manual-visual modality is not clear, mainly because participants with different degrees of language dominance are missing. Altogether, the findings from SL studies, which corroborate findings from spoken language studies, suggest that PP is the modality-independent property of language processing, although the relatively small number of studies on PP in SLs limits our understanding of the modality-specific characteristics. Further studies are needed to improve our understanding of prediction in other linguistic domains in the visual-manual modality, e.g., syntax, morphology, pragmatics, as well as the interfaces between linguistic levels. In addition, the development of corpora from different SLs is needed to enable the extraction of linguistic measures from specific levels. Finally, the question of the underlying mechanism(s) of PP in relation to population parameters is relevant to the effects of age of acquisition on PP and whether it facilitates comprehension and/or production in SLs.

LIMITATIONS

It is highly likely that publication bias has affected the availability of study information. By publication bias, we mean that studies with negative evidence (those that tested for a specific level/modality of PP and did not find statistically significant effects) were not published. This bias can be mitigated by the inclusion of doctoral dissertations (two included in the final study set) and registered reports (studies that pre-plan the assessment, and are accepted for publication prior to data collection, when analysis results are not known). However, the systematic search did not yield any registered reports in the domain.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

TR and EM contributed to the design of the study. TR collected the data and wrote the first draft of the manuscript. All authors contributed to the revision of the manuscript and analyzed the data.

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APPENDIX

Search Strategy

We performed an advanced search in the databases listed in section "Data Sources and Search Strategy." In the Scopus database, we used the following query: (KEY ("sign language") OR KEY ("signed language")) AND (KEY (prediction) OR KEY (anticipat*) OR KEY (forward) OR KEY (entrain*)) AND (EXCLUDE (SUBJAREA, "COMP") OR EXCLUDE (SUBJAREA, "ENGI")). Three exclusion filters were applied, so that records from the subject areas "Computer Science" and "Engineering" and non-English records were excluded.

Then, for the Web of Science database, we used the following sequence of terms: (AK = ("sign language" OR "signed language")) AND AK = ((prediction) OR (forward) OR (entrain*) OR (anticipat*)), where AK stands for "author keywords." We further refined the results by excluding the Web of Science category "Computer Science Artificial Intelligence."

In ScienceDirect, we used the following sequence of terms under the section "Title, abstract or author-specified keywords": ("sign language" OR "signed language") AND ((prediction) OR (forward) OR (entrainment) OR (anticipatory)). In addition, the subject areas Computer Science, Engineering, Medicine and Dentistry, Energy, Material Sciences, Biochemistry, Genetics and Molecular Biology were excluded.

Next, the ProQuest database was searched for doctoral dissertations, with the following search query string: IF ("sign language" OR "signed language") AND IF ((prediction) OR (forward) OR (entrain*) OR (anticipat*)), where IF stands for "identifier." No exclusion filters were applied as there was only one result.

We searched APA PsycInfo database via EBSCOhost, using this search string for keywords: ("sign language" OR "signed language") AND ((prediction) OR (forward) OR (entrain*) OR (anticipat*)). We did not apply any additional filters.

Finally, we conducted an advance search of the MEDLINE database, which was accessed through PubMed. The title and abstract fields were searched using the following string: ("sign language" OR "signed language") AND ((prediction) OR (forward) OR (entrain*) OR (anticipat*)). No additional filters were applied.

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On the Reflexive KENDİ in Turkish Sign Language

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Linguistic analysis is improved when it includes language beyond the spoken modality. This paper uses sign language data to explore and advance cross-linguistic typologies of *reflexives*, constructions expressing that co-arguments of a predicate are also co-referent. In doing so, we also demonstrate that the lexical item **KENDİ** in Turkish Sign Language (*henceforth,* TİD) can function as a traditional reflexive, in addition to its previously documented emphatic functions. We further show that **KENDİ** is a DP-type reflexive, which helps to explain the emphatic usages of **KENDİ** that have been the focus of previous research. We end by outlining a plan for future research that can further probe and unify the superficially distinct functions of **KENDİ** and the typology of anaphoricity across modalities. Data for the present research comes from recently conducted fieldwork interviews with two signers of the İstanbul dialect of TİD, both of whom have been exposed to TİD since birth.

Keywords: Turkish Sign Language (TİD), reflexives, emphatic reflexives, co-referential relations, anaphora, typology, sign languages, syntax

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INTRODUCTION

Sensitivity to event participant structure is evident in the earliest stages of language acquisition (Pinker, 2013; Pace et al., 2016) and distinguishing the participants in an event is so fundamental to human language that it is present even in homesign (Goldin-Meadow et al., 2009). Interestingly, languages also universally have mechanisms for indicating that event participants are *not* distinct: reflexive constructions. Conceptually, reflexivity is a specific type of dependency relation between two arguments of a predicate where the two arguments are co-referent. Languages of the world have different strategies to mark this relation (Faltz, 2016/1977), as we discuss in more detail in "Background on Reflexivity." In English, for example, this relation can be marked *via* reflexive pronouns (1).

(1) a. John$_i$ saw **himself**$_i$ in the mirror. English: Faltz (2016/1977:1).

Compared to the research on spoken languages regarding reflexivity (Frajzyngier and Walker, 2000; Büring, 2005b; Geniusiene, 2011; Faltz, 2016/1977, i.a.), there is limited literature on sign languages. This is partly because the linguistic study of sign languages is a fairly new endeavor. Though scattered earlier documentation exists (e.g., Desloges, 1779), linguistic analysis of sign languages began in earnest with Stokoe's (1960) work on American Sign Language (*henceforth*, ASL). Though Stokoe made some observations regarding ASL syntax, his focus on the phonetics and phonology of signs left "much more" to do "in establishing exactly what are the structural principles of the sign language sentence" (Stokoe, 1960:32). Though much progress has been made

since then (as one sees from all the work on sign languages cited in this paper as well as the other contributions to this volume), Stokoe's (1960) statement still holds: there is still a tremendous amount of research to be done.

The research that has been done has shown that sign languages employ several strategies to form reflexive structures. For example, Kimmelman (2009) reports that ASL[1], Russian Sign Language, Dutch Sign Language, Israeli Sign Language, and Croatian Sign Language all have reflexive pronoun strategies. Because reflexivity is present in some form across various languages and language families (Frajzyngier and Walker, 2000; Büring, 2005b; Geniusiene, 2011; König et al., 2013; Faltz, 2016/1977, to name a few) and across modalities, it may be a universal phenomenon of language. In that case, describing and analyzing reflexivity in understudied languages like sign languages provides an opportunity to expand existing accounts and holds a great deal of importance in testing our existing generalizations about argument structure and reflexivity. This is the aim of the present paper. We hope to contribute to the ongoing endeavors to document, describe, and analyze sign languages in the pursuit of a better understanding of human language.

Our focus will be the lexical item KENDİ in Turkish Sign Language (*henceforth*, TİD), which is produced by tapping in the middle of the chest with an open hand, fingers bent inward, as depicted in **Figure 1**.

There has been little work on KENDİ in the existing literature, much of it limited to in-passing observation that the sign KENDİ exists. Zeshan (2002) and Sevinç (2006:16) briefly note that the form is attested but observe only an emphatic function (2a). In their recent grammar of TİD, Kelepir (2020a), citing data from Dikyuva et al. (2017), nevertheless label KENDİ as a reflexive pronoun (2b):

(2) a. MAN$_i$ TREE CLIMB WANT KENDİ$_i$ FELL-DOWN.
"The man wanted to climb the tree but he himself fell down."
Interpretation: Nobody caused his fall.

TİD: adapted from Sevinç (2006:16).

b. YOU KENDİ READ IMPROVE EXIST.
"You improve yourself by reading (studying)."

TİD: Dikyuva et al. (2017:205).

Our study looks to build upon these limited observations to examine if KENDİ can be used both as a traditional reflexive [as Dikyuva et al. (2017) and Kelepir (2020a) suggest] and/or as an emphatic marker [as Zeshan (2002) and Sevinç (2006) observed]. We focus on the İstanbul dialect of TİD. The layout of the paper is as follows: "Background on Reflexivity" summarizes the notion of reflexivity and provides an overview of the previous literature on reflexives in signed and spoken languages. "Methodology" explains our methodology of data collection. "KENDİ Marks Co-referential Relations" lays out the co-referential properties of KENDİ as a traditional reflexive. Having established that KENDİ can function as a traditional reflexive, we then turn to where KENDİ stands within reflexive typologies. Building on the data from earlier sections, "Co-referential Relations With KENDİ" further probes the syntactic and semantic properties of KENDİ in its traditional reflexive function. The functions of KENDİ beyond its traditional reflexive role is the focus of the final section before we close by summarizing our findings and laying out directions for future research.

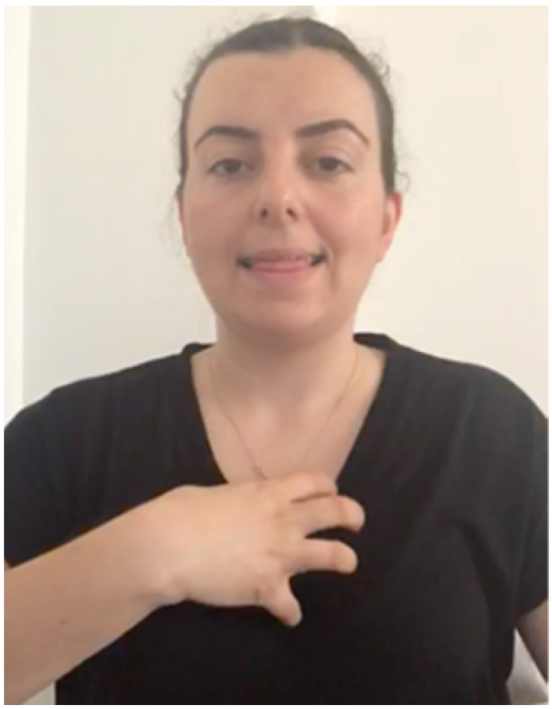


FIGURE 1 | KENDİ.

BACKGROUND ON REFLEXIVITY

In this section, we will overview basic properties of reflexivity that are relevant for this study and summarize the reflexivity patterns that have been documented in spoken and signed modalities.

Reflexivity in Spoken Languages

The literature on reflexivity suggests that it is a universal part of language, observed in many languages across different language families, albeit encoded with different grammatical mechanisms. With respect to the strategies that encode reflexivity, we can talk about two main kinds of reflexivity: *lexical* reflexivity and *grammatical* reflexivity. Lexical reflexivity, which is also sometimes called *inherent* reflexivity, is a phenomenon we observe on predicates that express events that are prototypically done to oneself, such as "bathe". The default interpretation of

[1]Koulidobrova (2009, 2011), Fischer and Johnson (2012), and Mathur (1996) observe that the reflexive pronoun "SELF" in American Sign Language also serves other functions. We discuss this phenomenon more in section "The Function of KENDİ Beyond Traditional Reflexivity".

an intransitive sentence like *I bathed* in English is reflexive, *I bathed [myself]*. Predicates like "bathe" can, however, express non-reflexive events, as with the transitive variant *I bathed the dog* in English. Lexical reflexives in English are also often compatible with (redundant) grammatical reflexivity, as in *I bathed myself* (emphatic interpretations, which we discuss below, may be more natural here). Here, the reflexivity relation is not only expressed *via* the semantics of the verb but also the argument structure of the utterance. Grammatical reflexivity manifests itself either *via* marking on the verb (a) or marking on the arguments (b):

(3) a. Çocuk soy-**un**-du.
child undress-**refl**-past
"The child got undressed."
Turkish: Özsoy (1983:3)

b. Jan heeft **zich** aangekleed.
Jan aux **refl** dressed
"Jan got dressed."
Dutch: Faltz (2016/1977: 274)

In (3a), the reflexive marker {-un}[2] is a verbal suffix. As for (3b), Faltz (2016/1977) observes that the reflexive pronoun "zich" in (3b) links the object of the verb to the subject, marking that the do-er and the patient are the same referent.

There is also variation *within* the categories of verbal and argumental reflexivity marking. Verbal reflexivity includes affixes like *-un-* in Turkish (3a) and clitics, such as the French *se* in *s'habiller* ("to dress oneself"). As for argument marking, we observe both free standing reflexive pronouns such as *zich* in (3b) as well as bound morphemes that shift a stem to a reflexive meaning (e.g., *-self* in English). It is not uncommon for languages to exhibit multiple reflexive strategies, or to combine them as part of a complex reflexive construction.

What unites these different strategies is that they are all subject to certain structural constraints. First of all, a reflexive requires an antecedent for co-reference, and the relationship between them is often called *binding*. Argument reflexives require being bound by a potential co-referent (4a-b) and are usually restricted as to what can bind them within what structural domain and/or configuration (4c-d), e.g., intra- or inter-clausal (see, among others, Chomsky, 1981; Reinhart and Reuland, 1993; Faltz, 2016/1977).

(4) a. Bruno$_i$ bothered himself$_i$ with his incessant worrying.
b. *[That it snowed]$_i$ bothered himself$_i$ throughout the winter.
c. *[That Bruno$_i$ had to shovel snow] bothered himself$_i$ throughout the winter.
d. *Bruno$_i$ claimed that Eva$_j$ bothered himself$_i$ with her$_j$ incessant worrying.

The literature on reflexives has long attempted to unify the structural constraints on the reflexivity. However, pinpointing these constraints isn't always an easy task and is further complicated by the fact that reflexives are commonly observed to serve other functions (Reinhart and Reuland, 1993; Faltz, 2016/1977; Déchaine and Wiltschko, 2017 i.a.) that may not be subject to the same structural constraints as a traditional reflexive. Emphatic anaphors (5a) refer to one of the participants within the event, but their function is to put focus on or set apart a particular participant without affecting the argument structure of the verb. Logophors (5b), on the other hand, are anaphoric items that can get their co-reference from outside of the structural domain of a traditional reflexive. Thus, emphatic markers (5a) and logophors (5b) still express co-reference, which makes them *anaphoric*. However, they do not necessarily express co-reference between arguments of the predicate, so they are not *reflexive*.

(5) a. Ankara-ya ben kendi-m gid-eceğ-im.
Ankara-DAT I self-POSS.1SG go-FUT-1SG
"I'll go to Ankara myself."
Turkish: Özsoy (1983: 111)

b. It angered John$_i$ that Mary should have the egotism to try to attract a man like himself$_i$.
English: Zribi-Hertz (1989:718, 74c).

Such multi-functionality has already been observed for KENDİ (Zeshan, 2002; Sevinç, 2006; Dikyuva et al., 2017), which we discuss in more detail below. However, what we first aim to show in this paper is that KENDİ can be used as a traditional reflexive. Before we move on to discussing that, however, we first provide a review of the existing reflexivity literature on *sign* languages.

Reflexivity in Sign Languages

As in other domains of linguistic structure, research on reflexivity in sign language is limited. However, the research that has been done observes key similarities across modalities. Sign languages, too, employ two main strategies to mark reflexivity: on the verb (6a), or on the argument of the verb (6b):

(6) a. BOY$_a$ IX$_a$ TEA POUR$_a$.
"The boy pours himself tea."
Russian Sign Language, RSL

b. BOY$_a$ IX$_a$ ZELF LOOK.
"The boy looks at himself."
Sign Language of the Netherlands, NGT
Kimmelman (2009:17).

The verbal reflexivity of (6a) is expressed *via* the spatial agreement markers, indicated by the subscripted "a"[3]. Here, the direction of the object agreeing verb's path movement agrees with the subject, linking the grammatical object and the subject of the sentence in co-reference. Kimmelman (2009) also reports argumental reflexive pronouns in NGT, glossed

[2]Note that the suffix noted here as *-un* is in fact {-(I)n} and becomes *-un* in this particular example due to vowel harmony (Göksel and Kerslake, 2004).

[3]The subscripts a, b, c are used to express locus, and the subscripts i, j, k are used to express co-reference throughout the glosses. For the examples in which both locus and co-reference is marked, they are used as "a_i".

as ZELF in (6b), similar to English *-self*. This parallelism across modalities is not unexpected considering that reflexivity reflects event participant structure, which may be conceptually and linguistically fundamental. This parallelism aside, what sign languages bring to the table is the way they use space for reference, which may lead to modality-specific effects on reflexivity. The role of space in modulating reflexivity is evident in (6a). These reflexivization strategies are not specific to the exemplified languages. **Table 1** below shows various reflexivization strategies attested in sign languages.

The multi-functionality of reflexive markers is also relatively well-documented in sign languages. As an example, SELF in ASL can also functions as copula (7a) and as an emphatic marker (7b):

(7) a. MILK SELF WHITE.
"Milk is white."
ASL: Fischer and Johnson (2012:243)

b. A: Who was driving the car?
B: KAY SELF
"Kay himself."
(The context of other drivers is available in the discourse).
ASL: Wilbur (1996:13) cited *via* Koulidobrova (2011:3)

All in all, the existing work, though limited, shows that reflexivity in sign languages is compatible with certain aspects of existing typologies. However, it is also the case that sign languages can provide unique and novel data to further explore the phenomenon of reflexivity, including how usage of space affects referential relations (Schlenker, 2018). Before turning to what TİD shows us about reflexivity, we first briefly explain how we collected and analyzed data in this study.

METHODOLOGY

The data for this work comes from fieldwork sessions with two Deaf adult female signers of the İstanbul variety of TİD. Both have been exposed to TİD since birth. The sessions took place 2020–2021 and were conducted online *via* Facetime and Zoom due to the limitations on travel and in-person meetings during the COVID-19 pandemic. The language of interaction was TİD, though both consultants also have proficiency in written Turkish. We have utilized acceptability judgments and having the consultant describe contexts and situations using KENDİ as methods of data elicitation. Only one consultant at a time was present for each fieldwork session. Because of quality issues that can arise in videoconferencing, the data reported here were also recorded separately by one of the consultants and can be accessed in an online repository (file names correspond to example numbers): https://tinyURL.com/KendiRepository.

KENDİ MARKS CO-REFERENTIAL RELATIONS

In the previous section, we described the basic patterns of where and how co-referentiality and, specifically, reflexivity is marked in language. In this section, we will look further into co-referential dependencies in TİD, and the core properties of co-referentiality marked by KENDİ. Our aim here is to lay the groundwork for the more detailed discussion of the distribution of KENDİ in later sections.

As noted above, co-reference is structurally constrained and certain classes of DPs are restricted in the co-reference relations they can enter into. Büring (2005b) categorizes the possible co-referential relations between DPs as obligatory co-reference (8a),

TABLE 1 | Reflexivization Strategies Attested in Sign Languages.

	Verbal marking
	-Israeli Sign Language (ISL, Meir, 1998) -American Sign Language (ASL, Sandler and Lillo-Martin, 2006 i.a.) -Sign Language of the Netherlands (NGT, Kimmelman, 2008) -Italian Sign Language (LIS, Branchini, 2020) -German Sign Language (DGS, Loos, 2020)
	Argumental marking
Free form reflexive pronouns	-American Sign Language (ASL, Liddell, 1980; Lillo-Martin, 1995; Mathur, 1996; Wilbur, 1996; Sandler and Lillo-Martin, 2006; Koulidobrova, 2009, 2011; Fischer and Johnson, 2012; Wilkinson, 2013; i.a.) -Israeli Sign Language (ISL, Meir, 1998) -Croatian Sign Language (CSL, Cicilianić and Wilbur, 2006) -Turkish Sign Language (TİD, Zeshan, 2002; Sevinç, 2006; Dikyuva et al., 2017; Kelepir, 2020a) -German Sign Language (DGS, Mehling, 2010) -Sign Language of the Netherlands (NGT, Kimmelman, 2008) -Russian Sign Language (RSL, Kimmelman, 2008) -Catalan Sign Language (LSC, Navarrete-González et al., 2020) -Italian Sign Language (LIS, Mantovan, 2020)
Derived reflexive pronouns	-Italian Sign Language (LIS, Mantovan, 2020)
Personal pronouns	-Israeli Sign Language (ISL, Meir, 1998) -Croatian Sign Language (CSL, Cicilianić and Wilbur, 2006) -Russian Sign Language (RSL, Kimmelman, 2008)

obligatory non-co-reference (8b), and optional co-reference, i.e., ambiguity (8c):

(8) a. Zelda$_i$ bores herself$_{i/*j}$.
(obligatory co-*reference*)
b. She$_i$ adores Zelda's$_{*i/j}$ teachers.
*(obligatory non-*co-*reference*)
c. Zelda$_i$ loves her$_{i/j}$ teachers.
(optional co-*reference/ambiguity*)

English: Büring (2005a:2)

In (8a), the reflexive *herself* has to refer to Zelda, as indicated by the subscripted referential indices. In (8b), the pronoun *she* has to refer to an entity *other* than Zelda. Lastly, in (8c), the possessive pronoun *her* allows reference to either Zelda or an individual outside of the clause, a discourse referent. The Binding Theory (Chomsky, 1981) aims to account for these patterns of obligatory co-reference (Principle A), obligatory non-co-reference (Principle C), and optional co-reference (Principle B):

> *Principle A: An anaphora must be bound by a suitable (c-commanding, matching features) antecedent within its binding domain/the same clause.*
> *Principle B: A pronoun must be free within its binding domain/in its clause.*
> *Principle C: An R(eferential)-expression must be free in all environments.*
>
> Haegeman (1994:228–229)

In (9), we document these patterns in TİD:

(9) a. ELVAN$_i$ **KENDİ**$_{i/*j}$ LOVE.
"E*lvan loves herself.*"

b. ELVAN$_{ia_i}$ [POSS$_{3sg_a_i/*j}$ SON] LOVE.
"Elvan loves her son."

c. IX$_{3sg_ia_i}$ [ELVAN$_{*i/j}$ POSS$_{3sg_a_j}$ SON] LOVE.
"S/he loves Elvan's son."

KENDİ in (9a) must refer to the subject, ELVAN, as indicated by the subscripted referential indices. This is obligatory co-reference, as one would expect of a traditional reflexive governed by Principle A. Skipping ahead to (9c), we again observe a familiar pattern: the sign name ELVAN and the 3rd singular subject cannot be co-referent. This is obligatory-non-co-reference, governed by Principle C. The structure that gives rise to optional co-reference ambiguity in (8c), however, patterns differently in TİD (9b) due to the spatialization of the possessive marker (see Cormier et al., 2013 for a discussion of pronominal spatialization in sign languages). POSS in TİD, as in many other sign languages, spatially indicates its referent (here, ELVAN). Thus, we have obligatory co-reference with a *non*-reflexive pronominal not so much because binding works differently in TİD (9b), but because spatialization can prevent certain ambiguities from arising in the sign modality (Quer and Steinbach, 2015).

Interestingly, optional co-reference *is* possible if the overt possessive is removed entirely, as in (10).

(10) ELVAN SON LOVE.
"Elvan loves (her/the/someone else's) son."

The ambiguity here is highly dependent on context and includes interpretation as definite nominal ("the son"). Ambiguity on a par with (8c), however, can arise due to the use of a null possessive. Because it is null, the possessive is not spatialized as in (9c). The null possessive can be co-referent with the overt (subject) argument (ELVAN) by default/without special context (on a par with the preferentially bound interpretations observed elsewhere, cf. Reinhart, 1983; Kehler and Büring, 2007). However, it can also refer to another contextually salient referent, as in (11):

(11) *Context: Noyan$_j$ and his friends are talking about whether Elvan$_i$ likes Noyan$_j$'s children, and Noyan$_j$ tells people that Elvan$_i$ loves his$_j$ son but cannot get along with his daughter.*

ELVAN$_i$ SON LOVE.
"*Elvan loves his$_j$ son.*"

Turning next to the structural distribution of these three co-referential patterns, Büring (2005b) shows that lack of an antecedent in a mono-clausal setting affects each type of DP differently (12):

(12) a. *That it rains bothers himself.
b. That it rains bothers him.
c. That it rains bothers Peter.

English: Büring (2005b:3)

There are also structural constraints on where an antecedent can be when it is present, and this is where notions of reflexivity are key. The sentences in (13) express a reflexive event. Unsurprisingly, that reflexive event can be described using an obligatorily co-referent reflexive pronoun (13a). The reflexive event cannot be described using an obligatorily non-co-referent R-expression (13c), nor can it be described using a non-reflexive pronoun (13b).

(13) a. Peter$_i$ watches himself$_i$ in the mirror.
b. *Peter$_i$ watches him$_i$ in the mirror.
c. *Peter$_i$ watches Peter$_i$ in the mirror.

English: Büring (2005b:4)

Parallel structural constraints hold in TİD. Like (12a), (14a) is ungrammatical because **KENDİ** requires a morphosyntactic antecedent (14a), unlike a non-reflexive pronoun such as IX$_{3sg}$ in (14b) or an R-expression such as ELVAN in (14c). Moreover, as in (13), we see that only **KENDİ** can be used in a reflexive environment like (15).

(14) a. *LIGHTS **KENDİ** BOTHER.
"The light bothers her/himself."

b. LIGHTS IX$_{3sg}$ BOTHER.
"*The light bothers him/her.*"

c. LIGHTS ELVAN BOTHER.
"The light bothers Elvan."

(15) a. ELVAN$_i$ **KENDİ**$_i$ IN-THE-MIRROR LOOK.
"Elvan is looking at her/himself in the mirror."

b. *ELVAN$_i$ IX$_{3sg_i}$ IN-THE-MIRROR LOOK.[4]
"Elvan is looking at her in the mirror."

c. *ELVAN$_i$ ELVAN$_i$ IN-THE-MIRROR LOOK.
"Elvan is looking at Elvan in the mirror."

Thus, **KENDİ** appears to behave like a traditional reflexive that (i) requires a co-referential antecedent that is (ii) in the right structural configuration.

These morphosyntactic constraints pertain to what is meant by "binding domain" in Principles A-C. Binding domains appear to be sensitive to structural proximity, often called locality, which we illustrate here with clause boundedness. The sentences in (16) present the three types of DPs in the object position of a subordinated clause in English, with their potential antecedent in the subject of the matrix clause.

(16) a. *Carla$_i$ thinks [that I hate herself$_i$].
b. Carla$_i$ thinks [that I hate her$_{i/j}$].
c. *Carla$_i$ thinks [that I hate Carla$_i$].

English: Büring (2005b:4)

The boundary between the matrix clause and the subordinate clause seems to also function to demarcate binding domains. Thus, the antecedent for the reflexive in (16a), as compared to (8a) or (13a), is "too far away" to satisfy its binding requirements. In the case of a non-reflexive pronoun, the added distance of (16b) relative to (13b) allows the optional co-reference to emerge. Lastly, (16c) affirms that co-referential dependency, even when not local, between an R-expression and a potential antecedent is ungrammatical. Recall that this dependency was ungrammatical when it was local in (13c), too. Focusing on the comparison of (13a) and (16a), these data show that a traditional reflexive *requires* binding by an antecedent within its own *local* domain. This then would predict that if **KENDİ** is indeed a traditional reflexive, we should see evidence of structural sensitivity and locality constraints (though they may not match, exactly, those of English). The TİD equivalents of (16) are presented in (17), and the data in (17a) show that this prediction is borne out. (17a) is only grammatical when **KENDİ** is bound by an antecedent in its local domain (IX$_{1sg_j}$) like in (16a), as opposed to an antecedent outside of it (ELVANi). As for the pronoun in (17b), we again observe the sentence is rendered grammatical as long as the pronoun is bound by a co-referent outside of its local domain, as opposed to being locally bound. Moreover, we see that an R-expression in TİD (17c) is degraded if it has an antecedent *at all*, even if that antecedent is in a different domain (though in TİD the judgment is that the sentence is highly marked, not fully ungrammatical):

(17) a. ELVAN$_i$ THINK [IX$_{1sg_j}$ **KENDİ** $_{*i/j}$ HATE].
"Elvan thinks I hate her(self)."
b. ELVAN$_i$ THINK [IX$_{1sg_j}$ IX$_{3sg_i/*1sg_j}$ HATE].
"Elvan thinks that I hate her."
c. ??ELVAN$_i$ THINK [IX$_{1sg_j}$ ELVAN$_i$ HATE].
"Elvan thinks that I hate Elvan."

Thus, in many respects, TİD aligns with the principles of binding theory. However, these principles are under debate, and a common critique is that there is not strict complementary in the distribution of the three types of DPs. Our key observation here, though, is that **KENDİ** is only grammatical when bound by an antecedent that is syntactically proximal to it, such as (IX$_{1sg_j}$) in (17a), as opposed to an antecedent outside of it (ELVAN$_i$). The basics of co-referential relations among nominals in TİD tells us that **KENDİ** behaves like a traditional reflexive. However, reflexives aren't a homogenous class, and reflexives with different morphosyntactic and semantic encodings may be subject to different restrictions (Thráinsson, 1976; Hellan, 1988; Reuland, 2011; Déchaine and Wiltschko, 2017). In the next section, we explore what type of traditional reflexive **KENDİ** is, using the typology proposed by Déchaine and Wiltschko (2017). As will become clear in below, this typologically informed analysis of **KENDİ** can help us better understand previous claims in the literature.

PATTERNS WITH KENDİ RELATIVE TO TYPOLOGIES AND ANALYSES OF REFLEXIVITY

In the previous section, we summarized the basic co-referential relations in TİD and showed that **KENDİ** can function like a traditional reflexive. As we noted briefly above, however, reflexives are not a uniform class in many respects, including their syntactic category. Thus, we next ask what *type* of traditional reflexive **KENDİ** is, using the syntactic typology of reflexives proposed by Déchaine and Wiltschko (2017). Déchaine and Wiltschko (2017) divide reflexives into five types, and provide examples of languages with each type of reflexive (**Table 2**).

The main types of reflexives are: clitics, bound nouns, agreement markers, intransitivizers, and DP constituents. In addition to differing in syntactic category, the different types also exhibit slightly different structural patterns and contribute somewhat different semantics (despite all being a reflexive).

One such difference is that the multi-functionality of the reflexive marker differs depending on its type. The typology laid out by Déchaine and Wiltschko (2017) can be used to determine where **KENDİ** stands among reflexive markers, laying more solid groundwork for further analysis of **KENDİ** and co-reference relations in TİD. We begin by using Déchaine and Wiltschko's (2017) diagnostics to identify the morphosyntactic category of the reflexive **KENDİ**. The results of these diagnostics show that **KENDİ** behaves like a DP-type reflexive. The classification of **KENDİ**

[4]Note that the string in (15b) could be grammatical as an intransitive structure in which the IX$_{3sg}$ that follows the subject is a post-nominal determiner that sets the locus for the subject (vs. a pronominal object). These strings can be disambiguated with pausing and other non-manual cues.

TABLE 2 | Déchaine and Wiltschko's (2017) typology of reflexives.

Language	Example	Category	Syntactic parallel	Other functions
French	se	Clitic	Case	Reciprocal, middle, inchoative, applicative
Halkomelem	Bound noun	Bound noun	Inalienable Possession	N-compound, numeral classifier, applicative
Shona	zvi-	Agreement Marker	Classifier	Agreement, evaluative, adverb
Cree	-iso	Intransivizer	Valency	Medio-reflexive, inchoative
English	xself	DP	Possessor	Logophor, emphatic pronoun

as a DP-type reflexive leads to predictions about its behavior and functions beyond marking traditional reflexivity, which we discuss further in "The Function of KENDİ Beyond Traditional Reflexivity."

KENDİ Is Not a Clitic

Much like traditional reflexives are semantically dependent on an antecedent, clitics are morphologically and phonologically dependent on a host. They cannot bear stress, and often come in a reduced phonological form, as exemplified by the reflexive clitic *m'* in (18), which is a reduced form of the pronominal *me*. As the gloss suggests, the reflexive clitic *m'* forms a phonological unit with its verbal host (*auto-suggère)*. Moreover, though French is typically a postverbal object language and *m'* is expressing the reflexive object of the predicate, the clitic appears in a preverbal position. Thus, the clitic has characteristic properties in terms of its morphophonology and its morphosyntactic distribution.

(18) Je m' auto-suggère plein de trucs.
1sg refl auto-suggest full of things
"I suggest things to myself."
French: Déchaine and Wiltschko (2017:72)

Turning to TİD, a default SOV language, note first that the typical position of object KENDİ is in the standard pre-verbal position, as illustrated in (9a) and similar examples. This distributional pattern is not inherently at odds with a clitic analysis, but if KENDİ were a clitic, we would expect it to form a phonological unit with a preceding or following element. However, as illustrated in (19), KENDİ can be morphophonologically separated from the verb (its following element) by an intervening adjunct (as illustrated in the repository video, the adjunct intervening in (19a) continues throughout the production of the verb, while the adjunct in (19b) is clearly sequential):

(19) a. ELVAN$_i$ **KENDİ**$_i$ IN-THE-MIRROR$_a$ LOOK$_a$.
"Elvan sees herself in the mirror."

b. ELVAN$_i$ POSS$_{3sg_a_i}$ MIRROR PREVIOUSLY DIRTY. IX$_{3sg_i}$ CLEAN. IX$_{3sg_i}$ **KENDİ**$_i$ NOW SEE CAN.
"Elvan's mirror was previously dirty. She cleaned (it). She can see herself now."

KENDİ is also morphophonologically independent from the elements that *precede* it. For example, KENDİ is adjacent to its antecedent, ELVAN in (19a), but separated from ELVAN by the intervening adverb NOW in (20).

(20) ELVAN$_i$ NOW **KENDİ**$_i$ IN-THE-MIRROR$_a$ LOOK$_a$.
"Elvan sees herself in the mirror now."

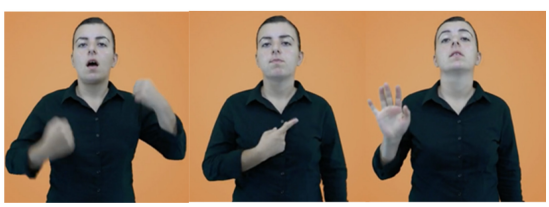
Another piece of evidence that KENDİ is not a clitic is that it can dislocate to the left periphery, giving rise to a contrastive topic meaning (21).

(21) **KENDİ**$_i$ ELVAN$_i$ IN-THE-MIRROR$_a$ LOOK.
"Elvan sees herself in the mirror (as opposed to someone else)."

In TİD, contrastive items are often observed with an eyebrow raise that is articulated simultaneously with the contrast-associated item (Gökgöz and Keleş, 2020 section 4.2). It is also the case that non-manual spread (annotated with the line above the manual sign glosses) (21) in sign languages has been associated with marking phrasal boundaries (Pfau, 2005, 2006). The non-manual marker associated with focus in (21) is not spreading over the subject ELVAN. Therefore, (21) not only shows that KENDİ can be linearly dislocated from what would have been its most plausible host, but also shows that it forms its own prosodic unit. This, then, backs up the narrative that KENDİ is a morphophonologically independent form.

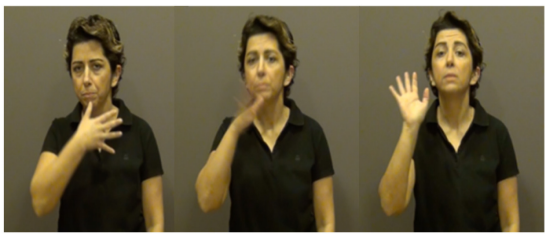
Comparing KENDİ to other clitics that *have* been documented in TİD -namely, the clitic form of negation—also reveals differences. Zeshan (2003, 2004) and Kelepir (2020d:3.5.1.1) observe that manual negation in TİD can occur as a free form (**Figure 2**) or a clitic (**Figure 3**)[5]. In its cliticized form, negation loses its syllabicity (reduced movement, shorter duration) and assimilates to the location of its host, instead of the neutral signing position used in **Figure 2**.

[5]See Pfau and Quer (2008) for a detailed discussion and analysis of manual and non-manual negation cliticization using data from Catalan Sign Language (LSC) and German Sign Language (DGS).



CAR MINE NOT
'The car isn't mine.'

FIGURE 2 | Adapted from Makaroğlu and Dikyuva (2017, entry: "değil"). Open-source image available from the online TİD dictionary: http://tidsozluk.net.



KNOW^NOT
'(I) don't know.'

FIGURE 3 | Adapted with permission from Kelepir (2020d: P4, 3.5.1.1).



_____headtilt
IX SPEAK KNOW^NOT
'I don't know how to speak.'

FIGURE 4 | Adapted with permission from Gökgöz (2009:20).

Unlike clitic negation, the signing position of KENDİ does not get assimilated to that of its host. This could be due to the body-anchored nature of KENDİ. However, there are other ways KENDİ differs from the negative clitic. Building on Zeshan and Kelepir's analyses, Gökgöz (2009) found that the non-manual marker for negation, a head tilt, patterns differently with the clitic and non-clitic form. With cliticized negation, the head tilt associated with negation spreads onto its morphophonological host, as indicated by the line above KNOW and cliticized ˆNOT in **Figure 4**. With non-cliticized, free negation, however, the non-manual marker only spreads over the negation itself (**Figure 5**).

Here, too, (21) provides the relevant evidence: we might expect the eyebrow raise in (21) to spread onto ELVAN too, had KENDİ cliticized to it. Thus, based on evidence from intervening items and the properties of clitics in TİD, the relationship between KENDİ and preceding or following elements is linear adjacency, not morphophonological dependency, as would be expected of a clitic.

KENDİ Is Not a Bound Noun

Bound noun reflexives are attested in languages such as in Halkomelem, where body part nouns attached to the predicate can be interpreted as co-referential with an argument, either the subject in an intransitive verb form (22a) or the object in a transitive verb form (22b). In the case of the predicate with an intransitive marker (*-em*) in (22a), *only* the reflexive interpretation is possible.

(22) a. th'exw-**xál**-em te Strang.
wash-**foot**-INTR DET Strang
"(i) Strang washed his own feet."
"(ii) #Strang washed someone else's feet."

b. th'exw-**xál**-t-es te Strang te sxele-s.
wash-**foot**-TRANS-3 DET Strang DET foot.POSS.3
"(i) Strang washed his own feet."
"(ii) Strang washed someone else's feet."

Halkomelem: Déchaine and Wiltschko (2017:91).

Data like that presented in the previous section also argue against a bound noun analysis of KENDİ's. KENDİ does not display the morphophonological characteristics of a bound element.

KENDİ Is Not an Agreement Marker

Our next step is to check if KENDİ is a verbal agreement marker. As discussed earlier, marking reflexivity on the verb is a commonly employed phenomenon in signed (and spoken) languages. Moreover, sign languages often make use of space for modulating agreement, and we know that TİD is a sign language that marks agreement spatially (Gökgöz et al., 2020 section 2.1.2.3.1). Spatial markers on predicates parallel agreement markers in tracking the event participants [see contributions to Lillo-Martin and Meier (2011) for discussion]. In fact, even intransitive predicates with a single argument can spatialize this way (Costello, 2016). However, we argue that this is not what KENDİ is doing for two reasons: (i) it marks reflexivity without being assigned a locus and (ii) still allows the verbal reflexive agreement marker to appear (if compatible with the predicate in general; Kelepir, 2020b section 3.1).



__headtilt
IX TEACHER NOT.
'I'm not a teacher.'

FIGURE 5 | Adapted with permission from Gökgöz (2009:21).

Before elaborating on those arguments, we first provide an example of a reflexive that is of the agreement marker type in Shona. The reflexive *-zví* in (23) has the distribution of an object agreement marker in the morphological template of Shona[6] (note that Shona also has a non-reflexive *-zvì* that differs in tone from the high-toned reflexive *-zví*):

(23) Ndà-kà-**zví**-bvùnz-à.
1SG-PAST-**REFL**-ask-FV
"I questioned myself."

Shona: adapted from Déchaine and Wiltschko (2017:82).

As discussed above, **KENDİ**, as compared to *-zví*, does not form a morphophonological unit with the verb. Indeed, **KENDİ** is not even obligatorily adjacent to the verb, as one might expect of an agreement marker in general. Moreover, **KENDİ** is body-anchored and does not make use of an assigned locus in the signing space. Thus, it's quite unlike how agreement *is* marked in TİD (Gökgöz et al., 2020:2.1.2.3.1) and in other sign languages (Cormier, 2012:124–125; Sandler, 2012: 44–45). Finally, if **KENDİ** *were* a kind of less common agreement marker in language that does *not* form a unit with the predicate it's marking "on", and an almost unattested kind of agreement marker in sign language that does not make use of space, we would expect it to show up post-verbally, because that's where functional items typically occur in TİD (Gökgöz, 2020).[7] The default position of **KENDİ**, however, is preverbal. Therefore, as above, both cross-linguistic and language-internal patterns argue against this analysis of **KENDİ**.

KENDİ Is Not an Intransitivizer

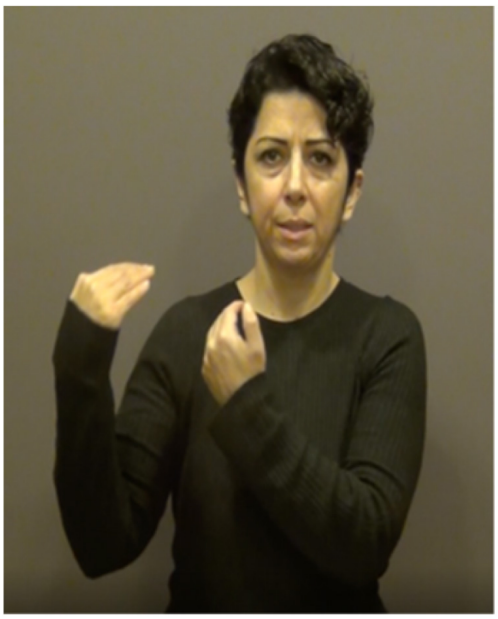
As for the intransitivizer category, Déchaine and Wiltschko (2017) point to the *-iso* suffix in Cree as an example. They observe that patient/object marking is absent on the verb when the reflexive marker is present (24a), but present then the verb is used non-reflexively (24b):

(24) a. 1pl ê-wâpam-***iso***-yâhk.
we COMP-see-***refl***-AGENT
"We see ourselves."

b. 1pl ê-wâpam-â-yâhk-ik.
we COMP-see-DIRECT-AGENT-PATIENT$_{3PL}$
"We see them."

Cree: Déchaine and Wiltschko (2017:86).

As described above, TİD and other sign languages can incorporate spatial locations to mark agreement. TİD also displays object agreement on some verbs through palm orientation (Kelepir, 2020c section 3.1.1.2). **Figures 6**, **7** illustrate how palm orientation marks object agreement in TİD. In **Figure 6**, the object is 1st person and the palm orientation is toward the signer, while in **Figure 7** the palm orientation is toward an established spatial locus away from the signer's body, the orientation of a 3rd person marker.



3SUPPORT$_1$

'S/he supports me.'

FIGURE 6 | Adapted with permission from Kelepir (2020c: P4, 3.1.1.2).

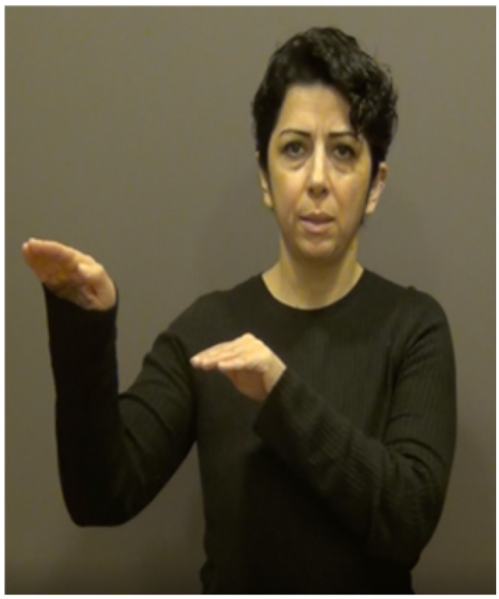
This palm orientation agreement marker is present in non-reflexive predicates like PROTECT or SUPPORT. Crucially, however, it is also present in reflexive usages of the same predicates. This is illustrated for reflexive and non-reflexive usages of the predicates PROTECT and SUPPORT in (25). In a sentence like (25a), the 3rd person palm orientation is toward a spatial locus away from the signers' body, whereas in (25b) there is the reflexive marker **KENDİ** *as well as* palm orientation toward the signer's body, just like **Figure 6**.[8] Note that the signer has omitted the subject agreement marker in (25b), as has been observed elsewhere in sign languages (Padden, 1988, 1983).

(25) a. (IX$_{1sg}$) $_1$PROTECT$_3$
"I protect him/her."

[6]Fv: final vowel. The final vowel on verbs alternate based on the features of its object in Shona, and therefore marked in glosses the same way it was marked in the cited source. See Storoshenko (2009) for a more detailed explanation.

[7]Handshape may serve as a kind of gender agreement marker in Japanese Sign Language, Taiwan Sign Language, and Korean Sign Language, but these too spatialize when marking verbs (Fischer, 1996; Zeshan, 2006).

[8]İşsever and Makaroğlu (2017) observes sentences like (25b), where **KENDİ** co-occurs with a verb that is marked for reflexiv(ized) agreement, are ungrammatical, and account for it by the Anaphor-Agreement Effect. However, one should keep in mind that their data comes from signers from Ankara, and ours from İstanbul, indicating there might be dialectal variation in this. Note that Kimmelman (2009) also observes an anaphoric reflexive being accompanied by a verb marked by reflexive agreement in RSL.



$_1$SUPPORT$_3$

'I support him/her.'

FIGURE 7 | Adapted with permission from Kelepir (2020c: P4, 3.1.1.2).

b. (IX$_{1sg}$) **KENDİ** PROTECT$_1$
"I protect myself."

Thus, **KENDİ** does not manipulate the argument structure like the intransitivizer *-iso* in Cree does, and we can conclude that **KENDİ** is not an intransitivizer because it co-occurs with a marker of transitivity, the palm orientation marker of object agreement.[9]

KENDİ Is a DP Reflexive

So far, we have seen that **KENDİ** does not align with the patterns of a clitic, bound noun, intransitivizer, or agreement type of reflexive. However, there is another kind of reflexive in the typology: a DP reflexive.

(26) I like ***myself***.

English: Déchaine and Wiltschko (2017: 61).

DP reflexives are basically reflexives that act like any DP, except for the specific dependency relation that they require a co-referring antecedent. Previous examples have shown that **KENDİ** is a reflexive that behaves like any DP (object) argument of the verb: it occupies an A position as the canonical object in the sentence and, moreover, can be dislocated to an A′ position the left periphery.

Recall that Déchaine and Wiltschko's (2017) typology includes syntactically parallel items for each of the reflexive types. For DP type reflexives, the parallel they observe is possessors. Note that in some DP type reflexives, the connection with possessors is transparent; the reflexive form in English contains a possessive: *my*self. For **KENDİ**, the connection with possessives is twofold. One, **KENDİ** can be combined with an overt possessor like the English "*xself*", as in (27).

(27) POSS$_{1sg}$ **KENDİ** *"myself"*
POSS$_{1pl}$ **KENDİ** *"ourselves"*
POSS$_{2sg}$ **KENDİ** *"yourself"*
POSS$_{2pl}$ **KENDİ** *"yourselves"*
POSS$_{3sg}$ **KENDİ** *"his/herself"*
POSS$_{3pl}$ **KENDİ** *"themselves"*

Two, **KENDİ** itself can also be used as an independent possessive (28), though this usage isn't very common.[10]

(28) HOUSE **KENDİ** BEAUTIFUL.
"My house is beautiful."

adapted from Dikyuva et al. (2017:204).

There are also cases of complementary distribution, where possessive usages of **KENDİ** block another possessive:

(29) ELVAN CHILDREN AT-ALL LOVE NOT. BUT IX$_{3sg}$ (??POSS$_{3sg}$) **KENDİ** SON LOVE.
*"Elvan doesn't like children at all. But she loves her **own** son."*

With respect to reflexive multi-functionality, additional functions of the DP type reflexives that Déchaine and Wiltschko (2017) observe are serving as emphatic anaphors (30a) and a logophors (30b):

(30) a. I saw Lucy **myself**.

English: Déchaine and Wiltschko (2017:77)

b. I$_i$ believe that Paul loves Mary more than myself$_i$.

English: Zribi-Hertz (1995:335).

As a reminder, emphatic anaphors are used to focus some aspect of the event or the referent's role in the event, often from a non-argument position, and logophors are anaphoric elements that seemingly skirt binding principles by getting their

[9]Moreover, comparing (a-b) below, we see in (b) that the movement for the verb starts from a locus in neutral signing space and moves toward the signer's body, which is being used as a stand in for non-first person (in addition to its use as shifted first person under role shift, Meir et al., 2007).
a. IX$_{3sg}$ IX$_{3sg}$ $_3$SUPPORT$_3$ b. IX$_{3sg}$ **KENDİ** SUPPORT$_1$.
"He supports him." *"He supports himself."*

[10]Dikyuva et al. (2017:204) observe that **KENDİ** is accompanied by a non-manual "op" mouth gesture when used as a possessor, and that it is a restricted to valuable and precious entities. Though we leave the "op" mouth gesture as a matter for future research, we do note here that our consultants did not share the intuition that possessive **KENDİ** is incompatible with ordinary noun possessees, as illustrated in (a-b). The reader is referred to Barker (1991) for a discussion of semantic issues like these in possessive structures, and to Abner (2013) for a discussion of these issues in ASL.
a. NOYAN$_{i_a}$ IX$_a$ **KENDİ**$_i$ BOOK $_a$GIVE$_1$.
"Noyan gave his own book to me."
b. NOYAN$_{i_a}$ IX$_a$ **KENDİ**$_i$ BOOK **KENDİ**$_i$ STUDENT$_b$ IX$_b$ $_a$GIVE$_b$
"Noyan gave his own book to his own student."

co-referent from a discourse antecedent outside of their local domain. Thus, emphatic anaphors and logophors are reflexive *forms* that are in grammatical positions that are not associated with reflexivity (emphatic anaphor), or have non-prototypical antecedents (logophor). We are currently investigating whether a logophoric usage of KENDİ possible, but we already know from previous observations by Zeshan (2002) and Sevinç (2006) that KENDİ does indeed function as an emphatic anaphor. We elaborate on the emphatic anaphor usage of KENDİ in "The Function of KENDİ Beyond Traditional Reflexivity."

To summarize, our fieldwork reveals that KENDİ in TİD can function as a traditional reflexive, and its previously observed usage as an emphatic anaphor is connected to its status as a DP-type reflexive, similar to English *xself,* and unlike other syntactic categories of reflexives discussed above. Moreover, we have seen that KENDİ shares other features that characterize DP-type reflexives, such as a structural parallelism with possessors. In the next section, we further explore the traditional reflexive usage of KENDİ, providing a more detailed description of its binding domain and its antecedents.

CO-REFERENTIAL RELATIONS WITH KENDİ

We have thus far provided some basic observations regarding co-referential relations in TİD and shown that KENDİ exhibits behaviors consistent with a traditional reflexive. We have also argued that KENDİ is a DP-type reflexive. In this section, we will explore KENDİ as a traditional reflexive in more detail and discuss its relation to potential antecedents in local and long-distance binding domains. We first examine whether KENDİ can be bound by null antecedents as well as overt ones, and then the clausal location of these antecedents.

Antecedents

A defining characteristic of a traditional reflexive is that it requires an antecedent. Whether this antecedent must be overt or not depends on whether the language in question allows null arguments. This is illustrated for KENDİ by the contrast in (31), where (31a) contains an overt antecedent (ELVAN) for KENDİ and is grammatical, but (31b) lacks an overt antecedent and is ungrammatical.

(31) a. ELVAN$_i$ **KENDİ**$_i$ IN-THE-MIRROR$_a$ LOOK$_a$.
"Elvan is sees herself in the mirror."
b. *__KENDİ__ IN-THE-MIRROR$_a$ LOOK$_a$.
"Herself looks in the mirror."

Judgments like those for (31a) and (31b) are in "out of the blue" contexts. However, language is rarely used in truly out of the blue contexts. Given that TİD permits null arguments, we would predict that KENDİ can be licensed by covert antecedents. The data in (32)-(33) illustrate that this prediction is borne out ("*e*" glosses the position of the null argument):

(32) ELVAN$_i$ POSS$_{3sg_i}$ MIRROR PREVIOUSLY DIRTY. IX$_i$ CLEAN. NOW e_i **KENDİ**$_i$ SEE CAN.
"Elvan's mirror was previously dirty. She cleaned (it). Now she can see herself."

(33) *Context: There was an election in the university to be the department chair. Aslı$_i$ and Meltem$_j$ are candidates. Aslı$_i$ is the former chair.*
e_i ONCE-MORE DEPARTMENT CHAIR BE WANT. e_i FOR **KENDİ**$_i$ VOTE. e_i MELTEM FOR VOTE NOT.
"(Aslı) wants to be the department chair again. (So, she) voted for herself, (she) didn't vote for Meltem."

These data show us that the required antecedent for KENDİ can be null arguments that are licensed by earlier portions of the discourse (32) or by contextual salience (33). Like KENDİ, the null argument that binds the anaphor, e_i, is subject to its own licensing conditions (*see* Kayabaşı et al., 2020 for a detailed discussion of null arguments in TİD).

These data affirm that KENDİ patterns like a traditional reflexive in requiring an antecedent, though independent patterns of null argument licensing in the language mean that this antecedent need not be overt. These findings are in line with existing research on null arguments and reflexive pronouns in other sign languages (Lillo-Martin, 1986; Bahan et al., 2000; Koulidobrova, 2012; Kimmelman, 2018; Kayabaşı et al., 2020 i.a.).

The Structural Relationship Between KENDİ and Its Antecedent

We have already briefly described KENDİ's relationship to overt and covert antecedents. In this section, we will talk about the structural logistics of KENDİ and discuss suitable structural positions for an antecedent to bind KENDİ, both in terms of hierarchy and proximity.

For a traditional reflexive like KENDİ, Principle A (Chomsky, 1981) is usually interpreted as requiring c-command of the reflexive by its antecedent. C-command is a structural relationship between two nodes, X and Y, neither of which dominates the other, but where every branching node that dominates X, also dominates Y (Reinhart, 1976; Büring, 2005b, i.a.). **Figure 8** illustrates how A can bind B but not the other way around since A c-commands B but not vice versa.

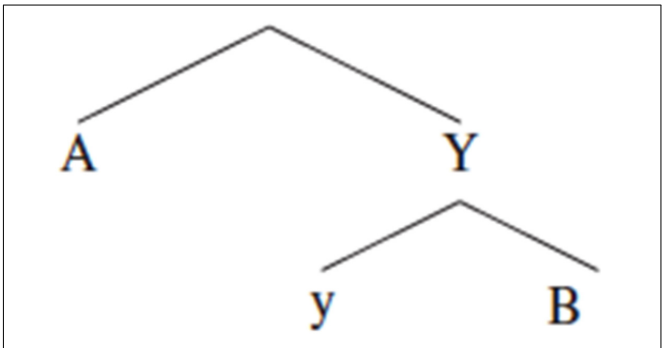


FIGURE 8 | Representation of C-command between A and B.

Crucially, there are patterns in language, like reflexivity, that show sensitivity to structural relationships like c-command. This is illustrated by the relationship between *Charlotta* and *her/herself* in (34). Note that the examples are structurally identical and *Charlotta* precedes the intended co-referential DP in both. Because *Charlotta* is "buried inside" the subject DP, however, it does not *c-command* the *her/herself* in either example. The resulting grammaticality differs depending on the use of a non-reflexive vs. reflexive pronoun. The non-reflexive pronoun in (34a) is grammatical because such pronouns are only optionally co-referent and do not need to be bound. However, a traditional reflexive is obligatorily co-referent, so the *herself* in (34b) *does* need to be bound. Consequently, expressing the co-reference *via* a reflexive, as in (34b), is ungrammatical.

(34) a. Charlotta$_i$'s dog accompanies her$_i$ to the kindergarden.
b. *Charlotta$_i$'s dog accompanies **herself**$_i$ to the kindergarden.

English: Büring (2005b:8)

A similar example for TİD is presented in (35). Here, there are two possible antecedents for **KENDİ**, the possessor ELVAN$_i$ and the full possessive DP [ELVAN$_i$ POSS$_{3sg_i}$ SISTER]$_j$. Only [ELVAN$_i$ POSS$_{3sg}$ SISTER]$_j$, however, is in a c-commanding relationship with **KENDİ**. As predicted, this is the only DP that can bind **KENDİ**:

(35) [(ELVAN$_i$) POSS$_{3sg_a_i}$ SISTER]$_j$ **KENDİ**$_{*i/j}$ IN-THE-MIRROR$_a$ LOOK$_a$.
"**Elvan's sister is looking at Elvan in the mirror.*"
"Elvan's sister is looking at herself in the mirror."

The fact that **ELVAN**$_i$ cannot bind **KENDİ** tells us that TİD is no exception to the rule that the relation between the antecedent and a traditional reflexive is structurally determined, and one that cannot be characterized by linear precedence. Though critiques have raised questions about whether c-command accurately characterizes the structural constraints imposed on binding, what is relevant here is that (35) shows that there is a *structural* constraint at play. So far, we described what type of antecedents **KENDİ** can take and showed that it can be bound by both overt and null antecedents. Moreover, we have shown that the relation between **KENDİ** and its antecedent is subject to some type of structural constraint. To assess the proximity aspect of the antecedent-reflexive relation, we turn next to the pattern of **KENDİ** in subordinate sentences. In (36), **KENDİ** is in the object position of the subordinated predicate SEE, and co-reference with the subject (ELVAN) of the matrix predicate WANT is possible (either *via* direct binding or mediated by an intervening null argument, itself co-referent with ELVAN):

(36) ELVAN$_i$ [$_{subordinate}$ MIRROR **KENDİ**$_i$ SEE] WANT.
"Elvan wants to see herself in the mirror."

Note, however, there are no other viable antecedents in (36). In (37), we see how **KENDİ** behaves when multiple possible antecedents *are* present in the sentence.

(37) IX$_{1sg_j}$ [ELVAN$_i$ **KENDİ**$_{i/*j}$ LOOK IN-THE-MIRROR] WANT.
"I want Elvan to look at herself in the mirror."

Here, too, **KENDİ** is in the subordinate object position, but now two overt and distinct referents are available to serve as antecedents: the matrix predicate subject, IX$_{1sg_j}$, and the subordinate subject, ELVAN$_i$. The only permitted antecedent for **KENDİ** in (37) is the closer subordinate subject. Note that the WANT type verbs in (36–37) are usually associated with non-finite sentential complements. In (38), we see the same binding patterns with THINK, a verb type that is often associated with finite sentential complements. There is currently very little known about finiteness in sign languages (and almost nothing known about this phenomenon in TİD) within the existing literature, but the patterns are the same across these predicate types.

(38) ELVAN$_i$ THINK [IX$_{3sg_j}$ **KENDİ** $_{*i/j}$ HATE].
"Elvan thinks s/he hates her/himself."

Together, (35)-(38) show us that **KENDİ** is sensitive to familiar, structural binding constraints of hierarchy and proximity. Having elaborated a bit on the co-referential relations of **KENDİ** as a traditional reflexive, we will now turn to **KENDİ**'s function beyond traditional reflexivity, emphatic anaphoricity.

THE FUNCTION OF KENDİ BEYOND TRADITIONAL REFLEXIVITY

KENDİ has already been observed to be used as an emphatic anaphor (*see* Zeshan, 2002; Sevinç, 2006), as is commonly true of other DP-type traditional reflexives (Déchaine and Wiltschko, 2017). In this section, we will further explore the emphatic anaphor function of **KENDİ**.

Two Types of Emphatics

Emphatic markers are anaphors that co-refer to a participant of the given event to cast focus on it and to contrast it from other participants in a possible set of participants (Kemmer, 1995; Stern, 2004, i.a.). They usually occupy non-argument positions, and they do not express reflexivity. Focusing on English, Ahn (2010) notes two distinct usages of the emphatic anaphor *xself* (here, *himself*), exemplified in (39). In (39a), *himself* creates argument focus on its event participant antecedent, a "specifically John and not someone else" meaning. In (39b), however, *himself* modifies the event (not an argument), and emphasizes that John performed the given event without help or the contribution of another causer/agent.[11]

(39) a. John **himself** did it. *(adnominal, DP oriented)*
Paraphrase: John (not his mother) did it.
b. John did it **himself**. *(adverbial, VP oriented)*
Paraphrase: John did it without any help.

English: Ahn (2010:10)

[11]See Ahn (2010:10) for a discussion of how the plain adverbial emphatic *himself* in (39b) compares to the *by himself* phrasal modifier.

He labels the interpretation that arises from modifying the DP (39a) as "adnominal", and the one that arises from modifying the DP as "adverbial" (39b).

In (40) we see the same two-way distinction with the emphatic function of **KENDİ**:

(40) a. ELVAN$_i$ **KENDİ**$_i$ SPORTS LOVE. *(adnominal, DP oriented)*
"Elvan herself loves sports."
Paraphrase: Elvan, among all of her peers, likes sports, while everyone else likes something else.

b. IX$_{1sg}$ **KENDİ**$_i$ T-İ-D LEARN. *(adverbial, VP oriented)*
"I learn TİD myself."
Paraphrase: I'm learning how to sign TİD without instruction.

As the translations show, (39a-40a) and (39b-40b) resemble one another with respect to the emphatic contribution of *himself* and **KENDİ**.

Notice, though, that the different interpretations of *himself* in (39a-b) also correspond to different syntactic positions. Interestingly, the two distinct interpretations in (40) are possible with **KENDİ** in the same linear position. However, **KENDİ** in its emphatic function can also occupy different positions in the sentence (41), including the rightmost position (41c), which is ungrammatical for a traditional reflexive **KENDİ** as (42) shows (note also that emphatic **KENDİ** in (41) is optional):

(41) a. CHILD **KENDİ** WINDOW BREAK.
Adnominal interpretation: "The child himself broke the window."
Adverbial interpretation: "The child broke the window himself."

b. CHILD WINDOW **KENDİ** BREAK.
Adverbial interpretation: "The child broke the window himself."

c. CHILD$_i$ WINDOW BREAK **KENDİ**.
Adnominal interpretation: "The child himself broke the window."
Adverbial interpretation: "The child broke the window himself."

(42) *ELVAN$_i$ LOVE **KENDİ**$_i$.
"Elvan loves herself."

Moreover, as the translations for (41a) and (41c) indicate, emphatic **KENDİ** has both adnominal and adverbial interpretive possibilities in each of these possible positions.

However, Ahn identified other diagnostics that distinguish adnominal and adverbial emphatic anaphora, such as: denying the event, specificity, thematic roles, context-free acceptability, stative verbs, prosody and stress. Here, we will use three of Ahn's diagnostics to probe emphatic usages of **KENDİ**: (i) denying the event, (ii) specificity, and (iii) thematic roles of the co-referent (research is ongoing, and we do not have enough data to conduct all the diagnostics suggested by Ahn (2010) at this stage).

Denying the adnominal emphatic requires denying that the focused referent was, in fact, the relevant event participant at all; in (43a), this is accomplished by asserting that someone else did the activity. Denying the adverbial emphatic, however, doesn't mean denying that the individual did the thing, just that they did the thing alone or without help. The felicitous adverbial denial pattern is given in (43b).

(43) a. John himself fixed the car. *(adnominal, DP oriented)*
Denial: No, John's mother did so.

b. John fixed the car himself. *(adverbial, VP oriented)*
Denial: No, he fixed it with Mary.

English: Ahn (2010:11)

In (44), we see that *both* denials are felicitous with emphatic usages of **KENDİ** in each of the positions identified in (41)—that is, all three positions are apparently compatible with both adnominal and adverbial interpretations of **KENDİ**.

(44) a. IX$_{1sg}$ **KENDİ** T-İ-D LEARN.
Adnominal Denial:
✓NO, WITH NOYAN IN SAME CLASS LEARN.
Adverbial Denial:
✓NO, ELVAN TEACH.
b. IX$_{1sg}$ T-I-D **KENDİ** LEARN.
Adnominal Denial:
✓NO, WITH NOYAN IN SAME CLASS LEARN.
Adverbial Denial:
✓NO, ELVAN TEACH.
c. IX$_{1sg}$ T-I-D LEARN **KENDİ**.
Adnominal Denial:
✓NO, WITH NOYAN IN SAME CLASS LEARN.
Adverbial Denial:
✓NO, ELVAN TEACH.

In addition to differences in deniability patterns, Ahn (2010) also observes that adnominal emphatic anaphors require a specific (but not necessarily definite) referent (45a,c), whereas no such restriction holds for adverbial emphatics (45b,d). "Specificity" here refers to the event participant being a unique entity as opposed to a generic one.

(45) a. #Which girl $_{DP}$herself solved the problem?
(adnominal interpretation).
b. Which boy solved the problem $_{VP}$himself?
(adverbial interpretation).
c. #Someone $_{DP}$themselves solved the problem.
(adnominal interpretation).
d. Someone solved the problem $_{VP}$themselves/$_{VP}$himself.
(adverbial interpretation).

English: Ahn (2010:17–19)

As for TİD, we again see a slightly different pattern. Non-specific referents—namely, WHICH CHILD (46) and SOMEONE (47)—are semantically compatible with the adverbial interpretation of emphatic **KENDİ**, as in English, but they are also compatible with adnominal interpretations. Here, too, these observations hold for **KENDİ** in multiple positions.

(46) a. ALL TOYS WHICH CHILD **KENDİ** BREAK?
Adnominal interpretation: "Which specific child (of all people/as opposed to others) broke all the toys?"
Adverbial interpretation: "Which child broke all the toys himself (without help or alone)?"

b. ALL TOYS WHICH CHILD BREAK **KENDİ**$_i$?
Adnominal interpretation: "Which specific child (of all people/as opposed to others) broke all the toys?"
Adverbial interpretation: "Which child broke all the toys himself (without help or alone)?"

(47) a. SOMEONE **KENDİ** ALL TOYS BREAK.
Adnominal interpretation: "Someone specific (of all people/as opposed to others) broke all the toys."
Adverbial interpretation: "Someone broke all the toys himself (without help or alone)."

b. SOMEONE ALL TOYS **KENDİ** BREAK.
Adnominal interpretation: "Someone specific (of all people/as opposed to others) broke all the toys."
Adverbial interpretation: "Someone broke all the toys himself (without help or alone)."

c. SOMEONE ALL TOYS BREAK **KENDİ**.
Intended adnominal interpretation: "Someone specific (of all people/as opposed to others) broke all the toys."
Adverbial interpretation: "Someone broke all the toys himself (without help or alone)."

The third and final diagnostic that we will cover from Ahn (2010) concerns the thematic roles that are compatible with the emphatic anaphor. He observes that adverbial emphatic anaphors are only compatible with volitional and agentive subjects, whereas adnominal emphatic anaphors have no observed thematic role restriction. However, (48) shows not only that **KENDİ** is perfectly acceptable and grammatical with a non-volitional inanimate subject, but that it is compatible with an adverbial interpretation (EXTCL glosses an extension classifier sign):

(48) WOOD EXTCL **KENDİ** BREAK.
"The wooden stick broke all by itself."
Paraphrase: There was no overt causer that broke the stick, it broke on its own.

Kayabaşı and Gökgöz (in press: 16)

So far, our assessment of the emphatic usages of **KENDİ** shows us that they have more flexibility than (i) their traditional reflexive counterparts in TİD and (ii) their emphatic anaphor counterparts in English. However, it is important to note that the semantics and pragmatics of TİD is very understudied, as is the cross-linguistic typology of emphatic anaphors. Future investigation can investigate the source of these cross-linguistic differences and further assess if there are differences between adnominal and adverbial interpretations of **KENDİ**.

Ambiguity Between the Emphatic and the Traditional Reflexive: Optional Argumenthood

In this section, we will explore cases where **KENDİ** can be ambiguous between a traditional reflexive and an emphatic anaphor. Such cases are possible when the predicate of a sentence allows for object drop or null objects and a potentially reflexive event. The predicate VOTE GIVE can take a DP (49a) or PP (49b) as an object, and it also can be used intransitively (49c):

(49) a. ELVAN EKREM IMAMOĞLU VOTE GIVE.
"Elvan voted for Ekrem İmamoğlu."

b. ELVAN EKREM IMAMOĞLU FOR VOTE GIVE.
"Elvan voted for Ekrem İmamoğlu."

c. ELVAN VOTE GIVE.
"Elvan voted (for someone)."

Thus, in (50), it is not clear whether **KENDİ** occupies an argument position as a traditional reflexive, or whether it's an emphatic anaphor, and within the latter both adnominal and adverbial interpretations are possible.

(50) ELVAN$_i$ **KENDİ**$_i$ VOTE GIVE.
Traditional Reflexive interpretation: "Elvan voted for herself."
Adnominal emphatic: "Elvan herself (of all the other people who could have done so) voted."
Adverbial emphatic: "Elvan voted herself (without anyone directing or helping her)."

We assume here that this is a case of structural ambiguity: despite **KENDİ** surfacing in the same linear position, it occupies different positions in the sentential structure. The intended interpretations can be contextually disambiguated but they can also be structurally disambiguated[12]. Examples of structural disambiguation are illustrated in (51), where the presence of a preposition (51a) or a separate DP (51b) unambiguously express the intended transitive interpretation (recall from (49a-b) that VOTE GIVE can take its object as a DP or PP, which is why the FOR is "optional").

(51) a. ELVAN **KENDİ** (FOR) VOTE GIVE.
"Elvan voted for herself."

b. ELVAN **KENDİ** EKREM IMAMOĞLU (FOR) VOTE GIVE.
"Elvan herself voted for Ekrem İmamoğlu."

The above examples are cases where we see a given token of **KENDİ** that is compatible with different types of interpretations.

[12]As noted, that context can disambiguate **KENDİ** with no added structural cue necessary:
Context: There was an election in the university to be the department chair. Asl$_i$ and Meltem$_j$ are candidates. Asl$_i$ is the former chair.
ASLI$_i$ ONCE-MORE DEPARTMENT CHAIR BE WANT. IX$_{3sg}$ **KENDİ**$_i$ VOTE. IX$_{3sg_i}$ MELTEM$_j$ VOTE NOT.
"Aslı wants to be the department chair again. She voted for herself, didn't vote for Meltem".

However, there are also cases where we see multiple tokens of KENDİ within the same utterance, as in (52).

(52) ELVAN KENDİ PROTECT$_1$ KENDİ.
Interpretation 1: "Elvan protects HERSELF"
Interpretation 2: "Elvan protects herself by herself (without help from someone else)."

For the first interpretation of (52), it might be the case that the doubling of KENDİ functions in a similar way to focus doubling (Makaroğlu, 2012). The second interpretation, however, provides clear evidence that KENDİ can serve distinct functions, which can be combined within the same sentence.

CONCLUSION AND FUTURE DIRECTIONS

In this paper, we discussed the co-referential properties and the syntactic category of the sign KENDİ in TİD, which we argue can serve both a traditional reflexive and emphatic function. We have shown that KENDİ in TİD can function as a reflexive in the traditional sense and we have used syntactic typologies to classify it as a reflexive of the DP type. As a reflexive, KENDİ is subject to structural antecedence requirements. As a DP-type reflexive, KENDİ is able to serve functions outside of traditional reflexivity.

Importantly, this study lays the groundwork for further analyses of KENDİ as well as reflexivity in TİD and other sign languages in general. With respect to TİD, future research can expand our understanding of (i) the shared and different properties of the traditional reflexive and emphatic function of KENDİ, (ii) whether these properties are associated with distinct merge positions in the sentential structure, (iii) if logophoric usages of KENDİ are possible, (iv) non-manual characteristics of these distinct functions functions, and (v) potential language contact and bilingualism effects, among others. Moreover, future research can explore these issues in other signed languages, and further contribute to a cross-modal understanding of how co-reference is encoded.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board of University of Michigan. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Written informed consent was obtained.

AUTHOR CONTRIBUTIONS

DK conducted the fieldwork and drafted the manuscript, with critical revisions provided by NA. Both authors discussed the literature reviewed, designed the content and structure of the article, and approved the final version of the manuscript.

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Redefining Multimodality

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The term "multimodality" incorporates visible gestures as part of language, a goal first put forward by Adam Kendon, and this idea revolutionized the scope of linguistic inquiry. But here I show that the term "multimodality" itself is rife with ambiguity, sometimes referring to different physical channels of transmission (auditory vs. visual), and sometimes referring to the integration of linguistic structures with more imagistic, less conventionalized expressions (see David McNeill's work), regardless of the physical channel. In sign languages, both modes are conveyed in a single, visual channel, revealed here in the signing of actors in a sign language theatre. In spoken languages, contrary to expectations raised by defining "modality" in terms of the physical channel, we see that the channel of transmission is orthogonal to linguistic and gestural modes of expression: Some visual signals are part and parcel of linguistic structure, while some auditory (intonational) signals have characteristics of the gestural mode. In this empirical, qualitative study, I adopt the term "mode" to refer solely to specific characteristics of communicative expression, and not to the physical channel. "Multimodal" refers to the coexistence of linguistic and gestural modes, regardless of the physical channel of transmission—straightforwardly encompassing the two natural language systems, spoken and signed.

Keywords: multimodality, modality, sign language, gesture, mode

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1 INTRODUCTION

Ever since the groundbreaking work of Kendon (1980, 2004) and McNeill (1992), researchers have increasingly paid attention to the gestural side of language, and there is now a very large body of literature about what is termed "multimodality" (see the extensive handbook of Müller et al., 2013, Müller et al., 2014). Because most linguistic organization in spoken languages is in the vocal/auditory channel and most gestural information is in the visual channel, researchers often assume that the types of expression involved can be distinguished by the physical channel. At the same time, since speech and gesture are closely integrated, other researchers hold that they must be considered part of the same phenomenon (Kendon, 2004; Fricke, 2013; Goldin-Meadow and Brentari, 2017). But this dichotomy of views has led to confusion in establishing a unified definition of modality.

Sign languages are characterized by all the traditionally defined levels of linguistic structure—phonology, morphology, syntax, prosody, and semantics (Sandler and Lillo-Martin, 2006; Pfau et al., 2012). But if the physical channel were the determining factor for separating the gestural from the linguistic, sign language would be an anomaly. In sign languages, the vocal-auditory channel is not available, and the linguistic signal itself is conveyed primarily by the hands, the head, and parts of the face, and perceived by the eyes. There should be no "modality" left for gesture and no multimodality in sign language. Yet we know and will show here that signers do gesture (Emmorey, 1999; Sandler, 2009).

In a research paradigm called The Grammar of the Body,[1] my colleagues and I were able to associate linguistic structures with precise articulations of face, hands, and body in established and

[1]More information about this approach and findings can be found on the website: https://gramby.haifa.ac.il/

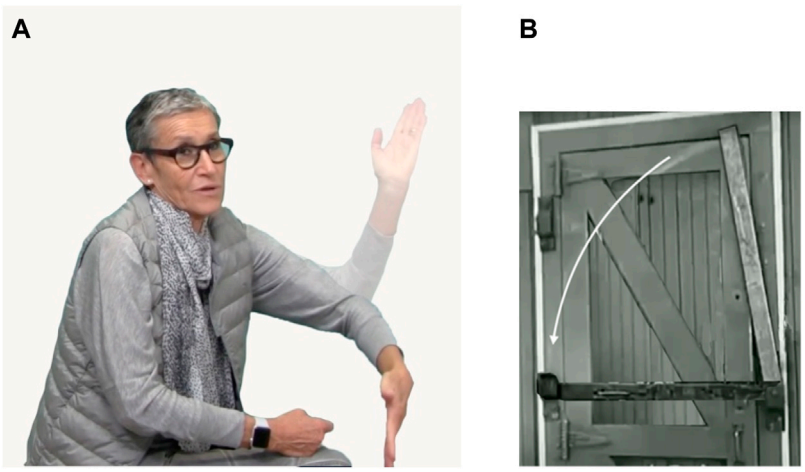


FIGURE 1 | (A) Iconic co-speech manual gesture indicating a latch coming down and locking the door to a lion's cage (pictured in **(B)**).

emerging sign languages, demonstrating how visible bodily articulations alone can convey bona fide linguistic structure (Sandler, 2012a; Sandler, 2018), described in **Section 2**. We will see in **Section 3** that the same physical apparatus in sign languages conveys expressions that are gesturally organized as well, and we adopt the term 'mode' to refer to either linguistic or gestural forms. By this distinction, identifying both the linguistic mode and the gestural mode in sign language becomes straightforward, so that all natural human languages, spoken or signed, are properly described as multimodal.[2] Here, to avoid confusion, I refer to spoken and signed languages as two kinds of language, rather than using the term "modalities."

This paper deals only with one family of gestures—iconic gestures. Iconicity means that the signal, whether auditory or visual, resembles its meaning. An example of an iconic co-speech visual gesture is shown in **Figure 1**. As background, **Table 1** shows the properties that distinguish iconic gestures from linguistic expressions (essentially, words), based on McNeill (1992), and further discussed in **Section 1.1**.

In his seminal book, McNeill (1992) distinguished gestural from linguistic form, asserting that together they comprise language. McNeill proposed that there are several kinds of gestures, among them, iconic gestures, which describe visual properties or locations, constituting the focus here; beats, which emphasize the rhythm of speech; metaphoric gestures, which abstractly represent concepts or topics in a discourse; and deictics, which point to or establish the location of a referent. Citing the temporal coordination of gesture and speech prosody (see also Brown and Prieto, 2017 for a recent, detailed analysis), McNeill's treatment proposes that gestural and linguistic form together make 'language', distinguishing between "the linguistic" and "language"—a seemingly blurry distinction, but one that I see as essentially correct, precisely because all natural language communication has linguistic and gestural modes of expression, and, although the two can be distinguished, the dividing line is not always clear (see Okrent 2002). **Section 1.1** elaborates the characteristics that distinguish the linguistic and the gestural modes in **Table 1**.

1.1 Linguistic and Gestural Modes

Gestural and linguistic organization comprise two modes of expression common to both spoken and signed languages, and not defined in terms of the physical channel of transmission. The following introduction to properties of gestural vs. linguistic modes, suggested by McNeill (1992) and represented in **Table 1**, includes certain amendments, that are motivated by the present exploration, as explained throughout this paper.

1.1.1 Duality of Patterning Versus Global

Spoken language morphemes and words are characterized by a meaningless phonological level and a meaningful level, a distinction described in terms of secondary articulation by Martinet (1960), and called duality of patterning by Hockett (1960). Iconic gestures are globally organized—an iconic gesture looks like what it means as a whole, without a list of internal meaningless elements that recombine in a systematic, rule-governed way that characterizes duality of patterning. In sign languages, signs are formed by a finite list of meaningless primitives, like spoken words, and substituting one for another can create new words (Stokoe, 1960). Another criterion for duality of patterning is that the primitive elements can be altered by systematic rules, referring only to the form but without reference to meaning (Sandler, 2012b). The important insight here is that there are systematically organized meaningless and meaningful levels in the linguistic structuring of spoken words and of signs in sign languages. This contrasts with iconic gestures, like the one shown in **Figure 1A**, in which there is

[2]While the term "multimodal" implies more than two modes, here I deal with the two primary modes—linguistic and gestural. In **Section 1.1**, I suggest that an additional mode is pantomime/enactment, defined and distinguished from other modes there, but not further explored in this article.

TABLE 1 | Dichotomy between the linguistic and the gestural, after McNeil (1992).

Linguistic mode	Gestural mode
Meaningless and meaningful levels (duality of patterning)	Global/holistic
Arbitrary	Imagistic/iconic
Combinatorial with respect to other elements of the same kind	Noncombinatorial with respect to other elements of the same kind
Conventionalized	Idiosyncratic, context-sensitive
Discrete	Gradient

neither a level of finite, meaningless building blocks, nor systematic rules referring to them. The gesture could be made in many different ways and still convey the image of a plank falling. Signs, like spoken words, have duality of patterning; gestures are globally structured.

1.1.2 Arbitrary Versus Imagistic

The forms of spoken language words typically have an arbitrary relationship with their meaning (de Saussure et al., 1959), while iconic gestures are imagistic; they create visual impressions to enhance meaning (see **Figure 1A**). While signs themselves, akin to spoken words, can also be imagistic or iconic, there are still many differences in degree and type of iconicity between the two kinds of language (see e.g., Sandler, 2009, Perniss et al., 2010, Downing and Stiebels, 2012, Dingemanse et al., 2015, Lepic et al., 2016, and Dingemanse et al., 2020 for more detail). The signs of sign languages have much more iconicity than words in spoken languages do, making the distinction between iconic and arbitrary more nuanced (see **Sections 2**–**4**), but the distinction between arbitrary and iconic is still relevant for distinguishing linguistic from iconic gestural form. Signs are "globally" iconic more often than spoken words (see for example **Figure 2**), and sublexical units, which behave phonologically like meaningless elements, can themselves be interpreted as meaning-bearing, as we will see in **Section 2**. **Section 4** shows how the underlying iconicity in the building blocks of signs can be invoked in artistic expression.

1.1.3 Combinatorial/Non-combinatorial Relations

Morphemes and words typically combine with other units of the same type to form larger constituents with predictable meanings (see Werning et al., 2012 (eds) on compositionality). Gestures coincide with constituents of the linguistic signal but do not enter into combinatorial relations with each other. For McNeill, the term combinatorialty is restricted to linear, syntactic combinations and relations; that is, the claim is that sequences of gestures are not combined with each other according to their own rules, which seems correct. While gestural elements can have internal and simultaneous combinatoriality (Calbris, 1990; Fricke, 2014), they do not enter into sequential combinations with each other, without linking independently to linguistic structures. The picture is made more interesting by the observation shown in **Section 5.3**, that gestures can appear sequentially before or after words (Schlenker, 2019), playing a semantic (linguistic) role. Yet gestures do not seem to combine in any rule-governed way with each other. The intent of the bifurcation in **Table 1** between combinatorial and non-combinatorial, then, is sequential combinatoriality of elements of the same kind: linguistic elements are sequentially combinatorial with one another; gestures are not.

1.1.4 Conventionalized Versus Idiosyncratic

Linguistic elements are conventionalized within a community in terms of meaning and distribution. But the same gesture can have different meanings (within and across individuals), depending on the linguistic context, and the choice and meaning of iconic gestural elements also vary within and across individuals. This idiosyncrasy implies context-sensitivity, since the intended meaning of the iconic image can only be interpreted according to context (See **Figure 9** below).

1.1.5 Discrete Versus Gradient

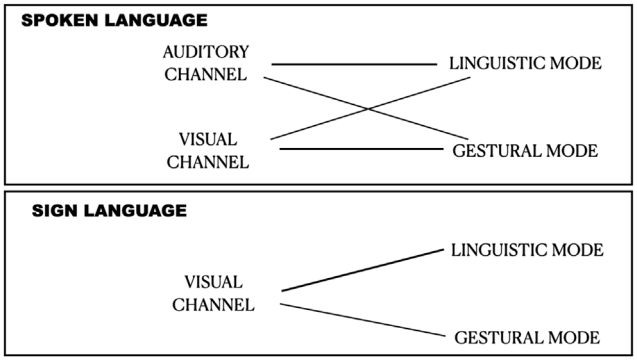
Put simply, this distinction means that linguistic elements tend to be underlyingly discrete in the senese that their form does not vary systematically in tandem with gradient degrees of emphasis or meaning.[3] Contrarily, any gradient variation in the production of iconic gestures is interpreted analogically to real world form or action. So, in English, adjectives such as big or heavy do not change their form systematically to represent degree of size or heaviness, nor is the form of verbs such as climb or run altered to represent degrees of difficulty or speed.[4] The complex word rewind means "to wind again," and one does not reduplicate the prefix to signal how many times this winding takes place. There is no *rererererewind indicating winding four times. Similarly, enlarge means to make bigger, and the form of the word does not analogically represent the resulting size. We will see in **Section 5.3** that this property is only partly definitive in distinguishing the linguistic mode from the gestural.

By these criteria, I will briefly exemplify linguistic structure in the phonology and intonation of sign languages in **Section 2**, mainly using Israeli Sign Language (ISL) as the example. **Section 3** demonstrates gestural elements in sign languages. **Section 3.2** demonstrates that, in addition to linguistic roles, the mouth is abundantly used for iconic gesture across sign languages. In so-called classifier constructions, which are hybrids of linguistic and gestural modes, discussed in **Section 3.3**, the hands combine the linguistic mode with the gestural. Since all of the same articulators used for gesture are also used for strictly linguistically organized material in sign language, dividing the material according to physical channel of transmission clearly does not capture the facts.

[3]Paralinguistic intonation (Ladd, 1996) can indeed reflect degree, but again, such devices are paralinguistic and are indeed better described as gestural and not linguistic (see **Section 5** here).

[4]Such iconic signals as speed of speech representing the speed of an activity have the characteristics of gesture; see **Section 5**.

TABLE 2 | The relations between channel and mode in spoken language and in sign language.



Redefining "multimodal" as comprised of gestural and linguistic modes, and divorcing it from the physical channel of transmission, allows for the interaction between the two types of organization that we find in both signed and spoken languages. An informative consequence of the distinction is this: If the gestural and the linguistic are two modes of language, and if they can naturally coexist in the same physical channel as they do in sign languages, this leads to the expectation that there will some interaction between the two in natural communication, and indeed there is. **Section 4** provides examples of interaction between linguistic and gestural modes from theatrical and poetic signing in the Ebisu Sign Language Theatre Laboratory. We will see there that signals that have made their way into the linguistic phonological structure still remain available for spontaneous gesture. So, sign languages cross the line between linguistic and gestural modes in one and the same visually perceived system, and they sometimes cross back, making the division a little less crisp than might have been thought. I will argue that this is a theoretically desirable consequence.

Turning to spoken language, here we assume traditional background in linguistic structure, and we will not delve into it here. We also know well that spoken languages exploit visual signals for gesture. But likening "modality" to the physical channel of transmission does not work for spoken language either. The modes of language and their physical instantiation criss-cross in spoken languages. The distinctions and their interactions can be seen schematically in **Table 2**.

Section 5 reviews evidence that spoken languages, like sign languages, exploit visual signals as part of the linguistic mode, but that they also exploit auditory signals for gesture. In other words, there is evidence that spoken languages, primarily transmitted in the auditory channel, also use visual signals in the linguistically organized system, particularly at the levels of reference (Fricke, 2013; Landau, 2016), and semantics (Schlenker, 2018; Schlenker, 2019; Ebert et al., 2020). At the same time, the auditory channel can exploit the gestural mode, specifically, in intonation and information structure (Bolinger, 1983; Ladd, 1996; Swerts and Krahmer, 2008; Prieto, 2015). Once again, we see that the division between the linguistic and the gestural has to do with characteristics of the modes of expression, and not with the channel of transmission. We conclude in **Section 6** that spoken and signed languages are not different language "modalities," but rather two different kinds of language, each multimodal, each exploiting the linguistic and the gestural modes in its own way. This analysis points to a flexible and dynamic model of human language.

1.2 Excluded Topics

Four topics that sometimes figure in gesture and sign language studies will not be dealt with in the present analysis, in the interest of economy. These are: emblems, a gesture-sign "continuum," pantomime/constructed action, and silent gesture. Here I briefly describe each, to delimit the goals of this study.

1.2.1 Emblems

Kendon, McNeill, and other gesture researchers have dealt with emblems (see also Efron, 1941; Kendon, 1988, Kendon, 2004, and Müller, 2019), such as OK, VICTORY, TIME-UP, BE-QUIET. Emblems are sometimes claimed to be closest to signs of sign language, and, according to Kendon, closest to words, precisely because they are conventionalized, unlike other gestures. But by familiar definitions, emblems seem to be the opposite of words. As Kendon also explains, emblems are whole speech acts. However, this is a function which individual words rarely bear, and therefore it seems to contradict the idea that emblems are closest to words. Emblems have no syntactic or other grammatical category, but rather stand for whole propositions; they cannot undergo inflection or derivation; and they do not enter into hierarchical or sequential relations with other gestures or words. Unlike signs, prototypical emblems are rarely iconic of objects and actions in the world. In fact, unlike iconic and deictic gestures, emblems very rarely become signs, though they can be used as conventional gestures, not only by speakers but by signers as well (Emmorey, 1999; van Loon et al., 2014). Emblems, at least the most prototypical sort, then, are not like other gestures, not like words, and not like signs. Instead, they could be described as a kind of communication game, that takes felicitous advantage of visual, cognitive and cultural affordances that we share. As such, they should certainly be considered in any typology of gesture, but they are not relevant for the present discussion.

1.2.2 A Gesture-Sign Continuum

Nor do I deal with a so-called continuum between gesture and sign (see Müller 2018 for a recent cogent exploration of continua). Although some signs may have gestural roots, the details of earliest signs are more like those of words than of gestures, right from the get-go. In the first-generation signer of Al-Sayyid Bedouin Sign Language that we studied, we found conventionalized signs (still used in the community) as well as pantomimic enactments of events, and we were able to distinguish the two on the basis of criteria in **Table 1**, even at this earliest stage of sign language emergence (Sandler, 2012b). I am unable to speculate about a single coherent continuum from gestures to words/signs, and I leave that issue outside the scope of this paper.

1.2.3 Pantomime

I also wish to exclude for the most part a system called pantomime (which overlaps with enactment, constructed action, and mimesis), in which signers in some way act out

events with part or all of the body (touched on briefly in **Section 5.3**). I define pantomime as a system in which each part of the body typically represents itself: the hands are the hands, the face is the face, and the body is the body of whoever is being enacted. I refer the reader to Sandler (2009), Sandler (2012b), Cormier et al. (2015), and Stamp and Sandler (2021), among many other sources, for more information about these systems. Pantomime is not irrelevant to the topic of multimodality. In fact, the existence of pantomime rescues the term multi-modal in the sense argued for here, by adding the pantomime mode to the linguistic and gestural modes. We leave exploration of this mode in the paradigm suggested here to future research.

Finally, so-called silent gesture—a research paradigm in which hearing people convey a message through gesture alone—is excluded, as it is not a typical natural form of expression. None of these topics are included in the present analysis. Here, the focus is primarily on linguistic structure and on iconic gesture that commonly comprise both speaking and signing.

2 THE LINGUISTIC MODE IN SIGN LANGUAGE

Sign languages are typically thought of as conveyed by the hands, and this is accurate at the level of the word. As central as the word is, there are other crucial levels of structure, such as syntax, prosody (including intonation), and the discourse level. At these levels, other parts of the body are recruited for explicitly linguistic purposes (Sandler, 2018). For example, prosodic constituents are separated by different positions of the head and articulations of the face (Nespor and Sandler, 1999), and conventionalized intonational patterns are conveyed by facial articulators (Baker-Shenk, 1983; Nespor and Sandler, 1999; Sandler, 1999; Coerts, 1992; Dachkovsky and Sandler, 2009; Kimmelman et al., 2020). Discourse continuity is maintained by the nondominant hand (Liddell, 2003; Sandler, 2012a; Sandler, 2018), and, since discourse units such as topics and comments are also prosodically marked, they involve the face, head, and torso articulators. Some researchers argue that facial expressions are explicitly syntactic and not intonational (Liddell, 1980; Wilbur and Patchke, 1999; Neidle et al., 2000; Cecchetto et al., 2009), while others argue for the intonational analysis (Nespor and Sandler, 1999; Sandler and Lillo-Martin, 2006; Sandler, 2010; Sandler et al., 2021). In either case, these facial articulations are conventionalized and represent linguistic structure—they do not have the qualities of either gesture or pantomime. For our purposes here, and for comparison with gesture in spoken language, the discussion is limited to the phonology of manual signs and to facial expressions.[5]

Willliam Stokoe's (1960) pioneering work showed that American Sign Language (ASL) signs are comprised of contrastive formational elements, so that ASL manifests duality of patterning, as noted above. This breakthrough set the ball rolling, and many researchers on other sign languages followed suit, admitting sign languages to the family of natural human languages. Many signs are iconically motivated (e.g, Perniss et al., 2010, Perniss et al., 2020), proportionately unlike most words in contemporary spoken languages, but they are typically not transparent. That is, sign naïve observers usually cannot guess their meaning (Klima and Bellugi, 1979; Thompson et al., 2020). Also, iconicity can only help children acquire signs if they understand the iconicity (for example that milk comes from milking cows). This understanding can require more world knowledge than small children usually have, nor is it completely clear the extent to which adult signers are conscious of iconic foundations, suggesting that the iconic motivation is only part of linguistic competence. The lexicons of different sign languages are mostly different from each other, suggesting a degree of arbitrariness in selecting the motivation for signs in each language. At the same time, there is a significantly greater overlap in similarity of lexical items across sign languages than across spoken languages (Guerra Currie et al., 2002, Meier et al., 2002). These observations make sign language lexicons fall somewhere in between iconic and arbitrary.

Interestingly, the sublexical building blocks of hand configuration, location, and movement, which productively create minimal pairs and are thus described as meaningless, are often iconically motivated themselves. For example, the location of a sign is often iconically motivated, literally or metaphorically (Fernald and Napoli, 2000; van der Kooij, 2002). The sign LEARN (**Figure 2A**) in Israeli Sign Language (ISL) metaphorically extends the iconic notion of putting something somewhere—in this case, putting knowledge in the head.[6] The signs EAT and LEARN in **Figures 2A,B** are a minimal pair distinguished by Location features. Their contrastive function shows that the features defining "mouth" and "temple," respectively, function phonologically. But these features are not arbitrary; they are iconically motivated. Many signs involving mental processes are signed at the temple Location Setting—[head, high, ipsilateral], like LEARN (**Figure 2B**), THINK (**Figure 2C**), and DREAM (**Figure 2D**). Many signs involving the mouth (like SPEAK, TELL, TASTE, EAT) are signed at the same Location ([low, mid, head] in the feature taxonomy of (Sandler, 1989). Similarly, the handshape of many signs that involve gripping something and/or putting something somewhere are iconically motivated, signed with the same "closed B" handshape (EAT, PUT, MOVE, and metaphorically for LEARN). We can call the result "dual duality of patterning," a level of structure with both meaningless and meaningful properties (Sandler, 2018).

Two-handedness (comprising about half the signs in any lexicon) can also be motivated. Comparing four unrelated sign languages, Lepic et al. (2016) found that signs conveying concepts such as interaction, location, dimension, and composition are significantly more likely to be two-handed in any sign language than chance would predict. Östling et al. (2018) show that two-handedness and body Location are both iconically motivated in 131 different sign languages.

[5]For analysis of linguistic expression by different parts of the whole body, see Sandler (2018); and for exhaustive background on sign language linguistics, see the chapters in Pfau et al. (2012).

[6]Taub's (2001) book describes how metaphor is incorporated into iconic signs in ASL. But sign language iconicity has a constraining effect as well. If the intended metaphor does not correspond to those aspects of an object or event that are ionically represented in a literal sign, the metaphor is blocked (Meir, 2010).

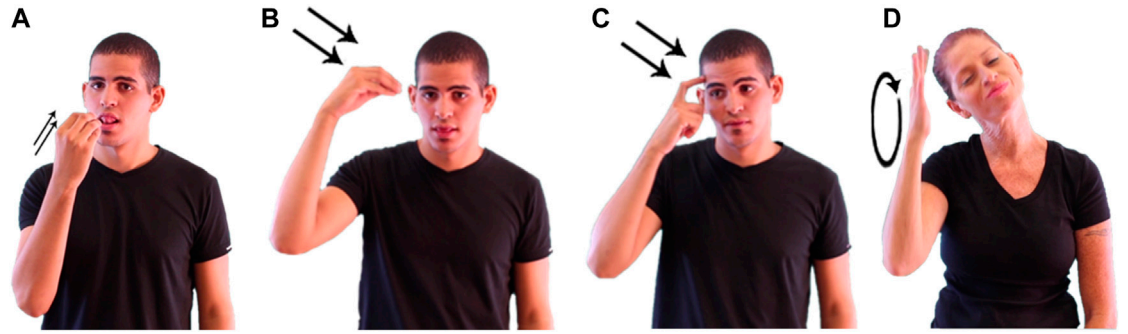


FIGURE 2 | Dual duality of patterning in ISL. **(A)** EAT and **(B)** LEARN are a minimal pair, distinguished by (iconic) Location features. Signs **(B)** LEARN, **(C)** THINK and **(D)** DREAM with iconic Location Settings near the head (Pictures from the online ISL Sign Language Dictionary).

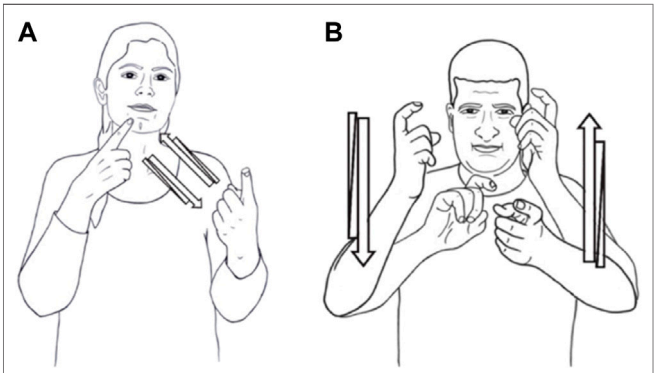


FIGURE 3 | Signs for NEGOTIATE/DISCUSS in **(A)** ISL and **(B)** ABSL. Two-handedness and repeated alternating movement are iconic and similar in these otherwise different signs.

Good examples of interaction as a motivation for two-handedness are the signs meaning NEGOTIATE/DISCUSS in two sign languages: Israeli Sign Language (ISL) and Al-Sayyid Bedouin Sign Language (ABSL), shown in **Figure 3**. Both the signs and aspects of sublexical motivations are different, showing the relative arbitrariness in selecting iconic elements in any given sign language. For example, in ISL the handshape of NEGOTIATE/DISCUSS represents a line of communication in other signs as well, while in ABSL the handshape of NEGOTIATE/DISCUSS commonly represents a person. But both signs are two-handed, motivated by interaction, and both involve alternating repeated movement, iconically (and metaphorically) representing the back and forth nature of the concept, NEGOTIATE/DISCUSS.

As in any language, sublexical elements of signs can't combine any which way, but are subject to constraints. There are constraints on the form and action of the two hands in two-handed signs (Battison, 1978), one of them requiring the two moving hands in **Figure 2** to be symmetrical in shape and movement. These constraints are relaxed in classifier constructions, which are partly gestural, as we will see in **Section 4**.

Signs, then, are linguistically organized in terms of contrastive sublexical elements as well as systematic constraints on their combination. More evidence for duality of patterning comes from phonological processes such as assimilation and truncation, whose conditions and effects are form- and not meaning-based (Liddell and Johnson, 1986; Sandler, 1989; van der Hulst, 1993; Brentari, 1998; Sandler, 2010; Sandler, 2012b; Fenlon et al., 2016). For example, lexicalized compounds in ISL and in ASL often truncate to monosyllables (Sandler, 1999), with the handshape of the second member of the compound spreading to replace the handshape of the first (Liddell and Johnson, 1986; Sandler, 1987, Sandler, 1989, Sandler, 2017). These systematic processes are based solely on form and can even distort or mask the iconic motivation of the signs. An example is the ISL compound SICK from the signs FEVER and TEA, shown in **Figure 4**. Similar examples are found in American Sign Language (Klima and Bellugi, 1979; Sandler, 1987, Sandler, 1989).

All established sign languages are characterized by linguistic facial expressions, akin to linguistic intonation in spoken languages (Nespor and Sandler, 1999; Sandler and Lillo-Martin, 2006; Sandler, 2010; Ormell and Crasborn, 2012, Hermann and Pendzich, 2014; Sandler et al., 2021). Though some of the facial expressions are common among speakers as well (see **Section 5.2**), they are not mandatory or rule governed when accompanying speech as they are in sign languages (Janzen, 1999; Janzen and Shaffer, 2002). In a sign language only, there is a finite list of conventionalized linguistic facial expressions (Dachkovsky and Sandler, 2009, Dachkovsky et al., 2013; Pfau and Quer, 2010; Hermann and Steinbach, 2013).[7] In spoken languages, some researchers propose that intonation is compositional (e.g., Pierrehumbert and Hirschberg, 1990; Hayes and Lahiri, 1991), with meaningful High and Low, accented and unaccented components following one another sequentially to convey different meanings.[8] In sign languages, intonational elements are also compositional, but since they are conveyed by independent facial articulators, they can cooccur simultaneously (Nespor and

[7]Different sign languages can activate different muscles to convey linguistic facial expressions with similar meanings (Dachkovsky et al., 2013).

[8]The terms "combinatorial" and "compositional" have different definitions (see de Boer et al., 2012), but are used somewhat interchangeably here, for simplicity. In compositional expressions, each component must bear meaning or grammatical function. Combinatoriality is neutral with respect to meaning.



FIGURE 4 | The lexicalized ISL compound **(A)** FEVER + **(B)** TEA, meaning **(C)** SICK. The two monosyllabic signs merge into a single monosyllable, and the handshape and two-handedness of the second sign, TEA, is assimilated to characterize the whole compound.



FIGURE 5 | Compositional linguistic facial intonation in ISL: **(A)** brow raise on a polar question; **(B)** squint on shared information; **(C)** brow raise and squint together in a polar question about shared information.

Sandler, 1999; Sandler and Lillo-Martin, 2006; Dachkovsky and Sandler, 2009). **Figure 5** shows ISL linguistic facial expressions: brow raise for polar questions ('Do you want to go to the movies?'), squint for shared information ('the movie that we saw together last week'), and a combination of the two for a polar question about shared information ('Do you want to see the move that we saw together again?').

It is quite possible that some of the linguistic facial expressions described above share properties with gestures used by speakers. There is evidence that iconic signs which may have shared properties with iconic gestures can become more arbitrary over time, obeying phonological constraints (Frishberg, 1975). My colleagues and I also found that phonologization emerges gradually from less conventionalized and less discrete signs in a young sign language such as ABSL (Sandler et al., 2011). Use of the conventionalized upper face expressions for linguistic intonation derives from more general enhanced perception of prosodic prominence on the upper face (Swerts and Krahmer, 2008). What is important is that, in established, contemporary sign languages like ISL (itself only about 90–100 years old, Meir and Sandler, 2008), every articulation of the hands and the upper face described above represents conventionalized, systematic, linguistically organized form.

Turning to the lower face, Liddell (1980) first showed that American Sign language includes linguistic actions of the lower face that are conventionalized as adverbial or adjectival modifications, and the same is true of Israeli and other sign languages. In Israeli Sign Language, for example, the same open-mouth configuration consistently means "protracted action" ("for a long time"), as we see in three different ISL signers' renditions of the same event in the Canary Row cartoon, when the cat falls through the air holding the canary, shown in **Figure 6**.

We now turn to the gestural mode sign languages.

3 THE GESTURAL MODE IN SIGN LANGUAGES

According to the definition of gestural organization in **Table 1**, signers of established sign languages incorporate gestures into their linguistically structured language.[9] Emmorey (1999) shows that ASL signers incorporate conventionalized emblem-like gestures from the broader community into their signed discourse, such as gestures meaning "well," "shh," and the like. More useful for defining the modes of language are the iconic

[9]The term "established sign language" is used here to mean sign languages that have been established within a community and are used for a range of social functions. Emerging sign languages are in the process of becoming established and are not addressed in this section.



FIGURE 6 | Conventionalized, linguistic adverbial mouth shape, meaning "protracted action."



FIGURE 7 | Emotional facial gestures in ISL, in reaction to information that evokes: **(A)** happiness, **(B)** disappointment, **(C)** sorrow, **(D)** fear.

gestures that signers employ that are not borrowed from conventionalized emblems. These include affective facial expressions, iconic mouth gestures, and the gestural part of hybrid classifier constructions. We turn to each, below.

3.1 Affect in Sign Language

Signers incorporate emotional and attitudinal facial gestures, like those shown in **Figure 7**, as hearing speakers do (e.g., Baker-Shenk 1983; Dachkovsky and Sandler, 2009; Hermann and Pendzich, 2014; Kimmelman et al., 2020).[10] These expressions are usually idiosyncratic, context sensitive, and gradient in terms of the intensity of the emotion or attitude expressed, and belong to the gestural mode. They are similar to affective facial expressions used by speakers, and can also be compared to paralinguistic intonation, described in **Section 5.1**.

3.2 Iconic Mouth Gestures

Relevant for any discussion of human language is the fact that the mouth is a salient articulator, whether for speech or for other functions. The mouth is important. In sign languages, which do not use the mouth for auditory speech, the mouth is constantly active, conveying a range of different functions, among them, linguistic adverbial and adjectival modification (Liddell, 1980), exemplified in **Figure 6** above, mimicry and enactment (Cormier et al., 2008; Stamp and Sandler, 2021), and intermittent mouthing of borrowed spoken words in some societies (see Boyes Braem and Sutton-Spence, 2001; Lewin and Schembri, 2013; Johnston et al., 2015). As for affective mouth actions, we have only to look at emojis to intuitively detect the various roles of the mouth in conveying attitudes and emotions. And even in speech, in which the mouth transmits words auditorily, the action of the mouth is visually salient, playing a role in speech perception (McGurk and McDonald, 1976). But the clearest sign language parallels with iconic manual gestures in spoken language are iconic mouth gestures, which are rampant in sign languages (Sandler, 2009).

The shape and action of the mouth often accompanies signing, to represent physical properties, such as the size and shape of an object, its weight or volume, or the vibrations it creates. In a study of ISL retellings by three signers of the animated cartoon Canary Row, we found that the signers often gestured with their mouths in iconic, idiosyncratic, and context sensitive ways (Sandler, 2009). One signer's retelling of part of the cartoon is shown in **Figure 8**.

[10]In **Section 5.1** below, the idea that vocal intonation can be iconic is motivated.

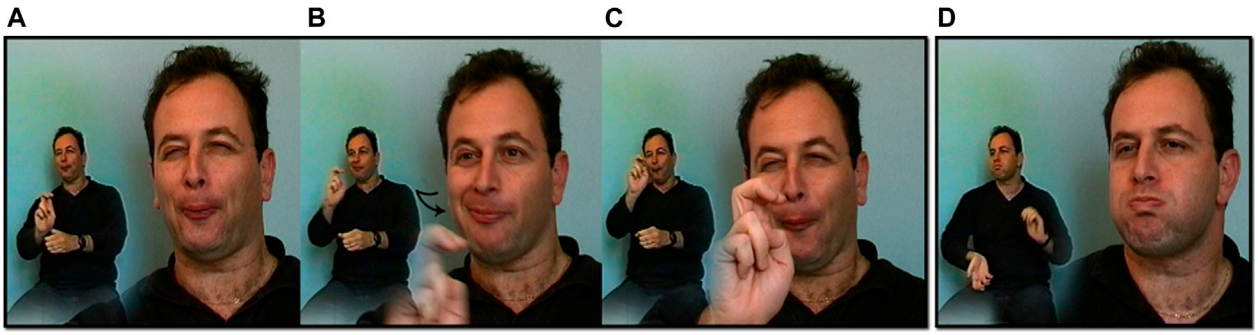


FIGURE 8 | Mouth gestures in ISL retelling of Canary Row cartoon. **(A)** Pursed mouth and sucked cheeks for a tight fit in a narrow space and climbing up inside the space (cat entering the drainpipe); **(B)** zig-zag mouth movement for the zig-zag crook in the drainpipe; **(C)** the cat making its way up inside the drainpipe; **(D)** puffed cheeks for the full round shape of the bowling ball (from Sandler, 2009).

The analysis goes on to show that different mouth gestures are indiosyncratic and context-sensitive, unlike linguistic signals. For example, signers use the same mouth gestures for different objects or actions. **Figure 9** shows two identical facial gestures with two different interpretations.

Gestures are also gradient. In spoken language, linguistic elements are typically discrete, i.e., their form does not vary analogically with their meaning. But gestures are inherently gradient. For example, a signer displayed one puffed cheek for the bowling ball and two puffed cheeks for the cat's body after swallowing the ball, shown in **Figure 10**.

Mouth gestures are not sequentially combinatorial; instead, they are linked to the combinations of manually signed phrases and sentences, just as iconic co-speech gestures coincide with combinatorially organized words, and are not organized with respect to each other.

Other sign languages—I venture to say all sign languages—also make use of mouth gestures. **Figures 11A,B** show mouth gestures in American and Russian sign languages. In **Figure 11C** we see a second generation signer in an emerging sign language in the Bedouin village of Al-Sayyid producing a mouth gesture to indicate the friction of water spraying from a sprinkler.

3.3 Hybrid Classifier Constructions

Such mouth gestures often accompany a particular kind of construction in sign languages, constructions which themselves are partly gestural: classifier constructions (Supalla, 1986; Emmorey, 2003; Zwitzerlood, 2012). In these forms, the conventionalized and lexicalized handshapes alone represent classes of entities, such as humans, small animals, or vehicles; or the size and shape of objects, such as flat, curved, or cylindrical. These classifier handshapes are conventionalized and lexicalized. But the location and movement, elements which are linguistically specified in regular lexical signs, behave gesturally in these hybrid classifier constructions (Schembri, 2003). As argued extensively in papers in Emmorey (2003), motions and locations in classifier constructions are idiosyncratic, imagistic (iconic), gradient, and noncompositional in the sense that their distribution and cooccurrence with other parts of the construction are not specified or systematic.

Handshapes are different. The same lexically specified handshape classifier can persist across several events, leading Sandler and Lillo-Martin (2006) to propose that they combine post-lexically with iconic gestural components of location and movement. Just as gestures tend to occur with expressive mimetics in languages like Japanese (Kita, 1997), mouth gestures tend to occur with classifier constructions in sign languages. In **Figures 8A–C**, for example, the handshapes are classifiers for a cylindrical object (the drainpipe), and a small animal (the cat). The spatial locations and relations and the movement path are gestural: they are gradient and analogical to the action of the cat in relation to the pipe in the cartoon, as we can see by comparing **Figure 8A** in which the cat is entering the pipe, **Figure 8B**, in which the hand (manifesting a small animal classifier) and mouth (manifesting a gesture) move in a zig-zag shape that the cat traverses in the pipe joint, and **Figure 8C**, where the cat is climbing up higher inside the pipe. Gestures in sign languages, then, are produced in the same visual channel as linguistically organized structure, but they manifest the characteristics of gestural organization, and therefore belong to the gestural mode.

4 LINGUISTIC AND GESTURAL MODES IN THE EBISU SIGN LANGUAGE THEATRE

As is often the case in artistic use of language, formational elements bubble to the surface. For example, poetic meter and rhyme reveal rhythmic properties and prosodic structure of a spoken language, such as onsets and rhymes as syllable constituents. Properties like these are extracted from language for artistic use, and sometimes even distorted, but in parallel they remain intact in the linguistic structure of the language. The Ebisu Sign Language Theatre Laboratory, formed in 2014,[11] offers an opportunity for analysis of sign language components via art. If gestural and linguistic organization are the two relevant modes, and if they can coexist in the same physical channel (see **Table 2**), then we should expect the barrier to interaction between the two to be easily traversed. Three examples will suffice to show the

[11]The Eibsu theatre was supported by Advanced Grant 340140 from the European Research Council. Ebisu is the name of a Japanese Shinto god of good fortune, who is deaf.

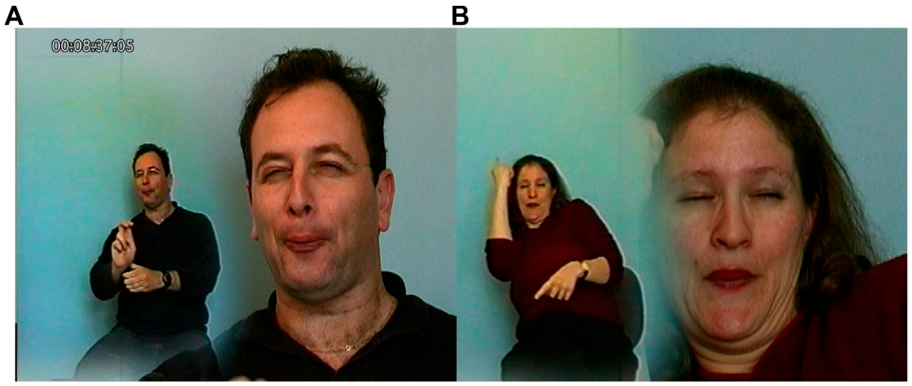


FIGURE 9 | Idiosyncracy and context-sensitivity. The same facial gestural conglomerate (Facial Action Units 8, 14, 17, 18, and 25) can mean "narrow space" as in **(A)**, or "swinging—whoosh," as in **(B)** (from Sandler, 2009)



FIGURE 10 | Gradience: **(A)** one cheek puffed to describe a bowling ball and **(B)** two cheeks puffed to describe the cat's body after swallowing the bowling ball (Sandler, 2009)

interaction between linguistic and gestural modes in sign language, in the Ebisu theatre. Crossing the lines in this way is not restricted to sign languages; **Section 5** shows criss-crossing of modes in spoken language.

The modus operandi of the Ebisu theatre director Atay Citron is improvisational, ultimately arriving at fully staged performances for deaf and hearing audiences alike, without interpreting (Sandler et al. in press). In an exercise designed to repeat and explore a sign, actress Nurit Shalom took the lexical sign LEARN (see **Figure 2B**), and altered it by gesturally selecting sublexical elements such as two-handedness (a kind of reduplication indicating large dimensions or intensity, Kouwenberg and LaCharité, 2015). In the basic sign, LEARN, in **Figure 12A**, the signer adopts an affective (gestural) facial expression conveying "wariness." The body posture with head averted in **Figure 12B** replaces the linguistic temple location of the lexical sign to gesturally convey "too much to take in," The gesture in **Figure 12C** indicating "large" has a different handshape and orientation than the lexical sign LARGE, and, unlike the lexical sign, which is located in neutral space in front of the signer, the gesture is located above the head, the lexical location of the sign LEARN, and the metaphorical seat of knowledge in lexical signs as those shown in **Figure 2**. "Too-large-quantity for the head" in **Figure 12C**, then, is a gesture, based on the sign LARGE. The puffed cheek mouth gesture enhances the meaning of a huge quantity. Note that this mouth gesture is similar to that indicating a round bowling ball in **Figures 8**, **10D**, showing the idiosyncrasy and context-sensitivity of gestural organization.

The second example demonstrates more mouth gestures in performance, shown in **Figure 13**. In telling the biblical story of Genesis, actor Alon Zino indicates that the earth was void with a closed flat hand gesture, interpreted as the barren surface of the earth, and a mouth gesture of sucked in cheeks—emptiness. He then raises flat, spread, open hands, indicating the rising surface of the water, accompanied by puffed cheeks, here conveying massiveness. The hands exploit the gestural mode as well, suggesting an empty surface (**Figure 13A**) and a rising and spreading mass (**Figure 13B**). The handshapes are not among the list of linguistic classifiers, instead manifesting iconic gestures. We have seen in **Figures 8D**, **10A,B**, **12C** that the puffed cheeks gesture can have many different meanings in different contexts. The sucked cheeks gesture appears in a different sign language, Russian Sign Language, indicating "very tall," in **Figure 11B** above.

In an original poem, actor Golan Zino manipulates the lexical sign BROKEN, normally signed in neutral space in front of the

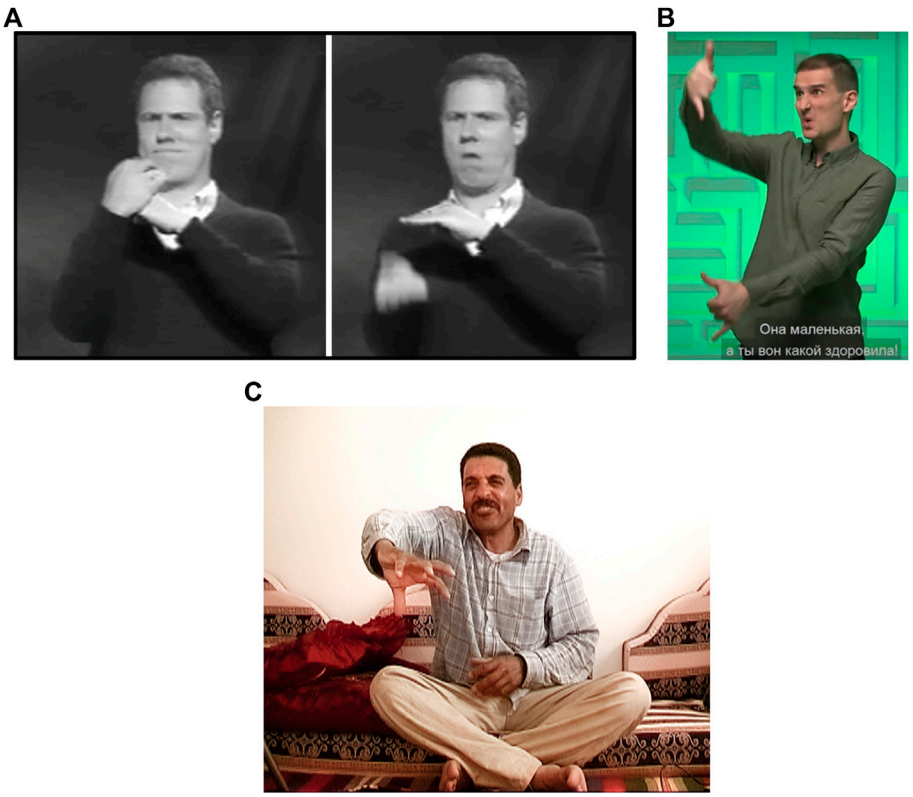


FIGURE 11 | (A) ASL opening mouth gesture for a drawbridge opening (Ben Bahan's telling of Hans Christian Andersen's "The Little Mermaid"). **(B)** Sucked cheeks Russian Sign Language mouth gesture for "very tall" (Chekhov's online story "Chameleon" in RSL). **(C)** Teeth-lip friction in Al-Sayyid Bedouin Sign Language mouth gesture for water spraying from a tap (retelling Laurel & Hardy's silent movie, "Big Business").

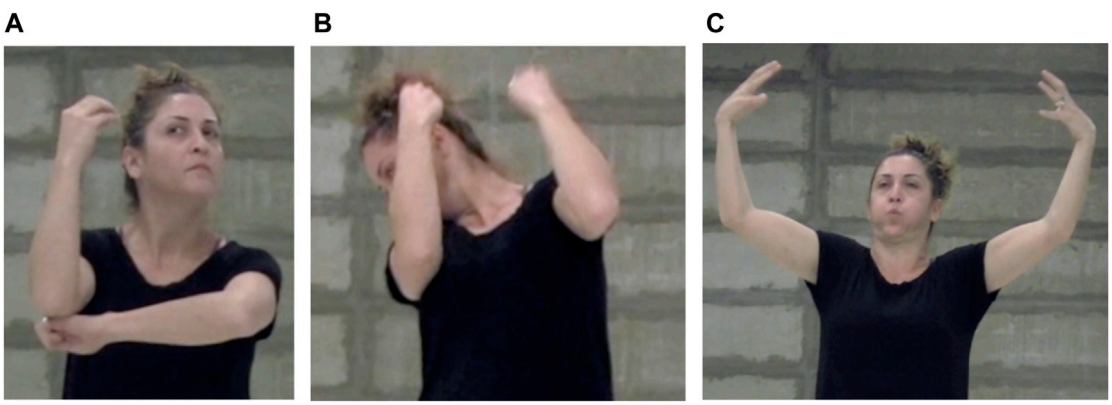


FIGURE 12 | (A) The sign LEARN with affective facial expression; **(B)** manipulation of the sign with a head gesture, meaning, "learning more than can be taken in"; **(C)** gestures of hands and mouth indicating "a huge amount" near the head location, indicating "too much knowledge."

signer as shown in **Figure 14A**. He adopts a different location iconically—the ear (Belsitzman, 2017). The expression conveys hearing people's distorted impression of deaf people as broken-ear people **Figure 14B**. We saw that the Location can be iconic across the lexicon, for example, the head (temple) representing mental processes, linguistically in **Figure 2**, and gesturally in **Figure 12C**. Here, the actor summons this underlying iconic property, giving the ear location iconic meaning, to confront the audience with a provocative image.

We have established that puffed and sucked cheeks function as gestures in ISL and other sign languages. These articulations can also be part of linguistic structure. **Figure 15** shows two lexical signs in ISL, FAT and THIN, each with obligatory mouth shapes as lexical features of the signs. Given that many signs are iconic



FIGURE 13 | Iconic mouth gestures: **(A)** "emptiness, void" with sucked in mouth and cheeks and closed flat-hands suggesting an empty surface, **(B)** "rising, spreading mass (water)" puffing mouth and cheeks and opening and spreading hands, suggesting a wide, flat mass.

and indicate their meanings directly, lexically specified mouth actions of this kind, also iconic, might belong to what Woll terms "echo phonology," in which the mouth enhances the picture portrayed by the hands, possibly providing an evolutionary link to speech (Woll, 2001). These mouth articulations, then, function both as idiosyncratic gestures (e.g, **Figures 8**, **10**, **12**, **13**) and as conventionalized lexical features (as in **Figure 15**). The point is that, since there is no physical barrier between linguistic and gestural modes, some expressions can belong to either mode. An example from spoken language is the use of high tone to linguistically mark polar questions or paralinguistically (I would say "gesturally") to express emotions like happiness or surprise. We return to spoken language in **Section 5**.

The types of iconicity we have seen in Ebisu involve retrieving and isolating iconic elements from signs and other expressions, and artistically exploiting gestures found in expressive signing as well. **Sections 3**, **4** show that the difference between the linguistic and gestural modes come to the fore as organizational principles, not defined by physical channel. Interaction is not surprising, then, and the same element can cross the line between modes. On this view, we should expect this to happen in spoken language as well—and, as schematized in **Table 2**, and expanded below—it does.

5 CROSSING THE CHANNEL IN SPOKEN LANGUAGE: GESTURAL ELEMENTS IN THE VOICE AND LINGUISTIC ELEMENTS ON THE HANDS AND FACE

Libraries are filled with treatments of the linguistic structure of spoken language, and there is no need to review it here. Analyses of spoken language auditory linguistic structure with accompanying visual hand gestures have also been abundantly covered in the literature. I consider here only contradictions to the common but confusing assumption that spoken language occurs only in the auditory "modality", and that gesture occurs only in the visual "modality". To show that this dichotomy is misconceived, the focus in this section is specifically on gesture that is heard, and linguistic form that is seen, in spoken language.

5.1 Gesture in the Voice in Spoken Language

Let's begin with intonation. It is well known that linguistic intonation is an important component of linguistic structure. Grammaticalized, linguistic intonation reflects information structure (Halliday, 1967; Gussenhoven, 2004) and can be represented abstractly with only two tones, High and Low, accented or unaccented, which combine to create contours, and which aggregate sequentially with phrasal tones at phrase boundaries (Pierrehumbert, 1980; Beckman and Pierrehumbert, 1986; Ladd, 1996; Shattuck-Hufnagel and Turk, 1996), although the phonetic instantiation of these phonemic patterns might vary widely (Prietro, 2015). This system is presumably linguistically organized and transmitted in the same physical channel as the rest of spoken language.

From an evolutionary point of view, intonation has iconic origins. Recall that iconicity means that the signal, whether auditory or visual, resembles its meaning. Regarding the origin of high and low pitch, Ohala (1983) reasoned that high pitch is associated with smallness (like sounds emitted by small animals with small vocal tracts) and low pitch with large size (commensurate with the vocal and resonance apparatus of larger animals). According to Gussenhoven (2004), this Frequency Code is one of three biological codes, which evolved into linguistically organized intonation over time. The others are the Effort Code, evolving into focus marking, and the Production Code, which accounts for high pitch at the beginning of utterances, and lowering toward the end. All three can be considered iconic reflections of their biological origins, in the sense that the signal sounds like what it means. The grammaticalization of these codes, then, is iconically related to their biological foundations, and accounts for linguistic intonational universals.

Intonation can also be paralinguistic (Ladd, 1996; Prieto, 2015), typically reflecting attitudes or emotions, and exhibiting more gradience in form and idiosyncracy in distribution than linguistically organized intonation. To the extent that paralinguistic intonation is holistic, idiosyncratic, sequentially noncombinatoric, and gradient, it could well be considered part of the gestural mode—and that is precisely what Dwight Bolinger

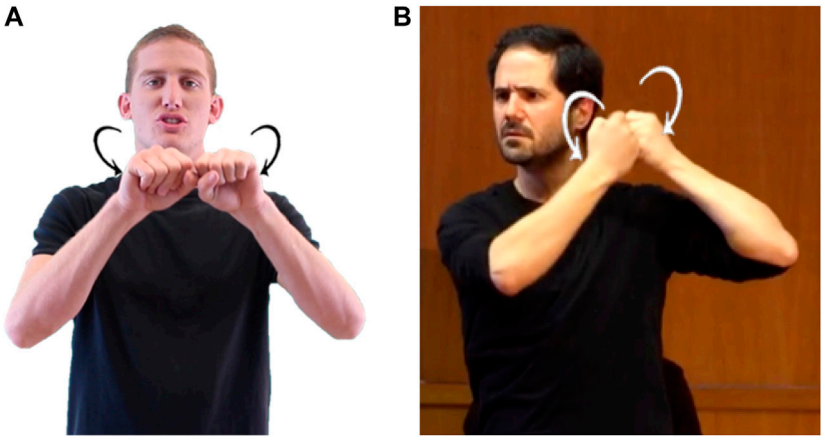


FIGURE 14 | (A) The lexical sign BREAK. **(B)** Poetic isolation of iconic location in the newly created sign: "broken ear."

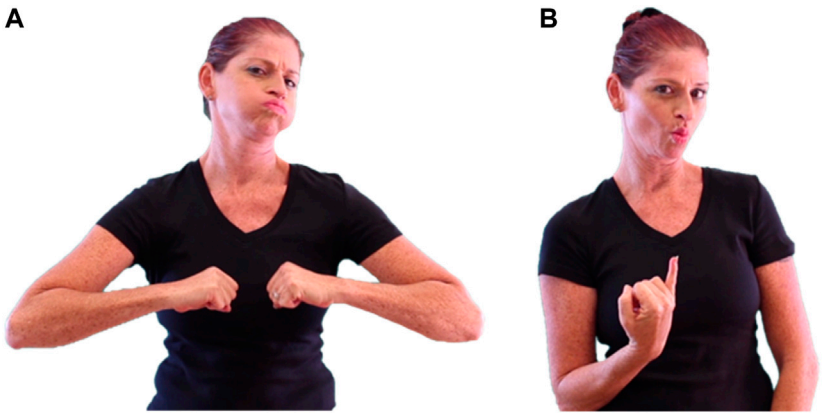


FIGURE 15 | ISL signs with iconic lexical (linguistic) mouth features. **(A)** FAT, **(B)** THIN.

argued in a brilliant exploration as long ago as 1983. Bolinger also provided many examples in which intonation combines simultaneously with face and body gestures, resulting in different interpretations of the linguistic signal. Such combinations suggest that the two—paralinguistic intonation and visible gesture—are of the same natural class, which he calls a "gestural complex."

One example in Bolinger is a question like, "Does he need it?", which has different interpretations, depending on the intonational and visual gestural signals. The string can be conveyed with rising intonation, typical of English linguistic polar questions, or with falling intonation across the question, introducing gestural idiosyncrasy. Each can be accompanied by various concomitant visual gestures of the face and hands. Some of these are: eyebrows raised or lowered, mouth open or closed at the end, hands outflared with palms up, and more, each imbuing the different intonational patterns of the question with different nuances of meaning and different expectations of the addressee. For example, with rising intonation, eye contact, brows raised, mouth left open, palms up, and head shake, the speaker is in an argumentative and rhetorical mood, and the addressee is expected to answer "Does he need it?" by saying "No." Bolinger proposes that easier agreement (an answer of "yes") by the addressee is sought with falling intonation (despite the polar question) and different facial and manual cues. These fine-tuned but important distinctions accompanying linguistic material are among the communicative advantages of the gestural mode.

In fact, prosody can iconically represent the speed of an event by a fast or slow rate of speech, and intonational pitches can also be analogically iconic, so that high pitch cooccurs with descriptions of objects going up and low pitch for objects going down (Perlman et al., 2015).

It is well known that we gesture while we talk on the telephone, even though the gestures cannot be seen by the interlocutor (Bavelas et al., 2008). This indicates that gesture might be critical for the speaker, but implies that the auditory signal alone coneys the linguistic information to the hearer. However, once facial gestures are included as part of the gestural mode, it becomes clear that we can also hear gestures. Bolinger points out that we can hear not only linguistic intonation, which alters the fundamental frequency (basic vocal cord pitch), but we also hear formant frequency differences (reflecting different configurations of the vocal tract), which characterize emotional/paralinguistic

intonation and affect vowel sounds. A simple thought experiment confirms that we can tell when the person on the other end of a phone call is amused (smiling, lip corners up). This is because facial gestures including upturned lip corners, jaw lowering, and many others change the configuration of the vocal tract, altering formant frequencies, and can therefore be perceived auditorily. In accord with Bolinger, we affirm that some kinds of intonation in the vocal channel belong to the gestural mode.

5.2 Linguistic Structure on the Face in Spoken Language

Like intonation, facial expressions in hearing speakers can also be seen as iconic from the point of view of evolution. For example, raised eyebrows widen the eye aperture, to perceive more information, evolving to iconically characterize emotional surprise, as well as linguistic polar questions, and focus (see Darwin, 1872; Fridlund, 2014). It is well known that visual gestures complement the linguistic signal, and in fact Janzen (1999), and Janzen and Shaffer (2002) argue that linguistic facial expression in sign language grammaticalized from this more general gestural system. But it is also possible to consider certain visual signals in spoken languages to be part of linguistic structure itself. In a series of papers, Swerts and Krahmer conducted several studies on prosody, investigating auditory and visual cues to polar questions, focus, as well as constituent boundaries. They found that there are consistent visual cues to all of these, typically accompanying the auditory cues. For example, high tones are typically accompanied by brow raise in polar questions, and participants more accurately identify polar questions that are characterized by both than by high tone alone (Swerts and Krahmer, 2008). Identification of questions with brow raise alone without high tone is less successful, suggesting that visible brow raise participates in the linguistic system, but together with auditory intonation. At the pragmatic level, facial expression can also distinguish polite from impolite utterances with the same intonational pattern (Brown and Prieto, 2017).

Though visual, such expressions are part of the spoken language linguistic mode to the extent that they manifest cues to information structure, and they also function as part of the gestural mode, in accord with Bolinger's gestural complex idea as well as McNeill's dichotomy, crossing the line between the linguistic and the gestural in a single channel.

5.3 Linguistic Structure on the Hands in Spoken Language

We usually think of visual gestures as cooccurring with speech and enhancing the verbal message in some way. But in recent years, researchers have noticed that visually transmitted gestures can actually represent linguistic structure directly. For example, Fricke (2013) shows that deictic gestures replace or further modify verbal reference and are thus part of the linguistic signal. Ebert et al. (2020) show that German 'so' transforms a manual action from gestural to linguistic. Proof of this is the fact that gestures accompanying 'so' become at-issue and thus linguistic information (as defined in Potts, 2005), as in Example 1, and, as such, can felicitously be qualified or negated, as in Example 2.

Examples 1 and 2. Examples are adapted from Ebert et al. (2020).

1. Ich bringe niemals [SO] eine Flasche Wasser mit zu Vorträgen
   I bring never SO a bottle water with to talks

BIG

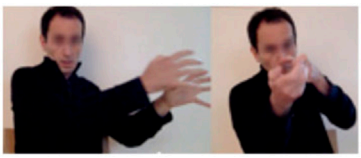


2. Eine kleine reicht mir nämlich
   'A small one is enough for me.'

Schenkler (2018, 2019) develops the notion of iconic semantics, and distinguishes pro-speech gestures from co-speech gestures and post-speech gestures. Pro-speech gestures precede and fully replace spoken words, and post-speech gestures occur after the relevant spoken expression. Crucially, Schlenker shows that the pro-speech gestures he analyzes are not simply imagistic versions of linguistic utterances (like many co-speech gestures) but are actually part of their semantics.

In his detailed exploration of "gestural semantics," Schlenker (2019) deals with several types of inferences, among them, presuppositions. In Example 3, the pro-speech gesture presupposes that Robin was not in a shooting position. In Example 4, the gesture presupposes that the lightbulb is in the ceiling.

Examples 3 and 4. Examples are from Schlenker (2018).

3. Is Robin going to 

('Is Robin going to take a rifle and shoot?')
Presupposition: Robin was not in a shooting position.

4. If you  this lightbulb, don't hurt yourself.

('If you unscrew this lightbulb, don't hurt yourself.')
Presupposition: The lightbulb is in the ceiling.

These gestures are actually a type of enactment—"acting out" an event with the body,[12] but they participate in the semantics of the sentence. Schlenker adds an additional nuance to the discussion, namely, that such iconic gestures belong to "a rich

[12]Thank you to Karen Emmorey for pointing this out.

inferential typology" (Schlenker, 2019: 780). Though gestural, they are part and parcel of semantic (and thus linguistic) structure and knowledge. They cross the boundary between linguistic and gestural modes, and between the two physical channels.

Schlenker's exposition indicates that gestures that are part of the linguistic (semantic) typology observe only two of McNeill's linguistic criteria: they are sequentially combined with words, and they are to some extent conventionally and not idiosyncratically interpreted (how many ways can you unscrew a lightbulb?). But they are imagistic/iconic, and potentially gradient—important properties of gestural and not linguistic organization. This ambivalence is not counterevidence to the approach I take here, but is rather proof of the idea that linguistic and gestural modes are not tied to the physical channel of transmission. This very fact makes their distribution in language more versatile: the same physical system can organize itself linguistically or gesturally—or both. Human language is expressive and flexible, encompassing both linguistic and gestural modes, and our species fully exploits the exigencies of our bodies in shaping it—in both types of natural language, spoken and signed.

6 CONSEQUENCES AND CONCLUSION

The goal of linguistic theory is to capture generalizations about language that significantly advance our understanding of the phenomenon. A major advance in our understanding that has taken place over the past 60 years is the inclusion of visual expression in our thinking about language, facilitated by the use of video and especially by inclusion of sign languages in the data about natural language. The field of gesture studies arose in part because of these advances, and it became increasingly clear that there is more to language than the auditory signal.

With this advance came the notion of "multimodality" to describe human language, but the term is ambiguous, meaning either more than one physical transmission system or more than one type of expression or organization. In spoken languages, the most straightforward (but superficial) interpretation of multimodality places gestural material in the visual channel. However, this definition is misleading. Gesture in the auditory channel, such as paralinguistic intonation (**Section 5.1**), would be a counterexample to the definition.

Since sign languages are conveyed in only one physical channel, the visual channel, they are the ideal test case for determining the most explanatory definition of multimodality. If "modality" refers to the physical transmission system, sign languages by definition cannot be multimodal, since they are conveyed in only one physical channel, the corporeal-visual. Yet, as **Section 3** shows, they do incorporate gesture.

By adopting the term "mode" as a particular type of expression, these problems disappear. We are able to show once again that sign languages are not anomalous but rather conform to universal generalizations about language. The message is that all language includes both linguistic and gestural modes. By following this paradigm, the essential differences between spoken and signed languages are revealed, which is equally important for our understanding of human language. Sign languages are more iconic than spoken languages, a natural and productive consequence of the corporeal/visual channel, and by focusing on the mode of expression rather than the physical channel we can see how this iconicity pervades both the linguistic mode and the gestural mode of these languages (**Sections 2**, **3**). Similarly, removing the physical barrier between the linguistic and the gestural in spoken language gives us the freedom to identify auditory gesture in paralinguistic intonation (**Section 5**)—it is no longer a freak accident.

The hybrid forms in both types of language are perhaps the most convincing consequence of the definition of mode offered here, and the paradigm that it generates. In sign languages, classifier constructions are comprised of linguistic, lexical classificatory handshapes, which combine with locations and movements that are gestural in terms of their organization (**Section 3.2**). Certain mouth expressions can double as lexically specified and gesturally organized as well (**Sections 3.1**, **4**). Meaningful sublexical components (such as locations, **Section 2**) can surface in gestural contexts (**Section 4**). In spoken languages, forms that are gestural according to most of the criteria in **Table 1** participate actively in the formal semantics (**Section 5.3**).

While the approach to mode vs. modality offered here unifies spoken and signed languages in some ways, it also captures their essential differences, structured by the physical channels of transmission. The physical transmission system is not irrelevant or unimportant. It is not a mere secondary "externalization" of inherent structural organization in the brain (contra Chomsky, 2007). Instead, defining linguistic and gestural modes in each language type now makes it abundantly clear how the physical transmission system contributes to the form of each mode of expression in each type of language. The resulting model of language is dynamic, flexible, and extraordinarily creative.

DATA AVAILABILITY STATEMENT

The submission relies on and extrapolates from previously published material, online dictionaries, and our Haifa lab materials. Requests for further information should be directed to WS, wsandler@research.haifa.ac.il.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Haifa and the European Research Council. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article. Images from the ISL sign language dictionary (**Figures 2**, **15**) are open access and do not require permission.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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REVIEW
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A Usage-Based Proposal for Argument Structure of Directional Verbs in American Sign Language

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Verb agreement in signed languages has received substantial attention for a long time. Despite the numerous analyses about the linguistic status of verb agreement, there is little discussion about the argument structure associated with "directional verbs," also known as agreeing/agreement or indicating verbs. This paper proposes a usage-based approach for analyzing argument structure constructions of directional verbs in American Sign Language (ASL). The proposal offers low-level constructions for reported speech, non-dedicated passive and reflexive, and stance verb constructions, which capture the patterns, abstracted from recurring usage events, that are part of users' linguistic knowledge. The approach has potential to push the field of sign linguistics in new directions of understanding the interplay of language use and structure.

Keywords: verb agreement, argument structure, usage-based linguistics, construction grammar, American Sign Language

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INTRODUCTION

We use verbs to discuss events and situations in everyday life. Verbs are the canonical predicates and generally express the action in a clause. This is true for any human language. What distinguishes signed languages from spoken languages is the use of space. Signers capitalize on the signing space to produce verbs, which often can appear to be an iconic or transparent conceptualization of events. Some verbs express the transfer of an object in the signing space, or the surrounding physical space that encompasses the signer's body. Such verbs are commonly labeled as *agreeing* (or *agreement*), *directional,* or *indicating* verbs. The terminological choice depends on the researcher's theoretical stance. **Figure 1** shows the production of the beginning of a complex clause in American Sign Language (ASL) in which the verb GIVE is represented as a sequence of initial and final locations. The initial location of the verb starts on the signer's right and the final location ends ahead of the signer. From looking at the verb form alone, one could get a prototypical interpretation of an agent/subject giving a theme to a recipient, i.e., "s/he/they gave it to you/her/him/them" and may be considered an instance of "verb agreement." Yet the larger construction in which the verb form occurs gives a rather different interpretation. An object is given to the recipient, who is identified as two people, while the agent is unspecified, as there is no antecedent or an overly expressed referent to identify it (Janzen et al., 2001; Leeson, 2001; Rankin, 2013; Barberà and Cabredo Hofherr, 2017; Nordlund, 2019). The construction functions as an agent defocusing construction, which may be either a passive construction or a R(eference)-impersonal construction, depending on one's view. This example suggest that the argument structure does not entirely come

from the semantics of the verb, i.e., the lexicon but rather the meaning of the argument structure construction contributes to the verb in it too (Goldberg, 1995, 2006; Diessel, 2015).

I take the above example as a starting point to discuss the scholarly bias toward "verb agreement" in signed languages. There are various morphological and syntactic analyses of verb agreement in signed languages (Padden, 1988; Meir, 2002; Mathur and Rathmann, 2010, 2012; Pfau et al., 2018; Quer, 2021, a.o.). There is also an extensive debate over the linguistic status of verb agreement (Liddell, 2003; Lillo-Martin and Meier, 2011; Fenlon et al., 2018; Schembri et al., 2018, a.o.). Some existing analyses rely on contextually isolated, elicited data, as the focus of these analyses is more theoretically abstract than empirical. The emphasis has been on positing linguistic mechanisms, both modality-independent and modality-specific, for the instantiation of agreement. Other analyses have used large-scale datasets such as corpora to test empirical observations about linguistic and social factors that may predict the spatial modification of verbs (de Beuzeville et al., 2009; Fenlon et al., 2018). Those analyses, regardless of the theoretical and methodological differences, are similar in their concentration of the morphosyntactic and syntactic properties of the verbs and the instantiation of agreement (or the lack thereof).

By comparison there has been little discussion of the argument structure constructions of directional verbs. The few exceptions are argument structure alternations of different verb classes from generative, cognitive, and typological perspectives (Kegl, 1990; Kimmelman, 2018, 2022; Johnston, 2019b; Oomen, 2020). However, there is little discussion argument structure constructions from a *usage-based* perspective with the exception of Johnston (2019b) who focuses on Australian Sign Language (Auslan). Usage-based linguistics tend to look at the occurrence of directional (and non-directional) verbs, the presence and absence of core arguments, and the realization of grammatical relations in a diverse range of argument structure constructions, ideally from a corpus (Johnston, 2019b), and posit abstract generalizations based on these constructions. **Figure 1** is such an example. This raises an empirical question: what argument structure constructions do directional verbs participate in and what kind of generalizations can be abstracted from these constructions? Directional verbs make an intriguing case study – they are transitive and can mark the core arguments in the signing space, though not all transitive verbs are directional verbs.

This is a position paper that argues for how a usage-based approach can advance our understanding of directional verbs in argument structure constructions in ASL (and perhaps by extension, many other signed languages). The goal is not to present a basic description of argument structure of all directional verbs *per se*, but rather to spotlight a few types of low-level constructions, or templates, in which directional verbs occur and to discuss how these constructions can expand our understanding of verbs and more broadly, ASL grammar. The constructions of interest are reported speech, non-dedicated passive/reflexive, and stance verb constructions, all which involve directional verbs. There is growing research on active and passive constructions that occur with different verbs (Janzen et al., 2001; Leeson, 2001; Rankin, 2013; Barberà and Cabredo Hofherr, 2017; Nordlund, 2019) and also recent research on a family of stance verbs (Hou, 2022). I build on the previous research with additional data from the internet and present a preliminary usage-based analysis that includes low-level constructions for argument structure of directional verbs.

The paper is organized as follows. First, there is a brief introduction to usage-based linguistics with a focus on argument structure constructions. Next, there is an overview of verb agreement in signed languages; the overview covers various theoretical perspectives. Then there is a discussion of data and methods, followed by a preliminary analysis of verb constructions. Finally, the paper wraps with some



"Hey so what happened was that the wrong envelope was given to these people who…"
Source: The Daily Moth (2017), The Daily Moth 2-27-17, Timestamp: 02:38-02:42

FIGURE 1 | The use of GIVE in an argument structure construction. Images produced with permission, source information available in the **Supplementary Material**.

suggested directions for advancing research on argument structure constructions.

Usage-Based Linguistics in a Nutshell

The analysis is based on a few fundamental assumptions about usage-based linguistics. First, language structure emerges from language use, and various aspects of the structure is constantly reshaped by continued use (Barlow and Kemmer, 1994; Bybee, 2010; Christiansen and Chater, 2018; Diessel, 2019). Language use is viewed as a dynamic product of domain-general cognitive processes, not based on a "language module" that contains rules for generating sentences. Users – speakers and signers – develop an abstract representation of grammatical knowledge from their experience of (re)using words in utterances (Langacker, 1987; Fillmore et al., 1988; Croft and Cruse, 2004; Bybee, 2006; Goldberg, 2006; Elman, 2009; Dąbrowska, 2014; Lepic and Occhino, 2018; Wilkinson et al., in press). The lexicon and grammar are not treated as separate components of linguistic knowledge with linking rules. Rather, linguistic knowledge is represented as a hierarchical network of constructions, learned pairings of form with semantic of discourse functions, that are organized and connected by taxonomic links (Croft and Cruse, 2004; Goldberg, 2006; Langacker, 2008). The constructions come in all sizes, ranging from words to complex constructions and varying along the dimensions of schematicity and specificity. Under this view, Example (1) contains twelve listed constructions that encompass individual words and syntactic clauses. A user can combine different constructions to produce an actual expression, provided that the constructions do not conflict with one another in according to one's grammar.

(1) A dozen roses, Nina sent her mother!
   a. Ditransitive construction
   b. Topicalization construction
   c. VP construction
   d. NP construction
   e. Indefinite determiner construction
   f. Plural construction
   g. Possessive construction
   h. *Dozen, rose, Nina, send, mother* constructions

(adopted and modified from Goldberg, 2006, p. 21).

Second, grammar is viewed as the cognitive organization of one's experience with language (Bybee, 2006, 2010). A user abstracts all linguistic expressions from recurrent usage events, or actual language uses, and categorize them based on similarities. Frequency plays a prominent role in the experience. The more frequent expressions with specialized functions are more entrenched, or committed to and stored in long-term memory; each additional instance of an expression strengthens its representation (Bybee, 2006). The categories are not static, but can shift and change over time, as the user accumulates more experience in the world. In the case of argument structure constructions, a ditransitive construction [*subject verb object*$_1$ *object*$_2$] in English language varieties would be entrenched in the user's grammar. This construction has a very high frequency of instances with different verbs such as *send, give, tell,* etc. that can occupy the verb slot. Other constructions vary in degrees of schematicity, or productivity, depending on one's idiolect. According to Goldberg (1995), Croft and Cruse (2004), the comparison of the Caused Motion construction [*subject verb object*$_2$ *to object*$_1$] and the Ditransitive construction [*subject verb object*$_1$ *object*$_2$] reveals a difference in the patterning of semantically similar verbs, *tell* and *whisper*. Examples (2) and (4) show that *tell* and *whisper* participate in the Caused Motion construction, but only *tell* participates in the Ditransitive construction. This suggests that some verbs can overlap with both constructions, but other verbs cannot. One construction is more schematic than the other construction.

(2) He told the news to the woman.
(3) He told the woman the news.
(4) Sally whispered some terrible news to him.
(5) *Sally whispered him some terrible news.

(adopted from Goldberg, 1995).

Finally, the term "argument structure constructions" implies a theoretical stance about the lexical representation of verbs. The meaning of the verb alone does not always determine the realization of the argument structure, i.e., the core arguments of the event and the syntactic expression corresponding to a specific meaning. Rather it is the syntax, or the whole syntactic construction, a learned pairing of form and meaning, that contributes to argument realization (Goldberg, 1995, 2006). Moreover, verbs are associated with specific argument structure constructions that repeatedly occur in language use. These constructions are organized in a hierarchical network in which constructions are represented at different levels of schematicity and connected by taxonomic links.

To the best of my knowledge, there has been very little research on argument structure constructions in signed languages. One major reason for the gap may be the ongoing controversy over the linguistic status of verb agreement morphology, which is discussed next.

BACKGROUND ON VERB AGREEMENT IN SIGNED LANGUAGES

The interest in verbs has long occupied the academic field of sign language linguistics, which was heralded by the pioneering publications of Stokoe (1960), Stokoe et al. (1965), *The Dictionary of American Sign Language*. Early on, verbs received substantial attention for their interaction with the signing space[1]. Many researchers documented their observations about such verbs in ASL. Friedman (1975) called them *multidirectional verbs,* listing only six verbs as examples: "give," "bring/take," "borrow/lend," "tell," "go/come," and "see." The verbs and their arguments are analyzed from a thematic role perspective: arguments are marked for their thematic roles by means of directionality, or "direction

[1]This is not to exclude classifier constructions, which also has received substantial attention (Zwitserlood, 2012).

of action from source to goal" (955). The arguments' locations determine the verb's direction of path movement and palm orientation. Friedman stated that ASL lacked true pronouns, but pointing encoded pronominal reference for first person, second person, and third person, and the directionality of the verbs did likewise. A change in the direction of path movement and orientation signals a change in the meaning of the sentence in which the verb occurs, hence the name *multidirectional*. As Friedman was giving a general description of the expression of space, time, and person reference in ASL, the discussion of multidirectional verbs was superficial.

Fischer and Gough (1978) investigated the variety of morphosyntactic properties of a bigger sample of ASL verbs that were taken from Stokoe et al. (1965). Like Friedman, Fischer and Gough observed that some verbs exhibit changes in the direction of path movement and/or palm orientation to mark the arguments and labeled these verbs as *directional verbs*. This term is sometimes still used to this day. It was also observed that some verbs can be reversible by changing the direction of the path movement and/or the facing of palm orientation. Other verbs are phonologically constrained from exhibiting path movement, but signers can produce them in various spatial locations. Such "locatable" verbs point to their arguments through the facing of palm orientation. A sign OWE was listed as such an example; one can mark the object of this sign by producing it near a spatial location associated with an argument. In Fischer and Gough's view, ASL did have pronouns to mark person, and pronominal arguments were incorporated in the verbs. The processes of directionality, reversibility, and locatability enabled verbs to mark grammatical relations such as the subject and the object.

Padden (1988) took the analysis of directionality to a new level by classifying ASL verbs as a tripartite system of verbs: *plain*, *spatial*, and *inflecting*. This work builds on the aforementioned earlier works as well as Klima and Bellugi (1979), Meier (1982), Supalla (1982), and various unpublished talks and manuscripts. In Padden's account, verbs are distinguished by their ability to participate in agreement. Central to marking agreement is the type of arguments, not just the directionality, reversibility, or locatability processes. Spatial verbs such as MOVE and PUT "agree" with locative arguments. Plain verbs cannot agree with their arguments; instead, they indicate grammatical relations by means of word order. Inflecting verbs "agree" with animate arguments for person and number. The term *inflecting* was later replaced with *agreeing* or *agreement*, since it was shown that plain verbs can inflect for aspect. Agreeing verbs have incorporated subject and object agreement markers; the initial and final locations of the verb are interpreted to mark core arguments, particularly the object.

Theoretical Views of Verb Agreement

Many signed language researchers have adopted and adapted Padden's analysis for describing and documenting verbs in ASL and many other signed languages. There is extensive research on this topic, as many researchers have detailed the formational properties of verb agreement. This research agenda is ongoing to this day; the agenda has been expanded and enriched by recent corpus and experimental studies. Much of the current literature suggests that the theoretical differences in analyzing the verbs would be grouped in two camps of linguistics, though this is becoming unmerited. The first camp is formal-generative linguistics. Researchers who are affiliated with this camp adopt some variation of the verb agreement analysis (Padden, 1988; Janis, 1995; Mathur, 2000; Meir, 2002; Rathmann and Mathur, 2002; Sandler and Lillo-Martin, 2006; Thompson et al., 2006; Mathur and Rathmann, 2010, 2012; Hosemann, 2011; Lillo-Martin and Meier, 2011; Wilbur, 2013; Costello, 2016; Pfau et al., 2018; Quer, 2021; a.o.). There appear to be several accounts, of which two are mentioned here (see Pfau et al., 2018; Schembri et al., 2018 for a recent review). Some researchers treat agreement as a morphosyntactic phenomenon, taking a syntax-semantics interface approach, while other researchers take a purely syntactic approach. What all these researchers have in common is that they tend to examine the formal structures independently of semantic or discourse functions; this is implied by how these approaches generally understand agreement as a syntactic relation between two linguistic elements. One element, the target, copies the morphosyntactic features of another element, the controller, so both elements encode the same features (Steele, 1978; Lehmann, 1982; Corbett, 2006). The corollary is that there are multiple various accounts that attempt to explain the phenomenon of agreement as a syntactic relation.

The second camp has been historically associated with cognitive linguistics, but the diversification of theoretical frameworks suggests that "cognitive linguistics" is too broad of an appropriate label for these frameworks. In the past, many researchers adopted the "indicating verbs" analysis in rejection of the verb agreement analysis (Liddell, 1995, 2000, 2003, 2011; de Beuzeville et al., 2009; Cormier et al., 2015a; Fenlon et al., 2018; Schembri et al., 2018). The indicating verbs analysis was originally inspired by the theory of mental spaces (Fauconnier, 1985) and are said to be "capable of being meaningfully directed to space toward entities, directions, or places" (Liddell, 2003, p. 97). By this definition, indicating verbs refer to both spatial and agreeing verbs. The directionality of the verbs is motivated by the actual or imagined locations of referents in the physical world. These verbs point to the referents, which are viewed analogous to pointing gestures by gesturers who employ similar cognitive mechanisms for referring to referents (see Fenlon et al., 2019 for a quantitative differences between pointing by signers and gesturers). Indicating verbs thus are viewed as a fusion of linguistic and gestural elements, or more specifically, "a structured composite construction of sign and co-sign gesture, similar to multimodal constructions of speech and co-speech gesture" (Schembri et al., 2018, p. 13). In an indicating verb, the handshape, orientation, and movement are morphemic and lexically specified, whereas the initial and final locations of the verb are not morphemic, i.e., gestural, and variable. The locations are not listable and predictable, since there may be an infinite number of possible locations, so a more plausible explanation is that they are motivated by the physical world or by the signer's cognitive representation. This view treats verb agreement what I call a *morphemic-gesture* relation.

Some researchers who adopt the morphemic-gesture relation do not research indicating verbs exclusively but rather take a "neo-Peircean" semiotic approach to linguistic analysis of signed languages more broadly. They are more interested in

investigating the diversity of semiotic resources for marking reference – and more broadly, for producing composite utterances (Ferrara and Hodge, 2018; Hodge et al., 2019; Johnston, 2019b; Puupponen, 2019). The indicating verbs are merely one of the many semiotic resources that deaf signers exploit for marking referents as part of composite utterances in spontaneous discourse. Other researchers take a "semiological" approach based on the "enunciation theories" for similar purposes with a different categorization of various signs and a greater emphasis on the functions of non-manual elements especially eye gaze (Cuxac, 1999; Fusellier-Souza, 2006; Cuxac and Sallandre, 2007; Pizzuto, 2007; Garcia and Sallandre, 2020). One key tenet of the semiological approach is the gaze behavior of the signer and the interlocutor, and how the interlocutor follows the signer's eye gaze in concurrent with their signing. It is the coupling of the eye gaze with the pointing sign or the directional verb contributes to the meaning of reference in discourse.

In addition to the mental spaces, the neo-Peircean semiotic, and semiological approaches, there is the Places view. Wilcox and Occhino (2016), Wilcox and Martínez (2020) take issue with the indicating verbs analysis, stating that it relies on structuralist assumptions about the cognitive representation of language. These researchers point out that the categorization of sign and co-sign gesture suggests that language is composed of "discrete symbols and classical categories with strict boundaries" (Wilcox and Occhino, 2016, p. 26). The categorization also suggests that deaf signers and hearing speakers would share the same understanding about the structure of language, regardless of one's access to language and experience with it. Wilcox and their collaborators adopt a Places view, which is strongly influenced by Cognitive Grammar (Langacker, 1987, 1991, 2008) and usage-based linguistics (Bybee, 2006, 2010), The Place is a "symbolic structure, a pairing of a meaning and a location in space" (Wilcox and Martínez, 2020, p. 2). On the surface, the mental spaces and the Place views appear very similar. But a major difference between these views is that the Place view does not consider the non-listability of locations to be a problem and instead views locations as schematic. The selection of the location would be motivated by a user's sensory experiences with the world and abstraction from recurring usage events. Pointing constructions and directional verbs are viewed as complex symbolic structures composed of a pointing device and a Place. The pointing device "functions *to direct or focus attention* to the Place" (Wilcox and Occhino, 2016, p. 8), so a directional verb would direct attention to Places associated with the referents and profile a process. As the pointing device and the Place are already symbolic structures, and pointing constructions and directional verbs are also symbolic structures, verb agreement therefore is framed as *multiple symbolization*.

A Proposal for a Usage-Based Analysis

Notwithstanding the extensive attention to directional verbs, there are numerous issues that have yet to be fully addressed. Directional verbs exhibit much morphophonological variation for marking person, which makes it challenging to generalize about the productivity what forms are "regular" and "irregular." Some verbs like OWE cannot exhibit subject agreement due to articulatory constraints (Rathmann and Mathur, 2002). There are a handful of verbs that cannot mark first-person object forms (Hou and Meier, 2018). These issues make it a challenge to identify argument structure constructions of directional verbs in ASL, particularly from a usage-based perspective, in the absence of a large-scale, searchable corpus of ASL, though this has been done for Auslan (de Beuzeville et al., 2009; Johnston, 2019b). Usage-based linguistics posits that verbs are associated with specific argument structure constructions. The representation of these structures is said to be shaped by two general properties: (1) frequency of occurrence of verbs and (2) the meaning of words and constructions in use.

In lieu of corpus data, empirical observations of directional verbs in argument structure constructions are grounded in a sampling of internet data for forming a preliminary usage-based analysis. For the time being, I take a non-committal stance on the linguistic status of verb agreement by using "directional verbs" (this term may include "spatial verbs" but I do not discuss them here) and view "verb agreement" as a language-specific concept but distance myself from multiple aspects of the formalist views of agreement. I do assume that the verbs mark person, as reflected by the glossing practice of the examples from my data collection, though I keep an open mind to a wider interpretation of person marking based on the data. I do not assume that agreement in ASL patterns like agreement in other languages regardless of whether they are signed or spoken, and furthermore, what may look like agreement may not be agreement. Using alternative terminology like "indicating verbs" that is not used for describing spoken languages is unfortunately not very accessible to the wider field of linguistics and renders signed language research obscure to spoken language linguists[2]. Using more conventionalized terminology, however, does not preclude sign language linguists from proposing an alternative proposal to analyzing verbs. Researchers can be more explicit about what they mean by a concept and what kind of theoretical assumptions are packed in their analysis. Thus it is possible to use "agreement" as a comparative concept for typological purposes while describing the operationalization of agreement in language-specific terms (Haspelmath, 2010; Croft, 2016). This principle extends to signed languages as well (Lepic, 2021). So using "ASL agreement" is a starting point for developing a usage-based analysis of the argument structure of directional verbs in ASL, but this should not preclude an expanded and nuanced understanding of "ASL agreement" to the point where it may be eventually described in other comparative and language-specific terms.

DATA AND METHODS

The present study utilizes internet data. Some of the data has been previously analyzed in a study on first-person object forms of directional verbs (Hou and Meier, 2018) and another study

[2]Some spoken language linguists do reject the formalist views of agreement (Barlow, 1999; Croft, 2001, 2013; Langacker, 2008; Haspelmath, 2013; Kibrik, 2019). This is reflected in the usage of alternative but also conventionalized terminology such as *multiple symbolization* (Langacker, 2008) and *indexical coded dependencies* (Croft, 2001).

about the functions of LOOK as a verb of visual perception and as a stance marker (Hou, 2022). Internet data refers to videos and vlogs in any signed language created and published by deaf signers on commercial social media platforms such as YouTube, Facebook, Instagram, and the likes. The rationale for using internet data is that there is no publicly available, machine-readable corpus for ASL yet (Morford and MacFarlane, 2003; Wilkinson, 2016; Lepic, 2019; Occhino et al., 2021). In lieu of an established corpus, the internet data is a suitable alternative (Hou et al., 2020, 2022). The U.S. variety of mainstream ASL is one of the most common signed languages represented on the internet, owing to the omnipresence of media sources such as the Daily Moth and DPAN.TV and widely shared public vlogs (Hou et al., 2020; Snoddon and De Meulder, 2020).

An issue with internet data (and data in general) is the frequency of signs in ASL. There have been only a couple small-scale studies that investigated the token frequency of occurrence for individual signs (Morford and MacFarlane, 2003; Mayberry et al., 2014; Sehyr et al., 2021). The limited sampling of data however means that these studies may not be wholly representative of the ASL lexicon. Still, these studies can indicate the frequency of occurrence of some signs. Morford and MacFarlane (2003) listed 37 signs that occurred more than four times per 1,000 signs in a database that consisted of 4,111 signs. The verbs TELL and LOOK, were listed among these signs. They had 7.1 occurrences and 6.3 occurrences per 1,000 signs, respectively. These findings align with what has been reported for BSL in Fenlon et al. (2018), who listed the frequency of 81 verb types of 1,436 verbs from narrative data in a considerably larger BSL corpus. Fenlon et al. reported the ten most frequent types in the following order: SAY, LOOK, LOOK2, GIVE, MEET, GIVE-INFORMATION, ASK, PAY, TEACH, and HELP.

One however must be careful about using reported frequency studies of verbs in other signed languages to speculate about the frequency occurrence of verbs in ASL. In a corpus study about the frequency and duration of signs and parts of speech in Swedish Sign Language (SSL), Börstell et al. (2016) listed the 300 most frequent types of signs in a sample of 44,786 signs. The ten most frequent types for verbs were TO-BE, HAVE, PERF, BE-INSIDE, TO-MEAN, SEE, TO-SIGN, REMEMBER, LOOK-AT, and COME-THERE[3]. As the researchers were interested in parts of speech, they did not distinguish the verbs based on their ability to participate in agreement. Therefore, for the purposes of this study, seven directional verbs were selected from two datasets: ASK, TELL, REMIND, AWARD, GIVE, CONVINCE, LOOK. The verbs were grouped for their semantic similarity: ASK, TELL, and REMIND for reported speech constructions, AWARD, GIVE, and CONVINCE for passive constructions, and LOOK for stance verb constructions.

The above seven verbs have been rated by deaf signers to have a moderate to high frequency of occurrence. Sehyr et al. (2021) discussed the signers' online frequency rating of signs from ASL-LEX, a publicly available, large-scale lexical database for ASL. The current version of ASL-LEX contains 2,723 signs. The signers were asked to rate different signs based on their intuition about the frequency of occurrence in everyday conversation, using a 7-point scale in which 1 indicated "very infrequently" and 7 indicated "very frequently." The signs were ranked in the following order of increased frequency: CONVINCE (4.036), REMIND (4.9), CALL (4.967), LOOK (5.08), AWARD (5.222), ASK (5.24), GIVE (5.667), TELL (5.933). These subjective ratings somewhat correlate with the corpus estimates, although the ratings do not distinguish lexical categories of the signs.

For all the seven signs, I selected the tokens that distinctly functioned as verbs, rather as nouns, for example, based on the sign's position and role in the utterance. All these verbs can be spatially modified to mark what look like first-person and non-first person object, though they vary in degree of reported frequency. The first dataset is for reported speech and passive constructions. There are seven videos totaling 1 h and 24 min with a total of 145 verb tokens. Most videos are monologs or live narratives. One video is a news report from the ASL radio show, *The Daily Moth*. The second dataset is for stance verb constructions with LOOK tokens used in Hou's (2022) study. There are 65 videos totaling 8 h 21 min with a total of 349 verb tokens. The videos encompass a more variety of genres, though dyadic and polyadic conversations are underrepresented. Both datasets total to 494 verb tokens; they overlap for the most part except for Video 5. This video was specifically selected for the repeated occurrence of GIVE and AWARD. **Table 1** shows the summary of the first dataset, and **Supplementary Appendix 1** lists the video sources for both datasets.

Analysis

The data was coded in ELAN. The verb forms were coded for person and syntactic and semantic arguments based on the discourse context. There has been discussion about how to judge whether a directional verb is modified or not (de Beuzeville et al., 2009; Fenlon et al., 2018), but the criteria is based on the concept of a citation form of a verb. A verb form could be "unmodified" or "congruent" but could be compatible with a modified interpretation. For example, a verb form precedes a non-localized object argument, i.e., an utterance like TELL PEOPLE, does not have PEOPLE localized in space. Another example is that a verb form targets a second-person object argument and may resemble the citation form. Such ambiguous forms occurred in the data. Only one clear exception was when

TABLE 1 | Summary of the verb tokens in the first dataset (n = 145).

Video source	Give	Tell	Award	Convince	Remind	Look
Video 1	0	4	0	0	1	22
Video 2	0	2	0	0	3	30
Video 3	0	0	0	2	0	18
Video 4	0	0	0	1	0	3
Video 5	18	6	5	0	1	1
Video 6	0	2	0	0	3	3
Video 7	0	2	0	0	1	9
	18	*14*	*6*	*3*	*8*	*86*

[3]The English glosses for SSL signs were translated in Börstell et al., since the glosses in the SSL corpus are originally in Swedish.

a verb form was not modified to mark a first-person object argument and was followed by a first-person pronoun; the form moved away from the signer instead of moving toward the signer, which appeared to understate the event of looking. Some LOOK tokens exhibited reduction in the modification, which I attribute to the ongoing grammaticalization of the verb as a visual perception verb to a stance marker. Overall, I decided that judging the spatial modification of verb forms for whether they were "unmodified" or "congruent" could lead to a deep rabbit hole, and moreover, spatial modification was not the sole contributor to the interpretation of the argument structure constructions. I only judged a verb form to be unmodified when there was a clear case like the above first-person object argument situation.

Many scholars have observed that there is a strong interplay between constructed action (CA) and the spatial modification of directional verbs in signed languages, i.e., a verb is more likely to be clearly modified during CA (de Beuzeville et al., 2009; Jantunen, 2017; Fenlon et al., 2018; Hodge and Cormier, 2019; Johnston, 2019b). CA is generally described as a stretch of discourse, of any length, that represents a role of a referent other than the present narrator or roles of multiple referents whose actions, thoughts, or feelings are depicted (Cormier et al., 2015b). The depiction emerges through hands, face, and other parts of the signer's body; the narrator can depict the referent by "telling" with signs and/or "showing" with their body and vary in the degree of saliency. CA has been described as a form of gestural enactment that represents the semiotic diversity of linguistic expressions. I adopted some of Cormier et al. (2015b)'s proposed criteria for coding a subset of the data – verbs of communication – for the occurrence of CA, since I observed that these verbs exhibited more explicit CA than the other verbs in the dataset. I relied on the changes of the facial configuration and eye gaze as well as shifts in body positioning. CA can include constructed dialogue (CD), which has been reported to co-occur or overlap with CA and involves the direct or indirect quotation, or perhaps both. For the sake of parsimony, I chose not to tease apart CA with CD from CA without CD or CD without CA, due to the small size of the data sampling in the present study. Moreover, I avoid positing constraints on the occurrence of CA in the proposed argument structure constructions since CA varies widely in its distribution and degree of explicitness in discourse (Cormier et al., 2015b; Jantunen, 2017; Koulidobrova and Davidson, 2020).

For this paper, the boundaries of clauses of all the argument structure constructions are not explicitly delineated. The complexity and ambiguity of identifying the clause boundaries of spontaneous signing in line with the Auslan corpus annotation guidelines (Johnston, 2019a) require extensive labor that requires more than that of an individual researcher available. The eye-gaze behavior is not explicitly delineated, either. Much of the internet data does not involve live shared eyegaze between the signer and the audience, which presents a somewhat novel problem for the interpretation of the signer's eyegaze. Thus, the proposed templates for argument structure constructions should not be interpreted to mark clausal boundaries.

ARGUMENT STRUCTURE CONSTRUCTIONS

Reported Speech Constructions

A reported speech construction involves verbs of communication used to report the speech of a person directly or indirectly[4]. ASL has a large group of directional and non-directional verbs of communication that may be used for constructed dialog such as ANNOUNCE, ASK, BAWL-OUT, CALL-BY-PHONE, INFORM, INSULT, MAKE-FUN, MOCK, ORDER, SAY, REMIND, TEASE, TELL, and WARN. The selected three verbs of communication are TELL, ASK and REMIND. These glosses represent the approximate meaning of the verbs, though REMIND primarily is associated with the meaning of bringing someone's attention to something that requires action.

I propose that there are two overarching types of recurring reported speech construction (hereafter RSC) that the three verbs participate in. **Table 2** presents the summary of the distribution of the verbs of communication across the RSC types. In the following written examples, for the sake of space, CA is indicated by the brackets [CA:]. Non-manual expressions are not included.

RSC Type 1: The verb occurs prior to or during constructed action. The verb either occurs prior to or during constructed action.
RSC Type 2: The verb occurs without explicit constructed action.

There are 16 tokens of TELL. All tokens except one appeared to be spatially modified for non-first person object arguments. All tokens of TELL except for one occur in RSC Type 1. In (6) and (7), TELL occurs prior to or during constructed action, as marked by the brackets. In (8), which is the only token that fits RSC Type 2, there is no explicit occurrence of CA, which can be attributed to the example presented as a comment about the story that the narrator was telling the audience.

(6) CA: PALM-UP FINISH PRO.1 **TELL.2** MORNING PRO.1 not-want
"Well, I already told you this morning I didn't want to (babysit)"
Source: ASLonline, Babysitting Blunder, Timestamp: 00:05:26-00:05:28

[4]Reported speech also can occur in the form of depiction of actions, characters, and events through enactment in both signed and spoken languages, which suggests that reported speech is not a dedicated syntactic domain (Hodge and Cormier, 2019). That is, a user does not need to use conventionalized quotative markers or verbs of communication to express reported speech.

TABLE 2 | Count summary of recurring RSC Types for the three verbs of communication.

Reported speech construction types	Tell (n = 16)	Ask (n = 7)	Remind (n = 9)	*Total* (n = 32)
Type 1	15	6	9	*28*
Type 2	1	1	0	*2*

(7) S-O PRO.1 **TELL.3** [CA: HEY I-T-S-O-K NO-BIG-DEAL]"
"So I told her, "Hey, it's okay, no big deal"
Source: Street Leverage, Trudy Suggs,
Timestamp: 00:04:57-00:04:59

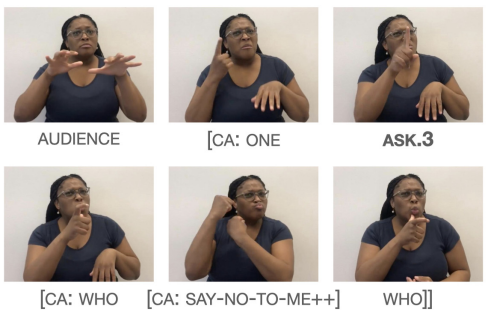
(8) PRO.1 WISH PRO.3 GRAB-OPPORTUNITY POSS.3 FAMOUS TO **TELL.3** PEOPLE
"I wish she had capitalized on her fame to tell people"
Source: Street Leverage, Trudy Suggs,
Timestamp: 00:20:05-00:20:10

For the seven tokens of ASK, all tokens of ASK except one appeared to be spatially modified for non-first person object arguments. Three tokens were modified for repetition, as indicated by "++," giving the reading of "to question" rather than "to ask a question." Six tokens occurred in RSC Type 1. **Figure 2** shows the occurrence of ASK in RSC Type 1; this example contains complex, nested constructed action. In this figure, during the production of ONE, the narrator's face and eye gaze changes, signaling a transition to constructed action to enact a referent. Following ASK.3, the signer starts quoting the first referent's question to a second referent, WHO, and then quotes a third referent who said SAY-NO-TO-ME + + from the second referent's perspective. Basically, the first referent is quoting what was being told to the second referent.

Example (9) represents one token of ASK that corresponds to RSC Type 2. In this example, the narrator recounts about being asked many questions, as indicated by the symbols + +, but does not quote or even paraphrase what the questions were.

(9) PRO.3 **ASK.1** + + RECEPTIONIST SIT-OVER-THERE. . .
"While they were questioning me, the receptionist was sitting over there. . ."
Source: Street Leverage, Trudy Suggs,
Timestamp: 00:04:04-00:04:07

For the 9 tokens of REMIND, six tokens were modified for non-first person object arguments and three for first-person object arguments. All tokens of REMIND occurred in RSC Type 1, as shown in (10) and (11). Note that (10) also exhibits complex, nested CA, as the signer mouths YOU HAVE THREAD and subsequently enacts the thread hanging from their own butt.



"One person from the audience asked them, "who kept saying no to you, who did that?"
Source: Frye (2020), Timestamp: 03:29-03:32

FIGURE 2 | An example of ASK in RSC Type 1. Images produced with permission, source information available in the **Supplementary Material**.

(10) [CA: PRO.1 **REMIND.3** YOU HAVE THREAD THREAD-ON-BUTT]
"I called her for attention," "You have a thread hanging on your butt"
Source: ASLonline, Gym,
Timestamp: 00:01:24-00:01:00:01:28

(11) EARLY-MORNING SISTER HAPPEN **REMIND.1** [CA:TAKE-CARE MY NIECE]
"Early in the morning, my sister implored me to take care of my niece."
Source: ASLonline, Babysitting Blunder,
Timestamp: 00:00:22-00:00:26.

What tentative generalizations can be abstracted from the above data? First, most verb tokens occur in RSC Type 1, suggesting that there is a strong interaction about directional verbs of communication and constructed action. These verb tokens tend to occur during CA or prior to the inception of CA. Second, very few verb tokens occur in RSC Type 2, suggesting that CA is, more or less, integral to argument structure constructions of these verbs of communication. Based on these findings, the following constructions are proposed to capture the various reported speech construction types. The paucity of the data does not allow for clear generalizations about the frequency of present and absent of subject and object arguments, so for the time being, I posit that these arguments are optional.

RSC Type 1 schema: [(*subject*) {ASK, REMIND, TELL. . .} (*object*) [CA: . . .]]

RSC Type 2 schema: [(*subject*) {ASK, TELL. . .} (*object*). . .]

Given the wide and varied distribution of CA in the grammar of many signed languages (Cormier et al., 2015b; Jantunen, 2017), it may be challenging to posit where exactly CA occurs in argument structure constructions. If one is concerned with parsimony, one could propose templatic constructions without CA. Garcia and Sallandre (2020) state that the semiological approach does not follow the CA model, as most approaches in sign language linguistics do, but instead categorize CA as part of the "highly iconic constructions[5]." Alternatively, one could draw more clear distinctions between different verb types and CA, if one has an adequate dataset for abstracting generalizations.

Non-dedicated Passive and Reflexive Constructions

Another type of argument structure construction of interest is the passive construction. This generally refers to defocusing the agent, which is the main pragmatic function of passives

[5]In some other approaches, "highly iconic constructions" refer to "non-lexical" (including CA) and "partly lexical" signs (Hodge et al., 2019).

(Shibatani, 1985). Defocusing the agent may occur by omitting the agent or not specifying it in various syntactic and morphological ways. In the dataset, I identified a few verb tokens, AWARD, CONVINCE, and GIVE that occur in both active and passive constructions, though a few tokens of the latter warrant further scrutiny. **Table 3** summaries the distribution of the three verbs for active and passive constructions. Most verb tokens are modified for third-person object arguments only, though the tokens of GIVE are modified for both subject and object arguments, all third-person. Only one token of AWARD and three tokens of CONVINCE are modified for first-person object arguments; these tokens occur in passive constructions. Three tentative types of passive constructions are proposed, following a short discussion on the formational differences between active and passive constructions and an examination of aggregated data from previous and current research.

There have been various proposals for how different signed languages express "passive constructions," which encompass R-impersonals and agent defocusing (Janzen et al., 2001; Leeson, 2001; Rankin, 2013; Barberà and Cabredo Hofherr, 2017; Nordlund, 2019). R-impersonal constructions have subjects that are human and non-referential such as impersonal subject pronouns (Siewierska, 2011). The current consensus is that passive constructions can be semantically marked but not morphologically or syntactically marked, since there is no change in the verb form and the object is not promoted to the subject position. The corollary is that such constructions can give indefinite readings; this is further discussed below. Signed languages therefore lack "dedicated" passive constructions, hence the "non-dedicated passive" title of this section.

In the case of directional verbs, there is no change in the direction of path movement and palm orientation. Consider GIVE, a highly cited verb for its morphological "versatility," i.e., it can be spatially modified to point to different locations, including the signer. In many signed languages GIVE exhibits strong transitivity for its three-argument verb structure (Börstell et al., 2019). The ASL GIVE is no exception to this generalization. Examples (12) through (15) shows GIVE in several double object-like constructions from Padden (1988). In (12) through (15), there is an explicit subject/agent, INDEX, and theme, BOOK. The verb form contains subject and object agreement markers, which are indicated by the subscripts ("1" for first-person, "2" for second-person, and "i" for index for third-person) attached to the gloss GIVE. The recipient may be an actual referent in which the real-world location serves as the final location of GIVE, or it may be based on an arbitrary location in the signing space and that location is already associated with the referent in prior discourse. These examples suggest that the ditransitive construction appears to be a prototypical representation of the argument structure of GIVE.

(12) $_1$INDEX$_1$GIVE$_i$ BOOK
"I gave him the book."

(13) $_2$INDEX$_2$GIVE$_i$ BOOK
"You gave her the book."

(14) $_1$INDEX$_1$GIVE$_2$ BOOK
"I gave you the book."

(15) $_i$INDEX$_i$GIVE$_j$ BOOK
"She gave him the book."
(Padden, 1988, pp. 58–59).

In (16) and (17), which are from Padden (1988), the subject agreement marker, indicated by the "0" subscript, can be omitted. The initial location of the verb is not associated with the subject. But the omission of the subject agreement marker does not alter the fundamental meaning of transitivity if there is an independent nominal (or pronominal) for an explicit agent in (16). Otherwise, the absence of an explicit agent in (17) and its English translation suggests either the example may be either an impersonal or passive construction. The ambiguous translation shows that both meanings are possible, though if there was an impersonal subject present, the example would give a stronger reading of an impersonal construction.

(16) WOMAN $_0$GIVE$_1$ NEWSPAPER
"The woman gave me a newspaper."

(17) $_0$GIVE$_1$ NEWSPAPER
"Someone gave me a newspaper/I was given a newspaper."
(Padden, 1988, p. 136).

Janzen et al. (2001) proposed a distinction between active and passive constructions in ASL. In their view, a passive construction is formed by the configuration of various grammatical features, including the use of constructed action and the defocusing of an agent in the clause. A prototypical passive construction foregrounds point of view of the patient (or the recipient) through constructed action while defocusing the agent (Janzen et al., 2001; Rankin, 2013). The verb form however does not change when it occurs in a passive construction, e.g., omitting the agent or demoting it to an oblique argument and promoting the patient to the subject argument. (18) shows the spatial modification of a two-handed form of GIVE, as indicated by "(2 h)," from a non-first person agent to a first-person recipient, which are represented as "a" and "1" in subscripts, respectively. Yet there is no explicitly identified agent. The only explicit argument is the basketball tournament, and it functions more as a theme than as an agent. Although the movement of the verb form implies an agent giving the basketball team a trophy from a

TABLE 3 | Count summary of active and passive/reflexive construction types for three verbs.

	Give (n = 18)	Award (n = 6)	Convince (n = 3)	*Total* (n = 29)
Active construction	1	1	0	*5*
Passive/ reflexive construction	17	4	3	*24*

first-person perspective, the agent is not specified and therefore is not referential.

(18) _____t
REMEMBER 1-YEAR-PAST BASKETBALL TOURNAMENT, EXCITE, WIN.
_____y/n q
$_a$**GIVE(2h)**$_1$ TROPHY. REMEMBER.
"Do you remember the basketball tournament last year, that we were excited to win? We were given the trophy, remember?"
(Janzen et al., 2001, p. 293).

Rankin (2013) argues that the omission of the agent *without* constructed action is the most common strategy for passive constructions with non-first person patients as shown in (19); the superscript $^{\rightarrow right}$ indicates the direction of the verb, so as to distance from referential indices. Constructed action, then, does not appear to be an obligatory element of passive constructions in ASL.

(19) TOMORROW MUST GIVE$^{\rightarrow right}$ RECEIPTS TO SECRETARY
"Receipts should be given to the secretary tomorrow."
(Rankin, 2013, p. 63).

The internet data corroborates the findings of Janzen et al. and Rankin. The above examples involve first-person object forms of GIVE that co-occur with and without constructed action, so I present a different example of GIVE with non-first-person interpretations in 20, which is the same as **Figure 1**. This example does not exhibit any elements of constructed action. The verb form can be interpreted to indicate the transfer of an object from a non-first person agent to a non-first person recipient. This interpretation is based on the initial and final locations of the verb: the verb starts at a spatial location to the signer's right and moves toward to another location ahead of the signer's chest. There is no explicitly identified agent, and prior to the clause, the signer was narrating about how one movie was erroneously announced as the winner of an award. This event is memorialized as "Envelopegate." The example marks the beginning of a long description of the snafu with the envelopes, indicated by the signer's calling attention with HEY and the co-occurrence of raised eyebrows with WHAT.DO HAPPEN as a rhetorical strategy of offering new information. There is a total of 18 tokens of GIVE in the entire discourse about the "Envelopegate." All tokens, with one exception, occur in a semantically passive construction; the last token co-refers to a newly identified agent.

(20) HEY WHAT.DO HAPPEN **3.GIVE.3** WRONG ENVELOPE TO THAT THOSE-TWO PEOPLE WHO. . .
"Hey so what happened was that the wrong envelope was given to those people who. . ."
Source: The Daily Moth, February 27, 2017,
Timestamp: 00:02:38-00:02:42.

What remains an open question is the number and type of directional verbs that can participate in similar non-dedicated passive constructions as GIVE. Another verb, AWARD, also denotes the transfer of an object to a recipient, except the object is specifically an award. Out of the six tokens of AWARD in the dataset, one only occurred in an active construction, specifically a ditransitive construction in (21).

(21) REMEMBER PAST IN 2015 PRO.3 WRONG **AWARD.3**
M-I-S-S UNIVERSE CROWN TO MISS COLOMBIA
C-O-L-O-M-B-I-A
"Remember back in 2015, he mistakenly awarded the Miss Universe crown to Miss Colombia."
Source: The Daily Moth, February 27, 2017,
Timestamp: 00:04:59-00:05:06.

Five AWARD tokens occur in a non-dedicated passive construction. One such token occurs in Example (22), in which the agent is omitted; there is no identification of the agent in prior discourse. The recipient occurs preverbally in the subject. Two other tokens have the recipient in a similar position and one token has the recipient in a post-verbal position.

(22) PRO.3 ONLY SECOND PERSON **AWARD.3**
O-S-C-A-R WITH D-A
"She is the only second person with a disability awarded an Oscar."
Source: The Daily Moth, February 27, 2017,
Timestamp: 00:06:38-00:06:42.

There is one more AWARD token that does not fit the structure of the other passive construction. This token is spatially modified for the first-person object argument. **Figure 3** shows AWARD.1 without the identification of an explicit agent in the discourse, and the initial location of the verb is not associated with a specific agent. This example stands out for the first-person object verb form, since (22) shows a non-first person object form targeted at the referent, who is represented on the signer's right side. This is also shown by the occurrence of PRO.3 in **Figure 3**. There appears to be two clauses as delineated by the brackets: [PRO.3 WIN AGE 21] [AWARD.1 WOW]. The AWARD.1 occurs in the second clause. Given the context and clausal boundaries, AWARD.1 does not mean "I was awarded" but rather emphasizes the reception of the award with the signer's body, given its strong association with the signer's body as first person (Meir et al., 2007). Thus, the example in **Figure 3** may be a verbless attribute clause[6].

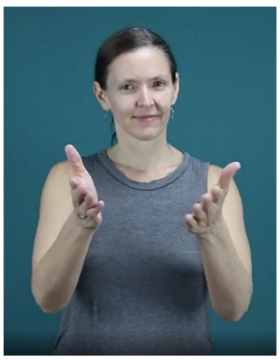
For CONVINCE, the passive constructions with this verb give a different reading than the ones with GIVE and AWARD. **Figure 4** is the dictionary entry for CONVINCE. It is listed as an "inflectional" verb in Padden (1988) and an "agreement" verb Mathur (2000). It is noted to have an "idiosyncratic first-person object form" which arguably must be listed because this particular form is produced on both sides of the signer's neck rather than the signer's chest (Meier, 1990; Lillo-Martin and Meier, 2011; Hou

[6]I thank one reviewer for raising this excellent proposal. They suggested that AWARD.1 may be a non-finite verb that functions as the subject of the clause, but there is no evidence of any signed language containing morphology to distinguish finite verb forms from non-finite ones. Alternatively, AWARD.1 may be nominalized and thus would not be participating in verb agreement.



"She won it when she was only 21 years old, her being awarded is amazing"
Source: The Daily Moth (2017), The Daily Moth 2-27-17, Timestamp: 05:35-05:38

FIGURE 3 | An instance of AWARD.1 in an apparently non-first person reading. Images produced with permission, source information available in the **Supplementary Material**.



Source: https://aslsignbank.haskins.yale.edu/dictionary/gloss/1984.html

FIGURE 4 | The dictionary entry for CONVINCE. Source: https://aslsignbank.haskins.yale.edu/dictionary/gloss/1984.html. Images produced with permission, source information available in the **Supplementary Material**.

and Meier, 2018). The chest is the most common location for the end point of first-person object forms of directional verbs, so the neck is marked for being the location for the end point of CONVINCE-1. No other directional verb has been documented to occur on the sides of the neck, although a few other signs do occur in the proximity of that location, such "bankrupt",[7] "vampire,"[8] and "accent"[9].

To date, there has been virtually no examples for CONVINCE. The internet data revealed only three tokens of CONVINCE, all modified for first-person object arguments. **Figure 5** shows the occurrence of CONVINCE.1, taken from a narrative about a signer's journey to atheism. Prior to this clause, the signer narrated about joining a group for skeptical pastors who had long, agonizing conversations about the existence of God. These conversations eventually led the signer to reach a conclusion. The verb form CONVINCE.1 alone could mean "they convinced me" in which the agent refers to the group. However, unlike GIVE, the initial location of CONVINCE does not clearly indicate the agent. There is a PALM-UP (an interjection meaning "well" here) and a first-person pronoun preceding CONVINCE.1 and PROOF following it without a discernible break. An alternative interpretation is that the verb has a self-reflexive reading as in, "I convinced myself with the proof[10]." The signs CONVINCE.1 and PROOF co-occur with similar head movement, suggesting that they occur within the same clause. Because PROOF appears to be part of the clause, functioning as an adjunct argument, it is difficult to determine whether the example in **Figure 5** is a non-dedicated passive construction or a reflexive construction.

Another example with the same string of signs of PRO.1 CONVINCE.1 and a similar interpretation occurs in **Figure 6**. The context of the utterance is about reading an academic paper and figuring out whether the argument in the paper is intelligible. The signer is asking if one finds the paper convincing, rather than asking if one convinces oneself. Again, the most appropriate interpretation would be, "Am I convinced (by the paper)?" or "Do I find this paper convincing?" The signer later produces another token of CONVINCE.1 for the same interpretation.

Interestingly enough, there were another three tokens of CONVINCE + ONE, all modified for non-first person object arguments in the same video for **Figure 6**. CONVINCE + ONE is a related verb construction, in which a one-handed version co-occurs with a non-dominant extended index finger. Some directional verbs have similar constructions, e.g., GIVE + ONE and REMIND + ONE, since they all use ONE. Other non-directional verbs also overlap with these constructions, e.g., FLATTER[11] and FOOL[12]. The function of ONE appears to mark affectedness, i.e., the object/patient is affected by the event. It remains an open question about the frequency of different forms of CONVINCE and CONVINCE + ONE in different argument structure constructions.

The paucity of the verb tokens makes it difficult to make a generalization about non-dedicated (and reflexive) constructions, so I propose several low-level constructions for GIVE.1, GIVE.3, AWARD.3 and CONVINCE.1 based on the aggregated data. The

[7]The sign BANKRUPT is a homonym: https://aslsignbank.haskins.yale.edu/dictionary/gloss/2607.html

[8]The sign VAMPIRE is one-handed that occurs on the ipsilateral side of the neck: https://aslsignbank.haskins.yale.edu/dictionary/gloss/1371.html

[9]The sign ACCENT is one-handed that occurs on the ipsilateral side of the neck: https://aslsignbank.haskins.yale.edu/dictionary/gloss/584.html

[10]Shibatani (1985) mentions that in several Indo-European and American Indigenous languages, there is a morphological correlation between passive, reflexive, and reciprocal constructions, i.e., the same morphology is used for these two or three constructions. Since first-person object forms of directional verbs can be used in passive constructions (with the agent defocused), this raises the question about whether they can be used in reflexive constructions too. It is important to notice, however, that in the aforementioned spoken languages, the morphology used for active constructions is not the same for passive, reflexive, and reciprocal constructions. Another question is whether personal pronouns in lieu of reflexive pronouns can be used for reflexive expressions in ASL as in the case of PRO.1 CONVINCE.1, but this has not yet been investigated (Erin Wilkinson, personal communication).

[11]This sign FLATTER can be found at: https://aslsignbank.haskins.yale.edu/dictionary/gloss/3409.html

[12]This sign FOOL can be found at: https://aslsignbank.haskins.yale.edu/dictionary/gloss/1491.html



FIGURE 5 | An example of in CONVINCE.1 in an indefinite construction. Images produced with permission, source information available in the **Supplementary Material**.

passive construction Type 1 and Type 2 differs by the verb form and the transitivity. First, the grammatical configuration of the syntactic positions appears to be shaped by the spatial modification of the verb for first-person and non-first person object arguments. Second, Type 1 is transitive but not ditransitive, whereas Type 2 is ditransitive for the occurrence of the direct and indirect object arguments and the introduction of the recipient by the sign TO.

Passive construction Type 1: [. . . GIVE.1 *object*$_1$]
Passive construction Type 2:
[. . . GIVE.3 *object*$_1$ TO *object*$_2$. . .]
Passive construction Type 3: [. . . (*subject*) AWARD.3. . .]
Passive/reflexive construction Type 4:
[. . . PRO.1 CONVINCE.1 . . .]

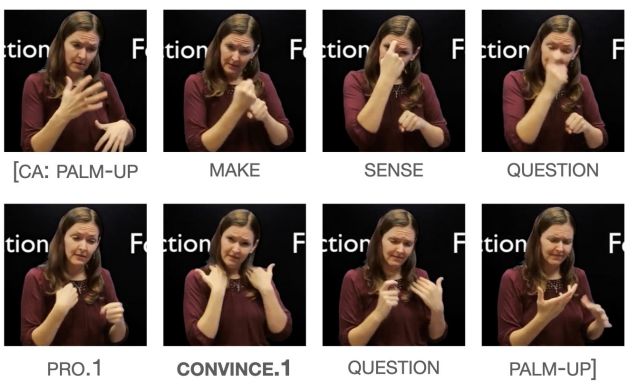


FIGURE 6 | Another example of CONVINCE.1 in a passive construction. Images produced with permission, source information available in the **Supplementary Material**.

Stance Verb Constructions

The third argument structure construction is the stance verb construction. This construction contains a verb that represents the user's (inter)subjective positioning toward a situation. The definition of stance is vast and varied (Englebretson, 2007). It can range physical embodied action to epistemic modality to social morality, and researchers vary in their approach to stance and how they understand it. Some scholars have argued that stance can be identified across whole phrases in discourse, rather than individual words only, since a word can have many functions based on its relationship with discourse (Hunston, 2007; Wang et al., 2021). English has been documented and described for complement-taking predicates such as *know, think, guess, doubt, hope,* or *wish* (Kärkkäinen, 2003). These verbs represent different types of stance relating to knowledge and certainty, and can have a positive clause or a negative one in its scope (Dancygier, 2012). A statement reading *I think she's there* signals a positive or affective stance, but another statement like *I think she's not there* signals a more neutral stance, which comes from the occurrence of the negator "not." There is extensive literature on stance as expressed lexically and grammatically in English and some other spoken languages, but not as much literature on signed languages. To date, research on stance in signed languages has been largely concentrated on modal verbs (Shaffer and Janzen, 2015).

The current focus is the stance function of a sign, LOOK, that collocate with a few signs, forming fixed and schematic multi-word expressions. LOOK is a sign visual perception that can be spatially modified for different types of meaning based on with path and manner of movement, the number of hands and

configuration of the hands, and the type of facial expressions (Klima and Bellugi, 1979; Naughton, 2001). This sign has been generally considered an agreeing/indicating verb, though it does not always denote a verb of transfer between two animate arguments, since the targeted stimulus does not have to be animate (Mathur and Rathmann, 2012). The sign may or may not be transitive. A recent typological study showed that signs with the basic meaning of "to look at" in five signed languages rank lower than spoken languages on the scale of transitivity prominence (Börstell et al., 2019). Although ASL is not part of Börstell et al.'s study, a similar pattern of transitivity prominence is observed in the LOOK data. The LOOK sign has two broad functions, vision and reaction. LOOK/"vision" functions as a directional verb that targets numerous animate and inanimate objects; in other contexts, it functions as an intransitive verb or as a noun. LOOK/"reaction" functions as a stance marker that conveys the signer's reaction toward a sensory, usually visual, stimulus (Hou, 2022). The reaction tends to occur in the form of a quotative or exclamatory statement. It is interpreted as "be + like," similar to what Padden (1986), Lillo-Martin (1995) used for translating quotative and non-quotative constructions in ASL to English. This interpretation also echoes the grammaticalized English "like" to introduce reported speech and thoughts (Romaine and Lange, 1991).

The two functions are distinguished by the multi-sign sequences which they participate in. Hou conducted a preliminary study of *n*-grams, a contiguous sequence of identifiable signs, that repeatedly co-occurred with LOOK/"vision" and LOOK/"reaction" (Hou, 2022). The sequence was considered recurring if a string of two or more signs occurred at least two times in the dataset. The sequence included at least one sign that precede and/or follow the verb. The dataset consists of 8 h 21 min of 64 videos by 38 unique deaf signers, which yielded 706 tokens belonging to the family of "look" signs. These tokens include OBSERVE, READ, and PERSPECTIVE, as they share the V-handshape and the visual perception meaning, so the LOOK/"vision" function is not limited to one sign. Some tokens are ambiguous in the sense that the function of a token simultaneously exhibits vision and reaction or overlaps with both vision and reaction. In some instances, the function is unclear. An example would be the co-occurrence of READ followed by a reaction. **Table 4** summarizes the number of tokens and types for both functions and the ambiguous tokens. **Table 5** summarizes the frequent bigrams, trigrams, and quadgrams for the "look" signs by function.

There are multiple recurring sequences observed in the 174 tokens of LOOK/"reaction." **Table 6** summarizes the 38 recurring bigrams for these tokens. The "s" is short for "sign," representing LOOK. The "s-1" represents the sign preceding LOOK while "s + 1," and "s + 2" represent following LOOK, respectively. Some signs recur in the s-1 or the s + 1 slot and have similar counts, so they are grouped together. What **Table 6** shows that 55% of the bigrams have PRO.1 in the s-1 slot and 21% have OIC (short for OH.I.SEE) in the s + 1 slot. Apart from PRO.1, various non-first person pronouns and referents occur in the s-1 slot. Apart from OIC, a handful of specific "reaction" signs such as PALM-UP an interjection meaning "well," GET.INSPIRED, HOLD.ON, MIND.PUZZLED, WOW, and FINE in the s + 1 slot. The rest of tokens collocate with hapaxes such as WHAT'S.UP, STOMACH.TURN, and CONCERNED. These low-frequency sequences reflect the schematic use of the specific argument structure construction for LOOK/"reaction."

Table 7 summarizes the 40 recurring bigrams for the 150 tokens of one type of LOOK/"vision" (this type is glossed as LOOK). Although PRO.1 is the most frequent sign to collocate with LOOK/"vision," PRO.1 only accounts for 15% of the 150 tokens[13]. There is a larger distribution of various signs collocating with LOOK/"vision" which includes various modals, negators, and nouns, possibility reflecting the schematicity of a different argument structure construction. None of these signs group together as a category that would distinctly signal to the signer's reaction to a visual stimulus, even when considered in the larger context of discourse.

[13]Hou (2022) found that there is a statistical preference for PRO.1 occurring in the s-1 slot to collocate with LOOK/"reaction" over LOOK/"vision," SEE and SEE-SEE.

TABLE 4 | Summary of the family of "LOOK" signs by function, token, and type.

Function	Token Count	Type Count
Reaction	174	1
Vision	369	18
Ambiguous	163	17
Total	*706*	*36*

TABLE 5 | Summary of frequent (n ≥ 2) n-grams of the "look" signs.

Function	Bigrams	Trigrams	Quadgrams
Reaction	38	24	4
Vision	77	13	2
Ambiguous	28	5	0
Total	*143*	*42*	*6*

TABLE 6 | Frequent (n ≥ 2) bigrams in 174 tokens of LOOK/"reaction."

Rank	s–1	s + 1	Count	
1	PRO.1		95	55%
2		OIC	36	21%
3		PRO.1	13	7%
4	PRO.3		11	6%
5		PALM.UP	10	6%
6	PEOPLE		8	5%
7	PALM.UP	WOW, YES	5	3%
8		FINE, GET.INSPIRED, HOLD.ON, MIND.PUZZLED	4	2%
9	DEAF, PRO. 2, SIGN.FLUENTLY	PRO.3, QUESTION, REALLY, THINK, WAVE.NO, WONDER	3	2%
10	MAYBE, WOMAN, WILL, SECRETARY	AWFUL, BE.FASCINATED, CAN'T, DISMISS, FEEL, GUT.INSTINCT, HOW, NO, NONE, THAT, THESE.TWO, THINKING.HARD	3	1%

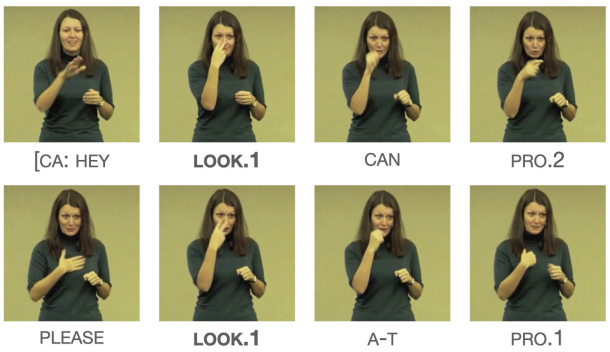


FIGURE 7 | An instance of LOOK/"vision." Images produced with permission, source information available in the **Supplementary Material**.

Figure 7 exhibits an utterance with two tokens of LOOK.1/"vision," both clearly modified for first-person object arguments. The whole utterance co-occurs with CA, and the string of LOOK.1 AT PRO.1 is attested to have two tokens in the dataset.

(23) PRO.3 [CA: LOOK **OH-I-SEE** DEAF FINE]
"He was like oh I see, you're deaf, got it."
Source: McFeely (2011), March 24, 2011,
Timestamp: 02:40-02:43.

Exhibits an utterance with a token of LOOK/"reaction," which is followed by a statement that shows the signer's positive stance toward the deaf person[14]. Both utterances in **Figure 7** and example (23) co-occur with CA, so the LOOK/"reaction" cannot be viewed strictly as a CA phenomenon. What distinguishes the utterances is the meaning that emerges from the collocation of certain signs with LOOK. The semantic roles of the subject are not necessarily the same. The subject of LOOK/"vision" is an agent who directs their eye gaze at a visual stimulus whereas the subject of LOOK/"reaction" is more closely aligned with an experiencer who processes the visual stimulus.

Additionally, there appears to be some formational differences of the verb among the two functions. Compared to LOOK/"vision," many tokens of LOOK/"reaction" exhibit less directional path movement, which may be indicative of phonetic reduction as part of an ongoing grammaticalization of the verb. In **Figure 7**, the verb form moves toward the signer's own face, but in (23), the verb form does not exhibit as much as path movement. The formational differences associated with the functions warrant further investigation.

The data for LOOK/"vision" and LOOK/"reaction" provides evidence for the differences in argument structure constructions associated with the functions. LOOK/"reaction" is more syntactically restricted than the former, occurring in more fixed sequences such as LOOK OIC. At the same time, these sequences allow for the instantiation of a more schematic template, allowing for low-level constructions with slots that can be filled with other signs for the positions of the subject and the reaction. The following constructions for the two LOOK functions are proposed:

LOOK/"vision" construction: [(*subject*) *(modal) (negator)* LOOK/"vision" (*object*)]
LOOK/"reaction" construction: [(*subject*) LOOK-AT/"reaction" *X-reaction*]

Recapitulation

What does the usage-based linguistics approach to argument structure constructions of directional verbs do for the controversy? The existence of multiple theoretical frameworks indicates that the controversy may never be entirely resolved, unless sign language linguists can put their views aside and "come to an agreement on how to segment sequences," including non-manual elements, for marking reference (Garcia and Sallandre, 2020, p. 15) for cross-linguistic purposes of comparing the structure of different signed languages. What I have shown here is that one can go beyond looking at the spatial modification of the directional verb and focus on the function of the verb based on the larger construction of the discourse. Although the data presented here is not comprehensively annotated and analyzed in line with the Auslan corpus annotation guidelines (Johnston, 2019a), the data does show how directional verbs function more than just marking pronominal reference and spatial transfer of objects.

FUTURE DIRECTIONS

This paper has advocated for a usage-based approach to analyzing argument structure constructions of directional verbs in ASL as a way of identifying some of the grammatical patterns that make up a user's linguistic knowledge. Seven verbs, ASK, TELL, REMIND, AWARD, CONVINCE, GIVE, and LOOK, were sampled from internet data and analyzed for argument structure constructions that they recurred in. The preliminary analysis revealed likely patterns for low-level constructions: reported speech

[14]https://www.youtube.com/watch?v=zlR2EGi6_wA

TABLE 7 | Frequent (n ≥ 2) bigrams with LOOK/"vision" (n = 150).

Rank	s–1	s + 1	Count	
1	PRO.1		23	51%
2	PALM.UP		9	6%
3		PALM.UP	9	6%
4	CAN, INDEX	PRO.1	6	4%
5	PRO.2	SEE	5	3%
6		INDEX	4	3%
7	NEVER, O-R	SUN, THAT	3	2%
8	CAN'T, FINE, GRAB.OPPORTUNITY, HAVE.TO, LOOK, MUST, NOT, NOT.YET, NOW, PICK.UP, START, TEND.TO, PRO.3-PL, WAIT, WILL, PRO.2-PL	FOLLOW, LOOK, ON, POSS.1-PL, POSS.3, Q-U-A-L-I-T-Y, T-V, V-I-D-E-O, WORD, Y-O-U-T-U-B-E, POSS.2	2	1%

constructions (ASK, TELL, REMIND), non-dedicated passive and reflexive constructions (AWARD, CONVINCE, GIVE), and stance verb constructions (LOOK). In reported speech constructions, it was shown that most tokens of verbs of communication occur in a construction that involved constructed action, whereas few tokens occur in a construction without explicit constructed action. For passive constructions, it was shown that many tokens AWARD and GIVE occur in agent defocusing constructions but one specific verb form of CONVINCE occurs in an indefinite construction that may be either non-dedicated passive or reflexive constructions. Finally, the stance verb constructions of LOOK reveal that it is the whole argument structure construction, not the verb itself, that give rise to the functions of vision and reaction.

Future research would look at a larger dataset of directional and non-directional verbs, allowing for more fine-grained generalizations about argument structure constructions. It has been many decades since the field of sign language linguistics became fascinated with verbs. With the advent of corpus and internet data, researchers are now in a position where they can abstract away from the controversy of verb agreement and to look for verbs in argument structure constructions, potentially advancing the field to a more holistic but deeper understanding of the interplay of language use and structure.

AUTHOR CONTRIBUTIONS

LH was responsible for every aspect of the contribution for the article, contributed to the whole conception and design of the study, wrote the entire manuscript and **Supplementary Appendix**, did the revisions, selected, transcribed, and organized the internet data in ASL, analyzed and discussed it thoroughly, and designed and edited all the figures.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.808493/full#supplementary-material

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Translating Poetry in Sign Language: An Embodied Perspective

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In the translation into sign language, where does the ≪sense≫ reside and how can it be constructed in the target language? To what extent does the orality of sign languages, intended as the absence of a writing system, affect the translation process? What role do the characteristics of sign languages, first and foremost iconicity, play? The issues we address in this study are placed at the crossroads between sign language linguistics and translation studies, thanks to the awareness that both disciplines have, respectively matured in recent decades. As regards the linguistics of sign languages, we refer to the *semiological model* proposed by Cuxac and colleagues. On the subject of translation studies, our main reference is represented by Meschonnic, according to whom the sense is found in the ≪rhythm≫ (understood as form). Analyzing the translation process, and more specifically the poetic translation, allows us to observe the centrality of the body. We take into account the perspective of *embodied cognition*, based on the link between the language and the sensorimotor system. Therefore, we question the role of the body in the construction of the sense: the body is considered above all in its sensorial dimension, in its being an entity that perceives and enters into a relationship with the world. That makes us hypothesize a *synesthetic construction of the sense*. In order to follow in practice what is stated theorically, we present one of our translations: the translation into LIS of a poem in Italian, *L'Infinito* by Giacomo Leopardi. The translation into sign language makes it possible to observe the role of corporeality in the process of re-enunciation of sense.

Keywords: translation, poetry, sign language, Italian Sign Language (LIS), embodied cognition

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INTRODUCTION

It is commonly said that the title constitutes the most extreme summary of a text. We would therefore like to begin our reflection starting from the title, or rather from the first part of the title: translating poetry in sign language. Taking into account that poetry, or more precisely a well-known Italian poem, is our reference corpus, we would like to focus on "translating" and "sign language." They both have begun to be perceived as disciplines only in recent decades. As we know, about 60 years have passed since the publication of William Stokoe's *Sign Language Structure*, the publication which, for the first time in 1960, proposed an analysis of sign language as a real language. As regards the theme of translating, we can say that, although the phenomenon has existed for millennia[1], the birth of translation studies as a discipline can be placed between the end of the 70's and the beginning of the 80's (cf. Lavieri, 2016a[2]). Consequently, the ontological dialogue between these two disciplines is recent.

[1]The phenomenon of translating is very ancient, as evidenced by the archaeological finds in several languages: we can for example refer to the bilingual Lycian-Greek inscriptions dated 5th-4th century B.C.
[2]Original edition 2007.

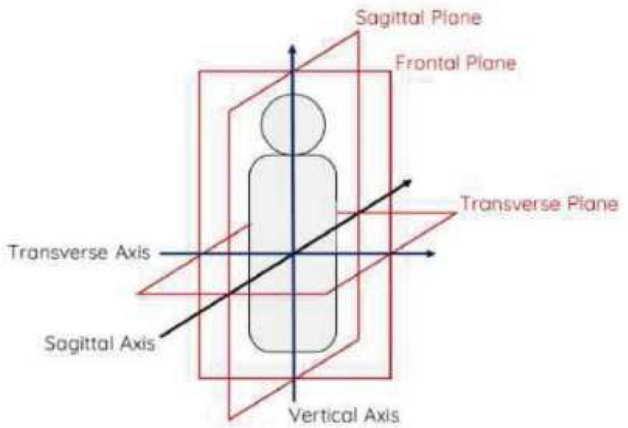


FIGURE 1 | Body planes (sagittal, frontal, and transverse) and axes (sagittal, vertical, and transverse)[3].

The encounter between linguistics of sign languages and translation studies was also due to the growing awareness of the existence of literature in sign language. Characteristics of the signed literature (and, more specifically, of the signed poetry) can be found in the best-known international scientific literature on the subject (Miles, 1976; Klima and Bellugi, 1979; Valli, 1993; Mirzoeff, 1995; Ormsby, 1995; Cohn, 1999; Peters, 2000; Sutton-Spence, 2005; Bauman et al., 2006; Sutton-Spence and Kaneko, 2016) and, as much as concerns the Italian context, in the studies concerning LIS (Italian Sign Language) (Russo Cardona et al., 2001; Russo Cardona, 2004; Rizzi, 2009). Works that deal with the poetic translation of sign languages (Celo, 2009; Catteau and Blondel, 2016; Chateauvert, 2016; Fontana, 2016; Pollitt, 2019; Houwenaghel and Risler, 2020; Raniolo, 2021), both theoretically and practically, have quite recently appeared.

One of the aspects that characterizes signed literature is represented by orality: the reason lies in the fact that sign languages are oral languages, that is, they do not have a written form shared by the communities of signers[4]. The oral nature of sign languages affects above all the process of language standardization: for this reason, sign languages present many diatopic variants (regarding LIS, cf. Volterra et al., 2019). Furthermore, the question of tools must also be taken into account. The dictionary, which is usually an ally for those who work in the field of translation or languages in general, is only partially useful in the context of sign languages. For a translator/interpreter it is rather necessary to start from a pragmatic and social dimension: the primary resource is represented by the users of the language, who are the only custodians of the social fact (Fontana, 2013).

We also specify that the use of the term translator / interpreter is due to the oral nature of sign languages. The choice of talking about a single figure may seem somewhat unusual, since the two professions are commonly distinct. Actually, these professions differ in a number of aspects[5], which can be summarized in the fact that the translator works with written texts and has a (relatively) long time available, while the interpreter works with oral texts in real time. It is precisely because of the absence of written form in sign languages that the professional who works with sign language can be defined as a translator / interpreter (cf. Buonomo and Celo, 2010; Celo, 2015): the central point is in fact that "the translation process takes place exclusively on the level of orality" (Fontana, 2013, p. 68, our translation)[6]. This peculiarity strongly affects the translation process (Fontana, 2013, 2014).

The work of the translator / interpreter, in addition to what has been stated, must take into account another characteristics that, in our opinion, proves to be fundamental. We are talking about the relationship with the public: not only a deaf public, but also a hearing public (not necessarily proficient in sign language), that, even if unable to grasp the nuances of the language, can still enjoy the poetic translation. In fact, one of the features that characterizes the figure of sign language translator / interpreter is its physical presence, a presence that gives life to a performance that is appreciable, as we will see, even by those who do not have specific linguistic skills. For the sake of clarity, we propose a comparison. With regard to vocal languages, in most cases the translators do not show themselves at all (we only see the finished product in its written form), interpreters only give access to their voice. In the case of the sign language translator / interpreter, his physical presence is a *sine qua non* for the translation process to be fulfilled. Let's consider the case of conference interpreting: the LIS interpreter is "placed in a high position and clearly visible from the whole audience" (Franchi and Maragna, 2013, p. 138, our translation). The reason lies in the fact that sign languages exploit the visual-gestural channel, therefore it is essential that the person who signs is clearly visible. The possibility of being perfectly seen is a fundamental characteristic, which assumes a central role in a reflection on translation such as the one we intend to conduct here.

[3]Image taken from Paredes et al. (2017).

[4]We underline that, however, various systems of writing / transcription of sign languages have been proposed over time. We could mention *Mimographie*, *Stokoe Notation*, *HamNoSys*, *D'Sign*, and last but not least *SignWriting*, the one which to date is the most widespread system in research (cf. Antinoro Pizzuto et al., 2008; Garcia and Sallandre, 2013).

[5]We propose to consider the distinction found in the *Routledge Encyclopedia of Translation Studies* edited by Mona Baker:

translators deal with written language and have time to polish their work, while interpreters deal with oral language and have no time to refine their output. The implications are:

- ≪translators≫ need to be familiar with the rules of written language and be competent writers in the target language; interpreters need to master the features of oral language and be good speakers, which includes using their voice effectively and developing a "microphone personality";
- any supplementary knowledge, for example terminological or world knowledge, can be acquired *during* written translation but has to be acquired *prior to* interpreting;
- interpreters have to make decisions much faster than translators.

A subtler level of analysis of the skills required in translation and interpreting must await advances in psycholinguistics and cognitive psychology. Unlike translation, interpreting requires attention sharing and involves severe time constraints≫ (Baker, 1998, p. 41).

[6]We specify that, even where we will not use the term in its double form, we always mean "translator / interpreter".



FIGURE 2 | Our translation of "E come il vento // Odo stormir tra queste piante." ("And when I hear / the wind stir in these branches").

With the aim of investigating the work of the translator / interpreter, we propose an interdisciplinary study[7] that has as its reference frames the linguistics of sign languages, poetics and translation studies, and finally the theme of movement and scene. In the next paragraphs we will therefore present the key points of our reference background; subsequently we will converge toward an embodied approach and present our theoretical proposal associated with the practical translation of one poem.

SUBSECTIONS RELEVANT FOR THE SUBJECT

Linguistics of Sign Languages

As regards the study of sign languages, we refer to the *modèle sémiologique* (semiological model) developed by Christian Cuxac (2000) and perfected over the years by his team. This model is structured taking into account above all the centrality of iconicity in the sign languages: according to this model, the so-called *Structures de Grande Iconicité* (highly iconic structures) have the potential not only to *dire* (to say) but also to *montrer* (to show)[8]. Through iconicity, these structures allow perceptive experiences, be they real or imagined, to be transposed into linguistic expression. In this process, the central role belongs to the body and to all its components that are involved in linguistic utterance (not only the hands, but also the direction of the gaze, the facial expressions, etc.)[9]. Sallandre (2010) noted that it is possible to identify a "va-et-vient" (come and go) of iconicity, that is an alternation, often rapid, of highly iconic structures, standard signs and linguistic structures in general. In this context we will not present all the specific characteristics of sign languages in detail, but in relation to the LIS (Italian Sign Language), that is the sign language that we take into consideration here, we suggest consulting Volterra et al. (2019).

Poetics and Translation Studies

With regard to poetics and translation studies, within this work we take as a reference the "poetics of rhythm" proposed by Meschonnic (1982a). The French scholar, starting from Benveniste's reflection (1996), takes up the original notion of rhythm understood as form[10]. According to Meschonnic, rhythm is the organization of the marks that allow the creation of a specific semantics, defined as *signifiance* (significance); these marks are located at all linguistic levels (not only lexicon, but also prosody, accentuation, syntax). Rhythm is the characterizing feature of each *discours* (discourse), it represents the element that

[7]For further information on our work, cf. Raniolo (2021).

[8]In his 2000 volume, Cuxac identifies three types of *transfert*: *transfert de taille et/ou de forme*; *transfert de situation*; *transfert de personne*. Despite having different characteristics, they are all structures characterized by a high level of iconicity. Over time, further types of *transfert* have been identified (Sallandre, 2010).

[9]We refer to this model because we believe it is particularly suitable for describing sign languages, precisely because it is structured starting from iconicity and centrality of the body, both aspects that prove to be fundamental in translation.

[10]Émile Benveniste, in his 1951 essay entitled "La notion de ≪ rythme ≫ dans son expression linguistique" (republished in the 1966 work), focuses on the notion of rhythm. Having recognized that the word has been generalized (in fact it could be applied to all human activities, when their duration and succession are considered), Benveniste retraces its origins and observes its change. The scholar comes to the conclusion that the concept that today is commonly attributed to the term (that is, an ordered sequence of movements), is not the original one but is due to Plato. The word ρυθμός in the Greek world meant "form" (to be precise, it meant distinctive form, proportionate figure, arrangement), in various contexts.

gives it unity: consequently, it occupies a central place. It should also be noted that Meschonnic attaches considerable importance to subjectivity, stating that "le rythme est l'organisation du sujet comme discours dans et par son discours" (rhythm is the organization of the subject as discourse in and by his discourse, our translation) (Meschonnic, 1982a, p. 217). We could summarize Meschonnic's thought by saying that, according to the French scholar, sense lives in rhythm: this represents a real revolution in the idea of "sense," of what makes sense. The author therefore considers how the new form is created in the translation process, how the sense is re-constructed (Meschonnic, 1999).

Closely related to the concept of rhythm is the question of orality. As claimed by Meschonnic (1982a,b), the concept of orality does not coincide with that of spoken, although this idea is widespread. According to him, orality goes beyond simple opposition to writing: even in the presence of writing it is possible to identify an orality, a rhythm, which allows to make sense.

Meschonnic's thought, which we have tried to present briefly here, constitutes the presupposition from which we intend to investigate how sense is constructed, how sense is re-enunciated in another language, in this specific case in a sign language.

Movement and Scene

We have mentioned that a translation can also be seen by people who do not know sign language: actually, the translation not only is accessible to a deaf audience, but also becomes enjoyable by a non-signing hearing audience. In fact, "Living a body that acts in the world becomes an identity paradigm that unites signers and non-signers and which allows a participation that goes beyond the knowledge of sign language" (Fontana, 2016, p. 134, our translation). The key is the body that generates movement, the body that acts on the scene. For this reason, we would like to introduce some considerations concerning these issues, framing them within a reflection on performance. First of all, we can consider poetry in sign language as performance by reason of its orality. Indeed, as the well-known scholar Ruth Finnegan (1977) states, for oral civilizations, the concept of text cannot be separated from that of performance. Furthermore, the use of the body as a primary means of expression in sign languages leads to a comparison with the theater, which once again takes up the idea of performance. Anyone who is involved in translating into a sign language, for pleasure or under professional circumstances, knows well that it is necessary to "go on stage." Of course, there are cases in which we can speak of a real stage (for instance, interpreting / translating deaf actors during a theatrical performance), but leaving out the artistic contexts proper, the scene is systematically present both in interpreting and in translation, it is an integral part of it: by entering the visual field, it helps to create sense.

DISCUSSION

Toward an Embodied Perspective

Sutton-Spence and de Quadros wrote in 2014 an essay dedicated to the vision that sign language poets have of poetry, with a very eloquent title: "I am the book"[11]. Becoming what is translated: the translator / interpreter is required to have his own body become the text to be translated. In other words, his role is to "embody" the translated / interpreted content. The body plays a key role in sign language translation, for several reasons. We have already referred to the visual-gestural nature of sign languages: they are produced with the body and grasped through the sense of sight. The very first studies on sign languages have emphasized the importance of the body: even the first ever, Stokoe's (1960), had placed attention on the body within the communicative process in sign language. The studies that have followed over the years have continued to emphasize the importance of the body, in an increasingly conscious way. We could quote Paul Jouison, who speaks of "configurations corporelles" (body configurations, our translation) (Jouison, 1995, p. 146) underlining their iconic value, or even Christian Cuxac, who hypothesizes a "processus d'iconicisation de l'expérience perceptivo-pratique" (process of iconicization of the perceptual-practical experience, our translation) (Cuxac, 2000, p. 27).

Let's start from Cuxac's words concerning perceptual experience to also remember that the body represents the seat of the senses: we would like to focus on this, taking into account the "embodied" perspective.

The perspective of *embodied cognition*, to which we intend to refer, is centered on the body, on possessing a body that acts in the world. The concept of *embodiment* presupposes the link between language and the sensorimotor system, the idea that the body entering into interaction with the environment and manipulating it is at the origin of human cognition. It is interesting to consider the potential of *embodied simulation* (Gallese and Sinigaglia, 2011): thanks to mirror neurons, the activation of neural circuits correlated to actions and perceptions occurs even when these are not experienced personally, but by others.

Starting from an embodied perspective means reflecting on language considering that it is linked to the physical characteristics of the human being: for example, the mind "is conditioned by the physical dimensions of the brain, and, secondly, by the body dimension in general and by the structure and the laws of the surrounding world (for example by the force of gravity)" (Gaeta and Luraghi, 2003, p. 22, our translation). Therefore, language is not an autonomous cognitive capacity, but is part of a network of capacities: it is precisely to the embodied perspective that we owe the idea of *continuum* between action, gesture, sign and word (Volterra et al., 2019). Although the embodied dimension belongs to both sign languages and vocal languages (Blondel, 2020), embodied cognition is a very suitable approach to describe sign languages, since they are languages centered right on the body. Moreover, this approach takes into consideration the body and its senses, therefore it allows us to focus on the senses with which deaf people perceive the world, an aspect that is naturally reflected in their language.

[11]The title is based on the opinion of Paul Scott, a deaf poet who composes in BSL (British Sign Language). The essay refers to the literature originally produced in sign language, but we think that the considerations can be extended to the translation.

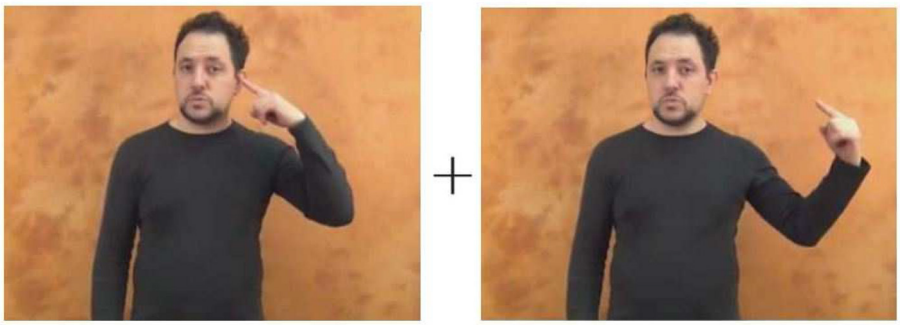


FIGURE 3 | SUONO (sound) – *Spread The Sign Dictionary, 2022*.

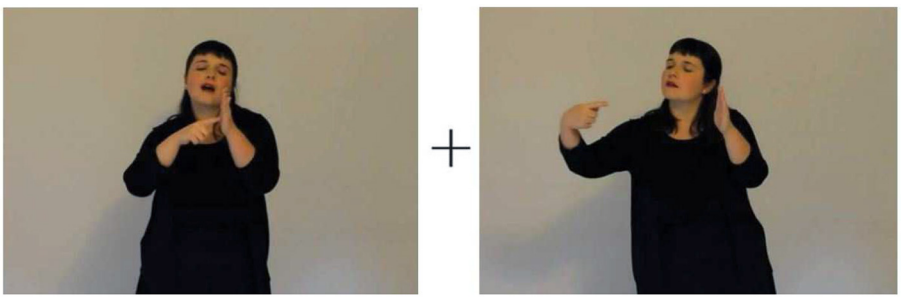


FIGURE 4 | Our translation of "e il suon di lei" ("and how it sounds").

In our opinion, considering the relationship between sensoriality and corporeality cannot ignore a philosophical perspective. According to philosophy, or to be more specific according to phenomenology, there is a distinction between *Körper* and *Leib*: the first is the anatomical body, while the second is the living body. For the purposes of our reflection, we are not interested in the body from an anatomical point of view, but rather we focus on the *Leib*, on the body that lives in the world and interacts with it, changing the world and changing itself. The embodied perspective seems to have a precursor in Maurice Merleau-Ponty, a French phenomenological philosopher. He recognizes the primacy of perception and affirms that it must be acquired, since it derives from the interaction between the organism and the surrounding environment: thanks to his own senses, the human being comes into contact with the world (Merleau-Ponty, 1945). His thought is particularly interesting because it starts from the assumption that being in the world is not separable from being flesh. The scholar also emphasizes the centrality of synaesthesia, which he believes to be systematically present in the perceptual process.

Given that different senses are involved in the translation process from a vocal language into a sign language and vice versa, we believe that synaesthesia, understood as the association of perceptions deriving from distinct senses, plays a pivotal role. Similarly to Chateauvert (2016), who in the context of sign language translation defines synaesthesia as a series of intertwined moments that aesthetically overlap, we elaborate a theoretical proposal centered precisely on the role of synaesthesia in poetic translation involving a sign language[12].

Poetic Translation: A Sensory Experience

The translation process to and from sign language is characterized by a mixture of sensory perceptions: this consideration leads us to the idea that the translation itself can be considered a synaesthetic process, built in close connection with corporeality.

Let us consider the concept of *signifiance* and the definition that Meschonnic gives to it, previously explained. In the attempt to ask ourselves how *signifiance* is re-enunciated in the passage from a vocal language to a sign language and vice versa, we notice the influence that the dialogue between the senses has. In our opinion, in this specific context *signifiance* itself has a synaesthetic nature: the sensory level, although it is not a linguistic level, affects the linguistic process and shapes it. In translation, *signifiance* is therefore reconstructed within what we can consider as a sensorial encounter: orality is redefined

[12]In this work we focus in particular on the poetic translation from vocal language into sign language, but our conclusions are reached in the light of a broader reflection that also includes the translation in the other verse. For further information, see Raniolo (2021).

and finds new lymph in a new sensorial form, the senses meet and create sense. The translation thus makes it possible to re-enunciate the rhythm itself within the framework of a different sensorial perception, giving life to what we have defined as *synesthetic construction of sense*.

Referring once again to Meschonnic (1982a), we can see that the scholar dwells on the relationship between body and language. He reflects on the presence of corporeality in different types of language and affirms that the body lives in language in relation to the role that rhythm plays in it: starting therefore from the identification of a link between bodily involvement and rhythm, he argues that poetic language is the most corporeal. About the specific case of sign languages, we would like to ask ourselves: can poetry be considered more corporeal than other uses of the language? Russo Cardona (2004) identifies a correlation between textual typology and iconicity: he believes that the iconic productive structures, characterized by "dynamic iconicity," are present mainly in poetry, while they are far less present, for example, in conferences[13]. This leads him to confirm his hypothesis concerning the presence of a relationship between "iconic stratifications" and different uses of language. Given that the iconic potential of the language is linked to the context of use, we believe that the iconic stratifications, the more or less frequent use of iconicity (related to corporeality, as argued by Jouison and Cuxac), can make it possible to identify greater or lesser bodily involvement. And it is precisely this bodily involvement that, in the manner of Meschonnic, we want to understand as rhythm, as sense.

With this in mind, poetry represents the ideal *corpus* to elaborate our reflections, since it can be considered a triumph of corporeality and iconicity. We therefore think that, in the case of poetic translation in particular, it appears necessary to give life to a *discours* constructed largely on iconic-corporeal aspects: these aspects are identifiable in the *Structures de Grande Iconicité*. Aiming at a full bodily involvement, not only it is possible to obtain a poem close in strategies to the original poetic productions in sign language, but it is also possible to give a central role to the body, which becomes the architect of the form-sense.

We would like to dwell once more on the figure of the translator / interpreter. As previously said, Meschonnic believes that subjectivity has great importance: the elements proper to the *sujet* (subject) play a key role in the organization of rhythm. In case the subject is a sign language translator / interpreter, his task is to embody the contents and create the sense starting from his own body. To fulfill his task, the translator / interpreter goes on stage, generates what we can consider a real performance. Giving considerable importance to subjectivity, and to the translator / interpreter as a *sujet*, means giving a place of honor to the translator who enters in his translation, or more generally in the scene, carrying all of himself. A theatrical self goes to the stage: the translator lives in the individual, but the translation lives in the body. When *I am the book*, to take up the title of Sutton-Spence and de Quadros (2014) previously mentioned, the awareness that, despite the central role of subjectivity, the self is not on stage as self, but as a translating body, as a body that builds the translation, is essential.

The translator / interpreter can produce his translation in recorded form or in person; in any case his physicality is included and in any case the translation is oral. We agree with Crasborn (2006), who affirms that, considering that sign languages do not have a writing system commonly used by deaf people, poems in sign language, both presented face to face and recorded, are always performances. We share the idea of a translation that privileges "the parameters of the recitability of sense, of its performativity" (Lavieri, 2016b, p. 29, our translation).

Another aspect that we should consider is that, just like performances, the translation, even if it is defined, is not fixed once and for all: since it is oral, every time it is produced, it is not the same as the previous time. Furthermore, especially in the case of translating a poem in presence, a new relationship is established each time with the audience. Regarding the relationship with the public, we would like to consider the thought of the well-known French playwright Artaud (1964)[14]: for him it was a priority that the spectator had the opportunity to 'enter the scene', thanks to an emotional sharing between the parties, a sharing through sight and hearing[15]. An intuition that, we could say today, has its foundation in mirror neurons, whose existence was not yet known at the time. Therefore, starting from the idea of a new ἐνέργεια (energy) that lives in the relationship between actor and spectator, we can say that translating into signs means creating a performance whose sense is corporeal energy. In fact, corporeal translation cannot ignore a bodily dialogue that is built with the spectator: a dialogue with an interlocutor who, whether physically present or only supposed, has a corporeality that in any case becomes presence. When we refer to the link between sense and corporeality, we think that it is appropriate to consider not single bodies, but several bodies in interrelation with each other: taking into account the thought of Artaud, we believe that we can speak of co-construction of sense.

A Practical Example of Poetic Translation

Meschonnic's wish is not to split the *théorie-pratique* union, in the awareness that one is indispensable to the other. Considering his teachings, in this paragraph we put into practice what we have expounded on a theoretical level: we translate one of the best-known poems of Italian literature, *L'Infinito* by Giacomo Leopardi (composed between 1818 and 1819).

Sempre caro mi fu quest'ermo colle,
E questa siepe, che da tanta parte
Dell'ultimo orizzonte il guardo esclude.
Ma sedendo e mirando, interminati
Spazi di là da quella, e sovrumani
Silenzi, e profondissima quiete
Io nel pensier mi fingo; ove per poco
Il cor non si spaura. E come il vento

[13]Iconic productive structures account on average for 13.5% of formal discourse (conferences), 43% of free storytelling and 53.4% of poetry [Russo Cardona, 2004].

[14]Original edition 1938.

[15]He proposed to go beyond the text, not to submit to it, but rather to subject it to a *compression énergique* (energetic compression, our translation) (Artaud, 1964, original edition 1938, p. 133).

Odo stormir tra queste piante, io quello
Infinito silenzio a questa voce
Vo comparando: e mi sovvien l'eterno,
E le morte stagioni, e la presente
E viva, e il suon di lei. Così tra questa
Immensità s'annega il pensier mio:
E il naufragar m'è dolce in questo mare[16].

We propose our translation in LIS, which is available online[17]. First of all, we note the sensory perceptions that characterize the poem: in the first part the prevailing sense is sight, the sensation of seeing, or rather of not seeing (impossibility of seeing beyond the hedge), while in the second part the auditory sensations prevail[18]. How can these sensory perceptions be translated? Let us begin our reflection by considering the double nature of infinity, which is both spatial and temporal.

As regards the time line, we would like to emphasize that in LIS temporality is expressed along the sagittal axis: the past is behind, the future is ahead. This structure, whose nature is metaphorical, cannot be considered a characteristic of sign languages in a broad sense since in other sign languages it varies [cf. Taub, 2001]. Having considered this, we have come to the hypothesis that the idea of infinity could be re-enunciated in sign language by taking up the axes by convention linked to a certain concept and going beyond them, even toward unusual axes. Consequently we have decided to create the "rhythm" of infinity (spatial infinity as much as temporal infinity) through the use of both the sagittal axis and the transverse axis (**Figure 1**).

By doing so, however, we obtained a result that is in line with what (Sutton-Spence, 2010) observes about the frequent use of the transverse axis in poetry, due to the embodied nature of sense. Sutton-Spence notes that the transverse axis is used above all to create symmetries: in our translation there are signs made on the transverse axis in a symmetrical, but also asymmetrical, way. We believe that the introduction of the transverse axis appears to have been inserted harmoniously: it is a harmony that arises precisely from a rhythm that is in line with the body, with the embodied nature of sense.

We would also like to reflect on the strategies adopted to achieve what we have defined as the synesthetic construction of sense. While sight, being an intact sense in deaf people, did not require any specific adaptation, the question of hearing is different. The part dedicated to auditory perception begins with "E come il vento / Odo stormir tra queste piante" ("And when I hear / the wind stir in these branches"): the poet's attention is attracted by the sound of the wind in the trees. We kept the idea of the wind in the trees but we transformed it into an image, a scene that the poet turns to look at (through the use of *transfert*, to use Cuxac's terminology). The combination of movement of turning and sign GUARDARE (to look) places emphasis on the permanence of visual perception: that allows to translate the conjunction E (And) found at the beginning of the line (**Figure 2**).

In the same way, when the poem mentions the sound of the present living season, with the words "e il suon di lei" ("and how it sounds"), we have used the sign SUONO (sound) with its movement that reproduces the waves but, instead of articulating it on the ear, we have articulated it on the hand. We resorted to a metaphorical strategy that exploits the variation of parameters (Sutton-Spence, 2005, **Figures 3**, **4**).

In doing so, we have kept the images and the rhythm, while letting them converge toward a sensoriality that is accessible to deaf people.

We believe that the strategies we have used also clarify what we mean by *co-construction of sense*. In person or through video, the recitation of the poem, and in particular the re-creation of the sense, can generate each time new sensations in the public: every member of the audience gives his own, personal interpretation, that enriches the sense and gives life to a co-constructed sense.

CONCLUSION

First we would like to emphasize that the analysis of translation processes clearly shows the pivotal role of the image, achieved in a particularly effective way by iconic structures with the potential of *donner à voir* (Cuxac, 2000). The realization of the image within the performative event is largely based on complex structures with a high level of iconicity, that are reproduced each time within the translation performance. Although, in the context of poetic translation, they are well-studied and predetermined, their rhythm is always new: it is a rhythm that can never be the previous one due to the oral nature of the sign languages.

The direct consequence of this centrality of the image created through the body is that the analysis of the translation processes also allows us to observe the role of the embodiment: it is precisely the body, whose relationship with the world determines the acquisition of perception (Merleau-Ponty, 1945), that plays a primary role in translation. The body constitutes the communicative channel in sign languages, but the same articulators deal with communication and daily actions (for example grasping an object). It follows that the link between language and sensorimotor system is strengthened, the language is sufficient to activate the areas that are neurologically responsible for perception and action, thus the mechanism of embodied simulation takes place (Gallese and Sinigaglia, 2011).

[16]The poem is taken from a collection dating back to about twenty years ago (Leopardi, 2001). Translation to English by Jonathan Galassi (2010): This lonely hill was always dear to me, / and this hedgerow, which cuts off the view / of so much of the last horizon. / But sitting here and gazing, I can see / beyond, in my mind's eye, unending spaces, / and superhuman silences, and depthless calm, / till what I feel / is almost fear. And when I hear / the wind stir in these branches, I begin / comparing that endless stillness with this noise: / and the eternal comes to mind, / and the dead seasons, and the present / living one, and how it sounds. / So my mind sinks in this immensity: / and foundering is sweet in such a sea.

[17]The translation is available on the website https://www.raniolotraduzionils.it/ The password is TRAD LS Raniolo, E., Traduzioni in LIS e LSF, accessed March 11, 2022 (Raniolo, 2022).

[18]Our choice of a poem based on perceptions allows us to give full realization to our reflections; however, in our opinion, they would still be valid even in the case of a poem of a different nature, but perhaps to a lesser extent (an aspect that could be interesting to investigate).

Our study allows us to observe that the centrality of the body in translation processes determines, as a direct consequence, the centrality of the senses. Translating poetry from a vocal language to a sign language (and vice versa) means starting from a *discours* thought to be received through a certain sensory modality and obtaining a *discours* thought to be perceived through another sensory modality. In our opinion, this passage generates a very specific encounter between the senses: the senses meet, the text has the potential to become such as to be 'heard' through sight, or to be 'seen' through hearing. Modifying the perceptual experience constitutes the strategy for constructing reflections based on the perceptual systems and the mechanisms of *embodied cognition*, with the aim of exploring the paths of sensoriality and observing how the senses cooperate, intertwine with each other, at the same time opposing and binding.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Iconicity as Multimodal, Polysemiotic, and Plurifunctional

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Investigations of iconicity in language, whereby interactants coordinate meaningful bodily actions to create resemblances, are prevalent across the human communication sciences. However, when it comes to analysing and comparing iconicity across different interactions (e.g., deaf, deafblind, hearing) and modes of communication (e.g., manual signs, speech, writing), it is not always clear we are looking at the same thing. For example, tokens of spoken ideophones and manual depicting actions may both be analysed as iconic forms. Yet spoken ideophones may signal depictive and descriptive qualities via speech, while manual actions may signal depictive, descriptive, and indexical qualities via the shape, movement, and placement of the hands in space. Furthermore, each may co-occur with other semiotics articulated with the face, hands, and body within composite utterances. The paradigm of iconicity as a single property is too broad and coarse for comparative semiotics, as important details necessary for understanding the range of human communicative potentialities may be masked. Here, we draw on semiotic approaches to language and communication, including the model of language as signalled via describing, indicating and/or depicting and the notion of non-referential indexicality, to illustrate the multidimensionality of iconicity in co-present interactions. This builds on our earlier proposal for analysing how different methods of semiotic signalling are combined in multimodal language use. We discuss some implications for the language and communication sciences and explain how this approach may inform a theory of biosemiotics.

Keywords: iconicity, indexicality, gesture, semiotics, sign language, typology

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INTRODUCTION

Iconicity is generally defined as 'fundamentally about resemblance', whereby 'just like paintings can resemble what they depict, so linguistic signs can look and sound like what they mean in various ways and to varying degrees' (Dingemanse et al., 2020: 2). We do not have to look far to find people making use of iconicity during their everyday interactions. For example, a hearing Siwu speaker produces the spoken ideophone *shû shû* while moving his hands upwards quickly to show that flames will flare upwards quickly after he sets two piles of gunpowder on fire (Dingemanse, 2013: 158). A hearing Ngaanyatjarra speaker using *mara yurriku* ('sign language' or 'signing', *lit.* 'moving the hands') traces the orthographic letters *AS* in the air while speaking to refer to the town of Alice Springs (Ellis et al., 2019: 105). A deaf signer of Norwegian Sign Language places her palms together on one side of her face while tilting her head and closing her eyes to show

a boy falling asleep for the night (Ferrara and Halvorsen, 2017: 385). While conversing with his deafblind aunt, a deafblind signer of Bay Islands Sign Language guides her hands to his face, so that she can feel him produce the mimetic head movement and facial mannerism that has long been the name sign of her youngest brother (Ali, 2020). Even without moving their hands or body, hearing English speakers make frequent use of iconicity, as evidenced by the prevalence of words such as *sniff, murky,* and *buzzing*, each selectively profiling the different sensorial qualities of various perceptual experiences (Winter et al., 2017).

Researchers from a range of disciplines have collectively demonstrated that iconicity is fundamental to human communication and language use (Peirce, 1931-1958; Jakobson, 1965; see Mandel, 1977; Haiman, 1980; Parmentier, 1994; Wilcox, 2004; Cuxac and Sallandre, 2007; Perniss et al., 2010 and many others). However, defining and operationalising construals of iconicity across different interactions (e.g., deaf, deafblind, hearing), modes of communication (e.g., manual signs, speech, writing), and languages (e.g., English, Japanese, Auslan) remain a slippery matter (Perniss et al., 2020). Researchers using experimental approaches have primarily viewed iconicity as perceptual resemblances construed in at least three different ways: (i) as a discrete property that is present or absent; (ii) as semiotic relations that come in kinds; and (iii) as scalar substance that comes in degrees (Dingemanse et al., 2020). As Dingemanse et al. (2020) explain, each construal helps to reveal different aspects of how perceptual resemblances manifest in language use and interaction, yet each one has limitations.

For example, when iconicity is operationalised as a discrete, categorical property (i.e., present or absent) or as a binary (e.g., strong vs. weak, iconic vs. arbitrary), it often falls apart when applied to real life language use in situated contexts (Blasi et al., 2016). When more fine-grained analyses of the dynamic, semiotic relations occurring within situated contexts are undertaken, it is often not clear if the resulting descriptive complexity is useful for understanding how people use or learn language in a principled way (Esposito, 1979). When iconicity is operationalised as a scalar substance perceived in varying degrees, results suggest that perceived iconicity is best explained by people's subjective experiences with their languages and modes of communication, rather than any objectively defined quality such as transparency, thus problematising the comparison of iconicity ratings elicited from signers and nonsigners (Occhino et al., 2017). There is not yet a unified construal of iconicity that addresses these limitations.

The situation is complicated by various hegemonic biases that have contributed to the marginalisation or pathologisation of different language and communication phenomena across the language sciences (Sicoli, 2014; Dingemanse, 2017; see also Goodwin, 1995). This marginalisation includes aspects of how iconicity is created and used during interactions between people who are deaf, deafblind, and/or disabled; between people who have sensorial asymmetries; and/or between people who have simply not been the focus of Western science in general (see Kusters et al., 2017; Di Paolo et al., 2018; Braithwaite, 2020). It also includes aspects of iconicity beyond material perceptual resemblances, such as diagrammatic iconicity and metaphorical iconicity (Haiman, 1985; Hiraga, 1994; Müller and Cienki, 2008). Yet if we are to strive for a comprehensive understanding of language and communication, it is necessary to remedy these biases and seek continuity across the various manifestations of iconicity evidenced in our interactions, as well as our methods for investigating them (Perniss and Vigliocco, 2014; Dingemanse et al., 2020). Only then can we do justice to human social complexity in our efforts to understand how languaging works and why it differs.

In the following sections, we outline two main issues with how iconicity has been defined and operationalised in the language and communication sciences. The first issue relates to the prominence of *form* in analyses of iconicity, and how iconicity is typically framed in terms of bounded language modalities ('spoken language', 'signed language', 'verbal modality', 'gestural modality'), modes of communication ('speech', 'sign', 'gesture') and/or small, single units ('words', 'signs'). The second issue relates to the prominence of *perceptual resemblances* in analyses of iconicity, without concurrently considering other kinds of resemblances, such as resemblances of *relation* and *association*. We offer some correctives by drawing on semiotic approaches to language and communication, especially the model of language use as signalled through describing, indicating, and/or depicting (Clark, 1996). Our aim is to illuminate the multidimensionality of iconicity in co-present interactions, thereby encouraging more unified progress in our understanding of how it works and why we use it. This builds on our earlier proposal for analysing how these different methods of signalling are combined in multimodal language use (Ferrara and Hodge, 2018).

We then apply this framework to a range of interactions documented in the literature to interrogate more closely how and why different aspects of these interactions look, feel, sound, or otherwise resemble what they mean. We consider how iconicity is integrated with other semiotics and bodily articulations within composite utterances (Enfield, 2009). We also consider how iconicity is used in terms of both referential and non-referential functions (Silverstein, 1976). In this way, we outline a semiotic construal of iconicity that can be operationalised across different interactions, modes of communication, and units of analysis. This construal aligns with others who broadly recognise iconicity as multimodal, polysemiotic, and plurifunctional (e.g., Nöth, 1999; Kendon, 2004; Mittelberg and Waugh, 2009; Green, 2014; Perniss and Vigliocco, 2014; Kok et al., 2016; Wilcox and Occhino, 2016; Iriskhanova and Cienki, 2018; Puupponen, 2019; Bressem, 2020; Murgiano et al., 2020). Finally, we discuss some implications for the language and communication sciences, and explain how this approach guides us towards a theory of biosemiotics.

ISSUES WITH DEFINING AND OPERATIONALISING ICONICITY

The Prominence of Form in Analysing Iconicity

There are two main issues with how iconicity has been defined and operationalised. The first issue is the prominence of *form* in driving investigations of iconicity, which results from the

traditional paradigm to 'focus on the means at the expense of the content' (Wacewicz and Żywiczyński, 2015: 37). Most studies have focused on iconic forms relating to specific modes of communication and/or single units. For example, spoken language researchers have investigated lexical spoken words such as ideophones, including onomatopoeia, and other types of sound symbolism, such as modifications to word length signifying smallness or lightness (e.g., Diffloth, 1994; Nuckolls, 1999; Dingemanse, 2012). Signed language researchers have analysed the iconic aspects of conventionalised manual signs, which are usually considered the closest equivalent to lexical words in spoken and written languages (e.g., DeMatteo, 1977; Taub, 2001; Padden et al., 2013). Others have analysed the iconicity of aspectual modifications, verb agreement, constructions and the meaningful use of space more generally (e.g., Engberg-Pedersen, 1993; Emmorey et al., 2000; Gray, 2013; Hou, 2018).

There is an extensive literature on the iconic dimensions of manual gestures with and without speech (e.g., McNeill, 1985; Goldin-Meadow, 2003; Kendon, 2004; Streeck, 2008; Müller, 2014). The close relationship between iconic manual gestures and spoken forms has been emphasised with respect to synchronous timing, semantic categories, and how language and speech influence the use of manual gestures and vice versa (e.g., Kita and Özyürek, 2007; Özyürek et al., 2008). Signed language researchers have also investigated iconicity in less conventionalized forms, such as tokens of partly or fully improvised manual signs that depict the shape and/or movement of an object ('classifier signs', 'depicting signs') and visible bodily enactments ('personal transfers', 'constructed action', 'quotation', 'role shift'; e.g., Cuxac, 1999; Liddell, 2003; Cormier et al., 2015; Davidson, 2015).

As scientific understandings of iconicity across languages and modalities have developed, so has interest in cross-linguistic and cross-modal comparisons. Specific iconic forms, such as spoken ideophones, have been compared across languages (e.g., Kilian-Hatz, 2001; Dingemanse, 2012). Various iconic forms have also been compared across languages and modalities, including comparisons of the manual depicting actions used by signers and speakers of different languages (e.g., Schembri et al., 2005; Cormier et al., 2012) and comparisons of lexical iconicity across signed and spoken languages (e.g., Hwang et al., 2016; Perlman et al., 2018). Researchers have also investigated how iconicity manifests more generally in the lexicon of spoken and signed languages (e.g., Waugh, 1994; Padden et al., 2013). Others have proposed hypotheses for cross-linguistic, cross-modal comparison of phenomena such as aspectual modifications, depicting constructions, ideophones, constructed actions, and mouth actions (e.g., Bergman and Dahl, 1994; Ajello et al., 2001; Pizzuto et al., 2008; Padden et al., 2013; Sallandre et al., 2016; Ferrara and Halvorsen, 2017; Lu and Goldin-Meadow, 2018; Akita, 2019).

A key point of interest for many is the suggestion that the visual and spatial affordances of signed languages facilitate different and potentially greater use of iconicity compared to spoken languages (see Perlman, 2017, for an overview). This idea stems from the observed homeomorphism (i.e., topological isomorphism) between the multidimensional world around us and the multidimensional nature of signed interactions, which has resulted in strong claims about signed languages being 'more iconic' than spoken languages (e.g., Klima and Bellugi, 1979; Taub, 2001; Pietrandrea, 2002). Yet empirical investigations of iconicity in spoken, signed, and even nonhuman primate communication have shown that iconicity is abundant, motivated, and systematic, regardless of whether it is spoken, signed, or vocalised (see Perniss et al., 2010; Dingemanse et al., 2015; Perlman, 2017). Instead, it may be that different modes of communication are shaped by different affordances, so that iconicity manifests across interactions and languages in patterned ways (Perniss and Vigliocco, 2014; Dingemanse, 2019; see also Caselli et al., 2022). For example, manual actions may be best suited for depicting what something looks or feels like, or how it is handled, whereas vocalisations may be best suited for depicting how things sound or smell (see e.g., Padden et al., 2013; Hou, 2018; Majid, 2020; Keränen, 2021).

A further key point is the suggestion that iconicity motivates grammar and is therefore an explanatory principle for the emergence of language (see Haiman, 2008; Meir et al., 2013). However, when different types of iconicity are teased apart and investigated, it is sometimes found to be not the only motivating factor, with some patterns best explained by other principles such as frequency of use (see Haspelmath, 2008). It is also not always clear that like is being compared with like. For example, Perlman et al. (2018) compared iconicity ratings of various lexical forms evidenced in American Sign Language (ASL), British Sign Language (BSL), English, and Spanish. They used a broad and impressive range of semantic categories in their analysis, including a category 'other grammatical words', such as the second person singular pronoun form used in each language (PT:PRO2SG,[1] *you* and *tú*). This category in ASL and BSL was rated significantly more iconic than for English and Spanish (see Perlman et al., 2018: 11). However, these forms are primarily indexical, so it was indexicality that was tested across these forms, not iconicity. Furthermore, English and Spanish speakers also often use visible finger-pointing actions in conjunction with spoken indexical forms such as *you* or *tú*, and ASL and BSL signers often use such pointing forms in conjunction with mouthings of forms such as *you*. Thus, while it is defensible that 'iconicity ratings really do measure iconicity' (Winter and Perlman, 2021: 8), this example demonstrates that like is not always being compared with like during cross-linguistic and cross-modal comparisons, and that there is a risk that indexicality is conflated with iconicity. We propose that deeper interrogation of iconicity—as an interpretation, an effect and an explanatory principle—is warranted.

The Prominence of Iconicity as Perceptual Resemblances

The second issue with how iconicity has been defined and operationalised relates to how iconicity as material *perceptual*

[1]https://bslsignbank.ucl.ac.uk/dictionary/words/you-2.html

resemblances has been prioritised, without also considering resemblances of *relation* and/or *association*. For example, Perniss and Vigliocco (2014: 2) define iconicity as 'any resemblance between certain properties of linguistic/communicative form and certain sensori-motor and/or affective properties of corresponding referents'. However, semiotician Charles S. Peirce (1839–1914) differentiated at least three dimensions of iconicity: (1) imagistic iconicity; (2) diagrammatic iconicity; and (3) metaphoric iconicity (CP 2.277; see also Hiraga, 1994; Nöth, 1999). The resemblances provoked through these three types of iconicity are often drawn from different sources, and they are not mutually exclusive. Imagistic iconicity is resemblance in quality, while diagrammatic iconicity is resemblance in relations or structure, and metaphoric iconicity is resemblance by association (Hiraga, 1994; Radwańska-Williams, 1994). The next paragraphs provide examples of these three types of iconicity as defined here.

Imagistic iconicity is about how given forms look, sound, feel, or otherwise materially and selectively resemble what they mean. For example, the first photographic self-portrait ever taken (c.1839) renders the man who was Robert Cornelius into a quarter plate daguerreotype (Carbon, 2017); the spoken Japanese ideophone *don don* echoes a loud drumming or thumping sound (Kakehi et al., 2011); and the manual ASL (American Sign Language) sign TREE[2] visibly depicts the trunk and branches of a living tree (Klima and Bellugi, 1979). Examples such as *don don* and TREE align closely with the definition of linguistic iconicity offered by Perniss and Vigliocco (2014) and widely adopted by others, but there are still at least two other types of iconicity that must be considered.

Diagrammatic iconicity is about how the systematic arrangement of different forms somehow mirrors the relationship between the things they reference. For example, the famous map of the London Underground mirrors the relations between different tube lines and stops along each line (Atã et al., 2014); the sequence of conjugated verbs in the phrase *veni, vidi, vici* attributed to Julius Caesar mirrors the order in which these events occurred (Jakobson, 1965); and the spatially motivated Auslan utterance POLICE CATCH THIEF mirrors both the spatial and agentive relations between policeman and thief (Johnston, 1996: 72). Diagrams do not perceptually resemble their object; they are better understood as a generality or schema (Stjernfelt, 2019). As such, diagrammatic iconicity manifests through the relations inferred by intentionally combining multiple forms, referents, and/or units.

Metaphoric iconicity, which Peirce mentions only briefly in his work, represents 'a parallelism in something else' and instantiates a triadic relationship between a sign, an object, and that 'something else' (Hiraga, 1994: 7). This relationship is 'beheld as an image in the mind's eye' (Radwańska-Williams, 1994: 23). In other words, metaphor is what happens when we express one idea, experience, or semantic domain in terms of another (see Lakoff and Johnson, 1980). Metaphors often manifest both imagistic and diagrammatic iconicity. For example, the oil painting *Judith Slaying Holofernes* (c.1620) resembles both the heroism of the biblical Judith slaying her enemy Holofernes, and the artist Artemisia Gentileschi avenging her rapist Agostino Tassi (Gotthardt, 2018); the ASL signs ANALYSE,[3] SURFACE,[4] and DEEP[5] all draw on the conceptual metaphor ANALYSIS IS DIGGING, relating depth of knowledge with physically digging into the ground to reveal objects (Taub, 2001); and the English expression *'my love is a rose'* signifies its object (*my love*) via a parallelism with something else (*a rose*; Hiraga, 1994).

While imagistic iconicity often manifests in single forms (e.g., words, signs), diagrammatic and metaphorical iconicity typically require larger sequences or communicative moves for their intended interpretation (e.g., clauses, composite utterances). In spoken language interactions at least, diagrammatic iconicity often relies on relationships between single forms composed within constructions, and metaphorical iconicity often relies on multi-form utterances (see, e.g., Hiraga, 1994, for a discussion of grammatical and conventional metaphor). Of course, we now accept that metaphorical iconicity in signed languages and co-speech gestures may be expressed in both single and multi-form constructions (Taub, 2001; Mittelberg, 2008). However, the heavy focus on analysing single forms or units may partially account for the inattention to diagrammatic and metaphoric iconicity during investigations of imagistic iconicity.

Imperatives for Defining and Operationalising Iconicity

Regardless how iconicity is defined and operationalised, one imperative is to recognise the semiotic diversity of human languaging by considering the range of bodily actions that people intentionally and jointly coordinate during their interactions, no matter how conventionalised these actions are or how they are articulated (Goodwin, 1986; Bavelas, 1990; Johnston, 1996; Kendon, 2004). Another is to recognise the multilingual and multimodal repertoires that different people and communities develop and draw upon in different contexts and for different (socio)linguistic and cultural reasons (Silverstein, 1976; Halliday and Hasan, 1989; Busch, 2012; Kusters et al., 2017). This entails moving beyond concepts of languages as bounded modalities to concepts of languaging as making use of the semiotic repertoires available within specific interactions and spatiotemporal contexts (see Kusters et al., 2017).

It is the semiotic intent which at least partly triggers how an utterance manifests (see Cuxac and Sallandre, 2007). As the examples described above demonstrate: if it is intended as meaningful within an interaction, it must be considered. The conceptual tools used for such investigations must also be 'modality-agnostic' (Dingemanse, 2019: 25). This is the aim of comparative semiotics, whereby various aspects of language and communication are compared across interactions, modes of communication, and languages (Kendon, 2008, 2014). In doing so, we can move beyond essentialist dualisms of 'signed vs. spoken languages', 'aural-oral vs. visual-gestural modalities',

[2]https://aslsignbank.haskins.yale.edu/dictionary/gloss/342.html

[3]https://aslsignbank.haskins.yale.edu/dictionary/gloss/812.html

[4]https://aslsignbank.haskins.yale.edu/dictionary/gloss/1148.html

[5]https://aslsignbank.haskins.yale.edu/dictionary/gloss/1237.html

'iconicity vs. arbitrariness', and 'convention vs. improvisation' to build a richer understanding of all our commonalities and differences, including how and why these emerge. In the next section, we draw on the model of language use as signalled via describing, indicating, and/or depicting (Clark, 1996) to build on these imperatives for a modality-agnostic, comparative semiotics of iconicity.

LANGUAGE USE AS SIGNALLED VIA DESCRIBING, INDICATING, AND DEPICTING

Making Language Theory More Inclusive

In Ferrara and Hodge (2018), we argued that a theory of language must account for the wide range of communicative practices used across the world, beyond speaking and writing. In order to make language theory more inclusive, we expanded on the proposal by Clark (1996) that language use is actioned via three methods of signalling, which he termed *describing-as*, *indicating*, and *demonstration*. This builds on Peirce's second trichotomy (*symbols*, *indices*, and *icons*), which was first applied to linguistics by Jakobson in his appeal for linguists to consider more the dynamic nature of signs (broadly defined) and the many relations between them (Jakobson, 1965; see Nöth, 1999). We reframed these three methods as *describing*, *indicating*, and *depicting* to correspond with more recent analyses of signed and spoken language interactions (e.g., Liddell, 2003; Dingemanse, 2013; Clark, 2016).

The central idea is that during our interactions, we use these three methods of signalling in varying degrees to create words, signs, grammatical constructions, composite utterances, and so on. Our communicative moves, such as composite utterances, involve combining different forms created with these three methods of signalling (Clark, 1996; see also Johnston, 2013; Puupponen, 2019; Cooperrider et al., 2021; Capirci et al., 2022). This approach aligns closely with other approaches developed through the analysis of signed language use, such as the Semiological Approach and Cognitive Linguistics frameworks, and comparative semiotics more generally (e.g., Cuxac, 1999; Cuxac and Sallandre, 2007; Ferrara, 2012; Wilcox and Occhino, 2016; Jantunen, 2017; see Garcia and Sallandre, 2020 and Capirci et al., 2022, for overviews). The three methods of signalling are summarised below in the rearranged order of *indicating, depicting*, and *describing* to more closely reflect the complex ontogeny of human communication (see Bruner, 1983; Tomasello, 1995; Diessel, 2006).

Signalling by Indicating

Indicating refers to how people index and anchor communicative intent to a particular time and place. In Peircean terms, it is the method of signalling with indices. As such, indicating depends on grounded contexts for accurate interpretation. Indicating combines conventional and non-conventional properties, and primarily functions to focus another's attention on specific referents in the discourse and/or situated context. Token finger-pointing actions and spoken indexical symbols such as English *this* or *she* are examples of indicating: the form is conventionalised, but accurate interpretation depends on recognising which referent one's attention is being anchored to. As these tokens are conventionalised, they also describe (see the section Signalling by Describing). Clark (2003) further differentiated indicating as *directing-to*, which involves directing attention to specific referents, and *placing-for*, which involves placing objects meaningfully within an interactant's field of attention. For example, when a person extends their arm to direct attention to their own car among many others in the car park, they are indicating by *directing-to*. When a person intentionally places a card on a table during a card game, they are indicating by *placing-for*. Thus, *placing-for* can be continuous and always involves an element of *directing-to*, whereas *directing-to* is transitory and does not necessarily involve *placing-for*. Both can manifest diagrammatic iconicity by creating relations between different referents (see also Wilcox and Occhino, 2016). Signed interactions often incorporate both kinds of indicating through visible or tactile pointing, tracing, and/or placement of signs (Edwards, 2015; Wilcox and Occhino, 2016; Martínez and Wilcox, 2019; Beukeleers, 2020).

Signalling by Depicting

Depicting refers to how people use resemblances of quality, relation, and/or association to show meaning. In Peircean terms, it is the method of signalling with icons. Most of the literature on depicting has focused on the use of imagistic iconicity to demonstrate what something looks, sounds, feels, smells or tastes like, so that we 'imagine what it is like to see the thing depicted' (Dingemanse, 2015: 950). Tokens of spoken ideophones, representational co-speech gestures, and bodily enactments that reconstruct what someone did or said are all examples of depicting in spoken language interactions (e.g., Kunene, 2001; Heath, 2002; Park, 2009). These forms can vary in degree of conventionalisation and/or their use of indicating by *directing-to* and *placing-for*. As such, they can be understood as compositions of depicting, describing, and/or indicating.

For example, Clark (2016) outlines a detailed typology of depicting in communication, focusing on how depicting can be signalled within speech utterances that also describe (see also Hsu et al., 2021). Among signed language researchers, there has been much discussion about depicting via iconic lexical signs (e.g., Frishberg, 1975; Mandel, 1977; Ferrara and Halvorsen, 2017; Lepic and Padden, 2017), partly conventionalised depicting signs (e.g., Supalla, 1982; Cuxac, 1999; Liddell, 2003) and bodily re-enactments of actions and utterances (e.g., Metzger, 1995; Cuxac, 1999; Cormier et al., 2015; Sallandre et al., 2016; Jantunen, 2017). These often also involve indicating and/or describing.

As explained above, the concept of depicting has typically been defined as manifesting imagistic iconicity. However, if we consider depicting more broadly as the creation of resemblances, we must also include diagrammatic and metaphorical iconicity in our definition. For example, some spoken ideophones exhibit 'quantity iconicity' in addition to imagistic iconicity, so that more form equates to more meaning (Hiraga, 1994; Bressem, 2020; although *cf.* Haspelmath, 2008, who argues that frequency of use is the only explanation necessary for quantity iconicity). Some co-speech gestures exhibit metaphorical iconicity, such as

when a cupped hand refers to an abstract entity (Mittelberg, 2008; Iriskhanova and Cienki, 2018). An instantiation of quantity iconicity, such as the Auslan sign GIVE[6] meaningfully directed to a referent located in space and produced with multiple iterations to signal plurality, can be understood as concurrently manifesting imagistic and diagrammatic iconicity, while a CUPPED HAND gesture manifests imagistic and metaphorical iconicity.

The definition of depicting can therefore be recalibrated to more broadly encompass imagistic, diagrammatic, and/or metaphorical iconicity. This enables us to mitigate the hyper-focus on imagistic iconicity, while also respecting the meaning-making that emerges through other kinds of iconicity (see the section Imperatives for Defining and Operationalising Iconicity). Thus, diagrammatic iconicity, which includes relational resemblances such as temporally isomorphic word order patterns and referential use of the signing space, and metaphoric iconicity, which can be identified in the single form of some signs and co-speech gestures as well as in more complex constructions, are analysed as depicting. We are then forced to consider more deeply how iconicity manifests within and across composite utterances, concretely through to schematically, and through different compositions of signalling in varying degrees and complexities.

Signalling by Describing

Describing refers to how people use agreed-upon forms to prompt more contingently stable meanings. In Peircean terms, it is the method of signalling with symbols. Describing is primarily interpreted and understood through conventions across communities of use. For example, the words *jour* and *nuit* are two examples of conventionalised symbols used by French speakers to refer to what English speakers know as *day* and *night* (Jakobson, 1965). The emblematic manual gestures MANO A BORSA ('purse hand') and MANI GIUNTE ('praying hands') used in Southern Italy to either express disbelief or make an entreaty are acts of describing, as are the conventionalised rising intonation contours that English speakers use to signal they are asking a question (Bolinger, 1983; Kendon, 1995). There are also many other regularities of language use that conventionalise and may therefore describe, such as specific word order patterns for disambiguating who did what to whom, and the agentive case marking patterns of Tibeto-Burman languages used to disambiguate the agent from other referents (Silverstein, 1976; Lapolla, 1995). Conventionalised symbols used to solve problems of understanding, such as the many forms of *huh?* that have evolved to initiate conversational repair, also describe (Schegloff et al., 1977; Dingemanse et al., 2013).

Describing also incorporates what de Saussure and others have observed as 'arbitrary' forms without any obviously motivated links between the given forms and their intended meanings. Yet it is important to recognise that arbitrariness is not an inherent or defining property of describing (*cf.* Hockett, 1960). Rather, arbitrariness is a consequence of our aptitude for abstracting *x* from multiple instantiations *i, ii, and iii*, so that subsequent instantiations are understood as *x* even when decontextualised (see Parmentier, 1994; Bybee, 2007; Cuxac and Sallandre, 2007).

[6]https://auslan.org.au/dictionary/words/give-1.html

The ability to create and interpret symbols, and therefore to signal by describing, depends on an interpretant first experiencing a triadic relation between themself, the referent and its associated form (CP 2.298; see also Radwańska-Williams, 1994; Mittelberg, 2019). It is through conventionalisation that descriptions can be arbitrary and discrete (Dingemanse, 2015). Thus, strategies for describing tend to evolve comparably late in the ontogeny of human semiosis, occurring only after one experiences such triadic relations in the first instance—relations that are typically initiated and interpreted through acts of indicating and/or depicting, but also scaffolded by the development of turn-taking and repair practices (see Kelly, 2006; Clark, 2020). As Peirce noted, 'Symbols grow. They come into being by development out of other signs, particularly from icons, or from mixed signs partaking of the nature of icons and symbols' (CP 2.302). For example, some lexical signs can be analysed as both icons and symbols, and sometimes also indices (see the section Iconicity as Signalled by Depicting, Indicating, and/or Describing).

Signalling by Indicating, Depicting, and Describing

These three methods of signalling—indicating, depicting, and/or describing—facilitate potentially infinite possibilities for meaning-making and building shared understanding through interaction. The examples provided in the previous sections illustrate the importance of recognising that each method is typically used in combination with other methods to create composite signals. As Peirce observed, 'a single sign may have iconic, indexical, and symbolic properties' (CP 4.447). As we will show in the section 'Comparing Iconicity Across Interactions', it is rare to observe a languaging form resulting from 'pure' indicating, 'pure' depicting, or 'pure' describing (Ferrara and Hodge, 2018; see also Capirci et al., 2022). For example, finger-pointing actions used to direct attention to real or imagined referents are widely regarded as the paragon of indicating in co-present communication (Tomasello, 2003; Cooperrider et al., 2014). Yet while these actions primarily indicate, they also describe, because the form of indicating may be both culturally and semantically specific (Wilkins, 2003; see also Johnston, 2013). It is simply that in cases of finger-pointing to indicate, the indexical qualities of the pointing actions are more prominent than other co-existing symbolic qualities (see also Johnston and Schembri, 1999; Cooperrider et al., 2021).

This principle of polysemiosis is often overlooked, yet it has significant implications for how iconicity is defined and operationalised across interactions, modes of communication, and languages.[7] As Jakobson recognised

[7]Note that others use the term *polysemiosis* to refer to combinations of different articulations or forms of communication, such as how pantomime might involve combinations of bodily gestures, vocalisations and facial expressions (e.g., Zlatev et al., 2020). This is fundamentally different to the definition of *polysemiosis* used here. Indeed, Zlatev and colleagues' definition is perhaps closer to our use of the term *multimodal*. Our aim here is to address issues with the prominence of form in studies of iconicity (see the section The Prominence of Form in Analysing Iconicity) and to encourage identification of similarities across human and nonhuman communication, not just differences (see the section Discussion).

early on, 'the iconic and indexical constituents of verbal symbols have too often remained underestimated or even disregarded; on the other hand, the predominantly symbolic character of language and its subsequent cardinal difference from the other, chiefly indexical or iconic, sets of signs likewise await due consideration in modern linguistic methodology' (Jakobson, 1965: 36). Indeed, Peirce concluded that 'the most perfect of signs are those in which the iconic, indicative, and symbolic characters are blended as equally as possible' (CP 4.448). Regardless which framework is used, when we talk about iconicity in language and communication, we are not just talking about depicting; we are talking about depicting, indicating, and/or describing combined in different ways. To emphasise iconicity as involving depicting alone, while ignoring any indicating and/or describing signals, is to reinforce a category error that has significant implications for how we investigate and compare iconicity across interactions.

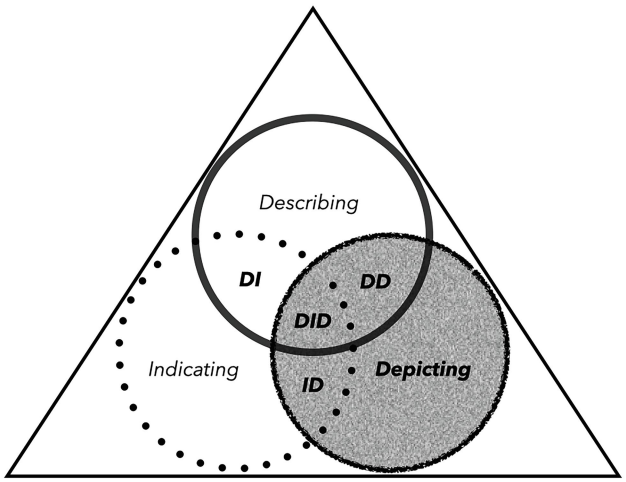


FIGURE 1 | Iconicity (shaded grey) as depicting, indicating, and/or describing.

ICONICITY AS SIGNALLED BY DEPICTING, INDICATING, AND/OR DESCRIBING

Recognising Iconicity as Multimodal and Polysemiotic

So far we have considered how iconicity is multimodal and polysemiotic. In this section, we consider how these two dimensions of iconicity may be reconceptualised in language theory and operationalised in analytical practice. We want to demonstrate that iconicity minimally involves depicting, but signalling solely by depicting is rare. Iconicity usually also involves indicating and/or describing, and often with more than one bodily articulator and/or situated semiotic resource, such as a shop counter. **Figure 1** illustrates the three methods of signalling as circles enclosed within a Peircean triangle. These circles do not represent bounded semiotic categories; they are intended to conceptually represent the potentialities of iconicity in terms of signalling through depicting, indicating, and/or describing. It is the triangle itself that can potentially represent a token form or aspects of an utterance (see also Puupponen, 2019; Capirci et al., 2022). In this way, iconicity can be reconceptualised as anything falling into the shaded grey areas. At least four polysemiotic manifestations of iconicity are possible: (i) depicting and indicating; (ii) depicting and describing; (iii) depicting, indicating, and describing; and (iv) depicting alone.

We now revisit examples of iconicity evidenced in a range of interactions and utterances documented in the literature, and consider how this reconceptualisation of iconicity can be operationalised in linguistic analysis. Some of the examples were originally analysed as iconic forms, while others were specifically chosen to redress bias in the field and further illustrate the framework proposed here. In each example, we consider how iconicity is signalled via depicting, indicating, and/or describing during the utterance, and whether these resemblances are imagistic, diagrammatic, and/or metaphorical. This approach offers liberation from the issues described in the sections 'The Prominence of Form in Analysing Iconicity' and 'The Prominence of Iconicity as Perceptual Resemblances', while upholding the imperatives outlined in the section 'Imperatives for Defining and Operationalising Iconicity.' It also highlights the composite multimodal and polysemiotic signalling within utterances as continuous and contingent processes, in addition to interpreting the token forms in each utterance as bounded, meaningful units.

In each example, we ask two questions: (i) how does the interaction signal depicting, indicating, and/or describing? (ii) how does the interaction manifest imagistic, diagrammatic, and/or metaphorical iconicity? Each figure is annotated with dotted lines (indicating), soft lines (depicting), and/or sharp lines (describing). These lines are intended to capture the prominence and co-occurrence of indicating, depicting and/or describing as the utterance unfolds in real time.[8] The number of lines represents the number of bodily articulators involved in signalling each method at a given moment, which are also labelled on the right hand side of the figure. The imagistic resemblances within each example are enclosed within a green dotted box. The diagrammatic resemblances are enclosed within a green dashed box. Metaphoric resemblances are enclosed within a green lined box. Our analysis demonstrates that while these interactions each manifest iconicity, each manifestation is iconic in its own way.

[8]It would be somewhat misleading to suggest that each mode of signalling is either 'present' or 'absent', because in Peircean terms, all three modes are always present in more or less degrees. In this sense, each instantiated token is also an icon of any previous instantiations. For example, a token finger-pointing action that indexes a location is also an icon of the type 'indexical actions pointing to a location'. We do not address this level of analysis in the current paper, but it is something to keep in mind.

Analysing Iconicity in Interactions

Dingemanse (2013: 158) analysed how hearing Siwu speakers coordinate spoken ideophones with manual depicting actions, documenting an interaction where one speaker produced the spoken ideophone *shû shû* while moving his hands upwards quickly to show how flames will flare upwards after he sets two piles of gunpowder on fire. In this instance, the speaker uses a speech and manual action ensemble to depict, indicate, and describe the look and sound of the flames (**Figure 2**, Image B). Three bodily articulations (speech and two hands) depict the audible and visible qualities of flames quickly flaring upwards. The sound quality and syllabic repetition of the spoken form *shû shû* depicts the audible qualities of these flames, while the upturned handshape, upward direction and repeated movement of the two-handed manual action depict the visible qualities of these flames. The initially low placement of the man's two hands indicates the gunpowder by *placing-for*, while the upward movement of the hands indicates by *directing-to*. The spoken form *shû shû* is a conventional ideophone for these speakers; hence, this form also describes. Altogether, the ensemble signals imagistic iconicity via depicting (speech and two hands), indicating (hands only) and describing (speech only). The prosodic aspects of the speech may also signal depicting, indicating, and/or describing, but we do not have access to this detail here.

Ellis et al. (2019) describe the wide range of signing practices used by Aboriginal communities of the Ngaanyatjarra Lands in the Western Desert of Australia. These include repertoires of conventionalised manual signs that may be used with or without speech; and air writing, whereby one traces the letters of a word on one's arm or leg, or in the sand or air. The first author, Elizabeth Marrkilyi Ellis, is a highly respected Ngaanyatjarra/Ngaatjatjarra speaker who is well versed in these signing practices. **Figure 3** illustrates how she combined air writing, manual signs, and speech to identify where an interactant's mother was living (Ellis et al., 2019: 105). In this composite utterance, Ellis creates an air writing and speech ensemble that depicts, indicates, and describes the place name *Alice Springs*. She coordinates two bodily articulations (one-handed actions and speech) to trace the outline of the letters *AS* in the air while speaking the forms *Alice Springs-ta* (*lit.* '*Alice Springs in that direction from here*). Her manual tracing actions prompt imagistic iconicity by resembling the conventional letters A and S, which emerges by both *directing-to* and *placing-for* these letter shapes in the air. The co-occurring English speech describes the location using the conventionalized English place name, and the Ngaanyatjarra speech describes and indicates the location using the conventionalized Ngaanyatjarra locative form. These speech forms also visibly index these English and Ngaanyatjarra words for people who cannot hear. Altogether, the imagistic iconicity of the Alice Springs ensemble is signalled by depicting (one hand), indicating (speech and hand) and describing (speech and hand).

Ferrara and Hodge (2018: 11) analyse a composite utterance produced by a hearing speaker of Australian English who is comparing the price of plane tickets from two different airlines

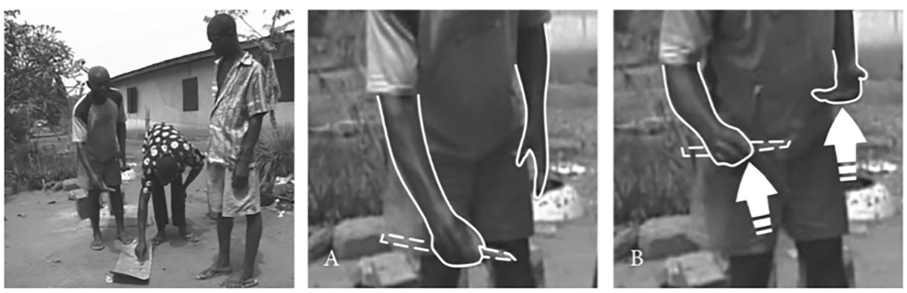


Figure 2.

(10) *ɔ̀-bra* *ì-a-bra* *shû* *shû*
PFOC-make it-FUT-make IDPH.flare.up IDPH.flare.up
| G1 | | G1 |
"It'll go *shû*, *shû*"
G1: both hands moving symmetrically in a quick upward motion; RH holds an object, LH is spread out palm upward

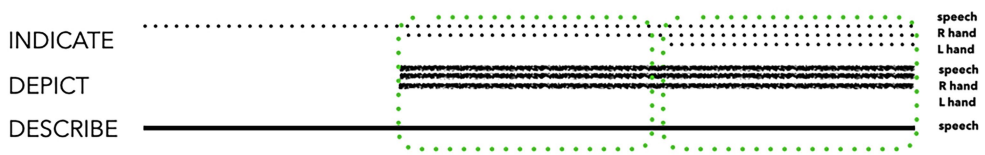


FIGURE 2 | Composite utterance produced by a hearing speaker of Siwu (adapted from Dingemanse, 2013: 158 and reproduced with permission from the author and John Benjamins Publishing Company, Amsterdam/Philadelphia, https://benjamins.com/catalog/gest).

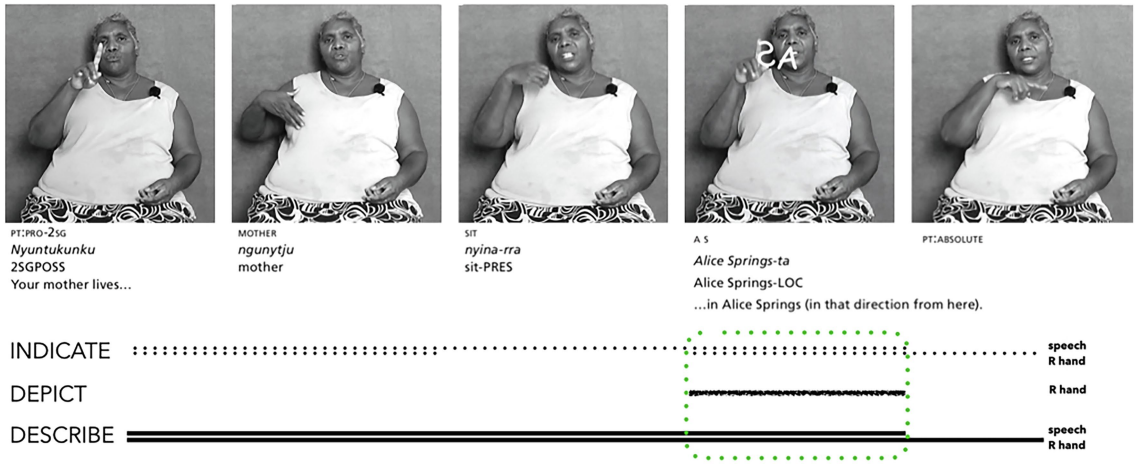


FIGURE 3 | Composite utterance produced by a hearing Ngaanyatjarra/Ngaanyatjarra speaker (adapted from Ellis et al., 2019: 105–106 and reproduced with permission from the authors).

(see **Figure 4**). The speaker says *'When I worked it out'*, while moving her left hand slightly upwards and downwards, as her right hand remains stable. In this composite utterance, the speech and manual action ensemble depict, indicate, and describe the two ticket options by using the metaphor COMPARISONS ARE SCALES. The speaker uses her two hands to depict the opposing surfaces of a scale being weighed, or two calculations being compared, so their distal relationship in space exhibits diagrammatic iconicity. As this metaphor is conventionally used to express CONTRAST for English speakers, these manual actions also describe (see Hinnell, 2019). The placement of the hands in space in relation to each other, while the speaker directs her eye gaze to them, are acts of indicating, as are the conventional spoken English words *I* and *it*. The imagistic, diagrammatic, and metaphoric iconicity manifested in this ensemble are signalled by depicting (two hands), indicating (speech and eye gaze) and describing (speech and two hands). The prosodic aspects of the speech may also signal depicting, indicating, and/or describing, but we do not have access to this detail here.

Goodwin (2003: 14) analyses an interaction during which two hearing archaeologists worked to identify a feature[9] marked on a map in an area of dirt near them. The speaker says, '*This is an extra thing here*', while simultaneously tracing a little curve on the map with his index finger (see **Figure 5**). While uttering the final word *here*, the speaker moves his finger to a nearby location on the ground where the feature referred to by *an extra thing* and the tracing movement above the map is visible in the dirt. He then repeats the curved tracing action above this feature within his own line of sight. In this composite utterance, the speaker's manual tracing action partially depicts the shape of the feature. It also indicates by *directing-to* and *placing-for*: directing others' attention between the map and the actual feature, and also placing the hand in each location.

This speech and manual action ensemble, produced within the situated participation framework of an archaeological dig, manifest both imagistic and diagrammatic iconicity by depicting (hand), indicating (eye gaze, speech, and hand), and describing (speech). This combination of signalling works to disambiguate the material resemblances of the referents on the map and on the ground. The two one-handed pointing actions used to trace the outline of the feature manifest imagistic iconicity, while the ensemble as a whole exhibits a diagrammatic relation between these two physical map and ground spaces. Indeed, Goodwin analyses this ensemble as an indexical pointing action overlaid on an iconic display. We agree with his conclusion that instead of maintaining a distinction between deictic gestures and iconic gestures, '…it seems more fruitful to focus analysis on an *indexical component* or an *iconic component* of a gesture, either or both of which may contribute to the organisation of a particular gesture (Goodwin, 2003: 230, italics in original).

Signers frequently manipulate the iconic potential of conventionalised manual signs (see Cuxac, 1999; Johnston and Schembri, 1999; Wilcox, 2004; Johnston and Ferrara, 2012; Ferrara and Halvorsen, 2017). While such signs can depict, describe, and/or indicate, the prominence of each signalling method can change (see also Capirci et al., 2022). Ferrara and Halvorsen (2017) analyse two tokens of the sign SLEEP produced by a deaf signer of Norwegian Sign Language across four clause utterances (see **Figure 6**). Both tokens conventionally symbolise the act of sleeping and therefore describe. Yet as Ferrara and Halvorsen (2017) explain, there are important differences between these two tokens: the signer manipulates the first token to profile a token description and the second token to profile a token depiction. The first token of SLEEP also co-occurs with the mouthing *sove* (*sleep*), which both indexes the spoken Norwegian word and describes this action. This manual sign and mouthed word ensemble result in a

[9]An indication of some non-portable human activity, such as a black stain indicating the cinders of a hearth.

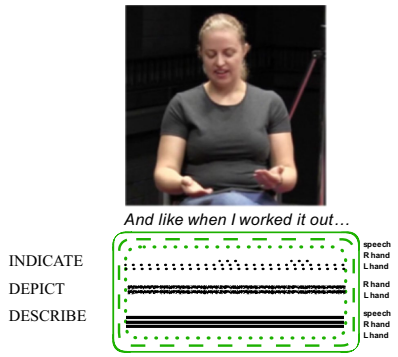


FIGURE 4 | Composite utterance produced by an Australian English speaker (adapted from Ferrara and Hodge, 2018: 11).

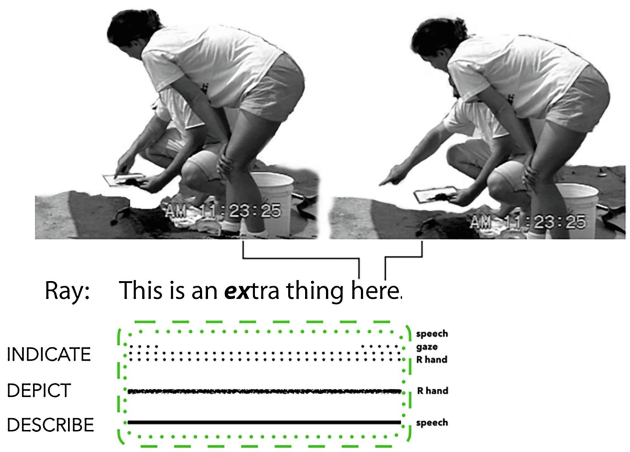


FIGURE 5 | Composite utterance produced by a hearing English speaker (adapted from Goodwin, 2003: 229 and reproduced with permission from Taylor and Francis Group, LLC., a division of Informa plc.).

'double description' that draws on both Norwegian Sign Language and spoken Norwegian, thus strengthening the descriptive profile of this token. The manual sign also depicts, as the perceptual resemblances between the form (a generalised act of sleeping) and meaning (*sleep*) manifest imagistic iconicity. However, the combined effect is to emphasise the symbolic aspects of this sign and mouthing ensemble: it is an iconic lexical sign instantiating a general type SLEEP, rather than a specific instance of sleeping that is depicted (see also Cuxac and Sallandre, 2007, who refer to this as 'degenerated iconicity').

Conversely, the second token SLEEP does not occur with any mouthing. Instead, the signer uses her face and body to emphasise selected visible action qualities of the token instance of sleeping that she wants to depict: the qualities of sleeping deeply and without interruption (see also Balvet and Sallandre, 2014). The second token SLEEP is also framed as a visible re-enactment of an event. While the first token of SLEEP may be analysed as primarily describing the general act of sleeping (describing with two hands and mouth, depicting with hands and face), the second token may be analysed as primarily depicting a specific act of sleeping (depicting with two hands, face, and body, describing with hands). In addition, this second token of SLEEP also occurs as part of a larger multiverb construction (see the sequence of signs: depicting sign:TO-LIE-SIDE-BY-SIDE BED enact:SLEEP in **Figure 6**). This construction also manifests diagrammatic iconicity, because these forms mirror the sequence of the events in the story, i.e., *the dog and boy lie down side by side on the bed and go to sleep*, and not *the dog and boy go to sleep and lie down side by side on the bed*. By incorporating these details into the analysis, we can better recognise the differences between these iconic forms as they are dynamically instantiated within the interaction.

It is also common for signers to manipulate the iconic potential of their immediate spatiotemporal context for syntagmatic reasons (Engberg-Pedersen, 1993; Johnston, 1996; see also De Weerdt, 2020, on the spatiotemporal manifestation of figure-ground relations in FinSL). Johnston (1996) analyses a token of the spatially motivated Auslan utterance POLICE CATCH THIEF (see **Figure 7**). The three individual sign tokens used in this utterance are all conventionalised Auslan signs, and therefore describe. Each sign also manifests imagistic iconicity signalled through depiction: the sign POLICE resembles the stripes on a policeman's uniform sleeve and/or the handcuffs used for an arrest; the sign CATCH resembles an act of grabbing a person or object; and the sign THIEF resembles the outline of an imagined thief's mask. These signs are similar to the first token of SLEEP produced by the Norwegian signer analysed above. Yet there are more schematically iconic aspects of this Auslan utterance in addition to imagistic iconicity. The sequential order and timing of these three signs, along with their meaningful *placing-for* in the signing space and *directing-to* between each signs' placement, mirror both the spatial and agentive relations between policeman and thief (Johnston, 1996). Thus, these manual signs each manifest imagistic iconicity, primarily through describing, depicting, and indicating, while the utterance as a whole manifests diagrammatic iconicity of location (POLICE on the left, THIEF on the right) and agent-patient relationship (POLICE as agent, THIEF as patient).

Strategies for depicting in signed interactions may also be used to name referents, in addition to depicting particular qualities of what people, animals, and objects look like or how they move. Omardeen et al. (2021) analyse how deaf signers of Providence Island Sign Language (PISL) use what they term 'embodied depiction' for initial person reference. They documented how one PISL signer depicts the specific manner of how another individual walks with a cane, as a way of introducing this non-present person into the discourse (see **Figure 8**). The signer's bodily action depicts the visible qualities of the person walking with their cane, while the shape of the signer's right hand indicates holding the imagined handle of the cane (and hence the cane as an imagined object). As this embodied depiction is conventionally used to refer to a specific individual in the signer's community, it also describes. In this composite utterance, the signer combines depiction, indication, and description within a manual and bodily action ensemble that manifests imagistic iconicity. The token icon primarily describes a known person into the interaction and



FIGURE 6 | Composite utterance produced by a deaf signer of Norwegian Sign Language (adapted from Ferrara and Halvorsen, 2017: 285 and reproduced with permission from the authors and John Benjamins Publishing Company, Amsterdam/Philadelphia, https://benjamins.com/catalog/gest). This example can be accessed online: Ferrara and Halvorsen, 2021; RPH12_PS_Frosk3.mp4; 00:00:15.39–00:00:20.59.

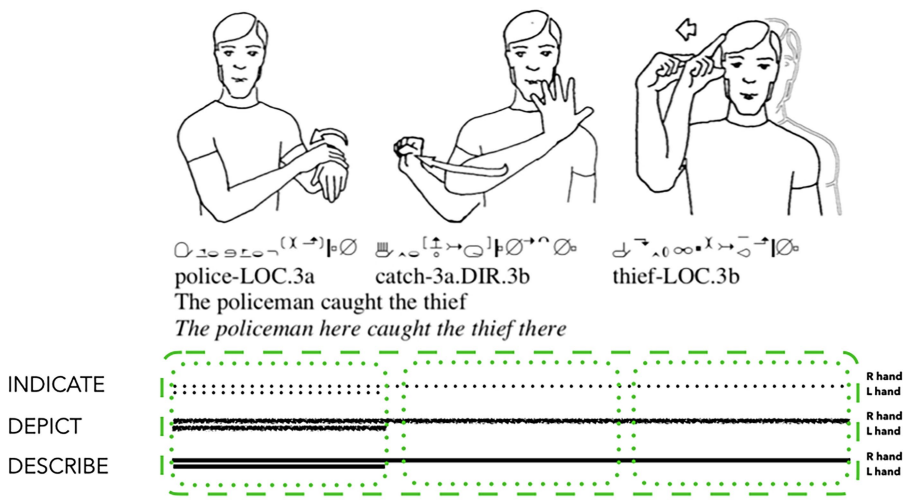


FIGURE 7 | Composite utterance produced by a deaf signer of Auslan (adapted from Johnston, 1996: 72 and reproduced with permission from the author and Taylor and Francis Group, LLC., a division of Informa plc.).

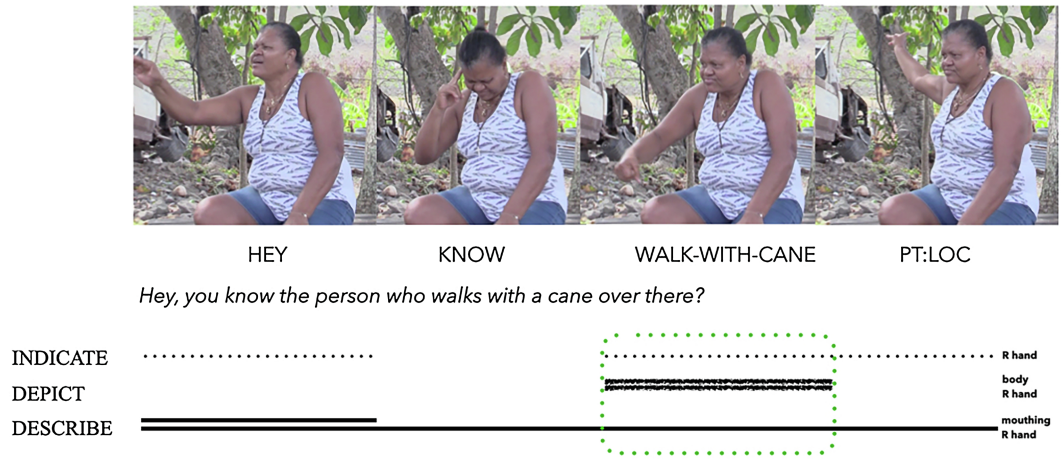


FIGURE 8 | Composite utterance produced by a deaf Providence Island Sign Language (PISL) signer (adapted from Omardeen et al., 2021: 23 and reproduced with permission from the authors and under CC-BY 4.0).

discourse context, while also depicting and indicating selected perceptual characteristics of this person. The imagistic iconicity of this ensemble is signalled by depicting (hand and body), indicating (hand) and describing (hand and body) within one composite utterance.

Deafblind signers also make use of iconicity for initial person reference through the tactile co-articulation of bodily actions. Ali (2020) analysed the composite utterances co-articulated by two deafblind signers of Bay Islands Sign Language (see **Figure 9**). In this instance, the signer on the left is conversing with his aunt on the right. While discussing their family relations, the signer uses his two hands to briefly hold his aunt's right thumb, thus indexing her fifth and youngest brother. While maintaining this hold, he then guides his aunt's left hand to his face, so that she can feel him produce the distinctive head nodding movement and facial mannerism that is the conventional name sign of her brother (see the image glossed as NS:BROTHER3 in **Figure 9**).[10] In this composite utterance, imagistic iconicity results from depicting (head and face) and describing (head and face) through co-articulation of the tactile name sign ensemble.

Tactile co-articulation of bodily actions is also used between people with sensorial asymmetries, such as deafblind signers and hearing speakers. Kusters (2017) analysed an interaction between a hearing shopkeeper and his customer Pradip, a deafblind man living in Mumbai (see **Figure 10**). In this example, Pradip is standing in front of a shop counter, behind which the hearing shopkeeper controls what people can see and buy. They have been interacting for some time, as Pradip labours to make himself understood. He wants to buy a specific type of biscuit: cream-filled Marie biscuits. The shopkeeper is closely attuned to Pradip during their interaction, although he sometimes incorrectly guesses or anticipates which type of biscuit Pradip wants. **Figure 10** illustrates the moment when the shopkeeper finally understands which biscuits Pradip is asking for. His understanding emerges through three icons that Pradip selectively profiles and co-articulates with the shopkeeper using two of his own hands and the right hand of the shopkeeper: (i) the sandwich shape of the biscuits; (ii) the shape and size of the package the biscuits are sold in; and (iii) the middle of the sandwich biscuits being filled with cream.

Pradip first uses his own two hands to depict the sandwich arrangement of the biscuits he wants, *placing-for* this manual icon where he assumes the shopkeeper can see it (**Figure 10p**). The shopkeeper turns away but returns with the wrong biscuits (**Figure 10q**). Pradip then uses his own fingers to trace the shape of the desired package on the surface of the counter, again *placing-for* an outlined depiction of this shape on the counter (**Figure 10r**). Pradip also gently takes the shopkeepers' right hand with his own left hand, using his other hand to tactily depict a smearing action on the shopkeepers' hand, thus beginning the third icon (**Figure 10s**). Keeping the shopkeeper's hand held in his own, Pradip then uses his right hand to complete the sandwich depiction, with the shopkeeper's right hand *placing-for* and co-articulating a depiction of the cream centre of the entire biscuit icon (**Figure 10t**). Finally, the shopkeeper understands. He turns away and returns with the correct biscuits. He seeks confirmation from Pradip by speaking an utterance combining English and Hindi, and gently pinching Pradip's left hand (**Figure 10u**). Pradip can feel the biscuits are the ones he wants and confirms this by nodding his head.

Notably, there is not much describing during this interaction: all propositional information is signalled by combinations of

[10]The nephew earlier produced four name signs for the other siblings on his aunt's face, as each name sign involves some form of external tactile touch and movement, such as tapping or gently pinching (see Ali, 2020). However, the younger brother's name sign involves movements that can only be done by the person who is signing, since it is not socially acceptable to forcibly move or contort a co-articulator's head or face in the way required (at least not in the way it is possible to do with arms and fingers). Thus, this rich example also highlights the intersubjective norms for co-articulated communication regarding whose body is recruited for what actions at any given moment (see Edwards, 2015; Willoughby et al., 2020; Clark, 2021). This point is relevant to understanding the different affordances that influence people's use of iconicity in different contexts.



FIGURE 9 | Composite utterance produced by a deafblind BISL signer (adapted from Ali, 2020: 07:18–07:24 and reproduced with permission from the author).

depicting and indicating, especially by *placing-for* on the shop counter. Describing is primarily used for solving problems of understanding during the interaction, as in Pradip's use of the widely known manual sign WHERE[11] to request information from a sighted person (**Figure 10q**), and the shopkeeper's strategy of gently pinching Pradip's hands to confirm the biscuits are filled with cream (**Figure 10u**).[12] The shopkeeper's use of describing by speaking English and Hindi to confirm understanding was not heard by Pradip, and therefore not considered integral to Pradip's interpretation. In these composite utterances, imagistic iconicity is jointly signalled by depicting (Pradip's two hands and the shopkeeper's right hand) and indicating (Pradip's two hands and the shopkeeper's right hand). Diagrammatic iconicity is also signalled by depicting and indicating (Pradip's two hands) during the creation of the first icon depicting the sandwich shape of the biscuits, the placement of the second icon on the shop counter, and again during the third icon depicting the cream within the biscuits. Furthermore, the physical presence of the counter heavily influenced the combination of strategies chosen and coordinated by Pradip, as he was observed using different strategies in other interactions that did not involve a shop counter (see Kusters, 2017). This example highlights the importance of sensorial affordances and spatiotemporal contexts for influencing how iconicity manifests during different interactions.

So far we have considered iconic ensembles from a range of co-present interactions. Yet even without moving their hands or body, hearing English speakers make frequent use of iconicity, as evidenced by the prevalence of words such as *sniff, murky,* and *buzzing*, each selectively profiling the different sensorial qualities of various perceptual experiences (Winter et al., 2017). Such words have often been subject to iconicity ratings within decontextualized experimental tasks, with some forms receiving higher ratings than others. For example, Winter et al. (2017) found that speakers of US English rate the words *clank, mushy, whiny, suck*, and *quick* as highly iconic. Forms depicting sound symbolisms (imagistic iconicity) often also depend on systematic arrangements of particular vowels and consonants across many different words in English, e.g., /s/, /z/, and /f/, with specific sounds prompting relational resemblances across networks of words (diagrammatic iconicity). Thus, while these forms are not presented within composite utterances, they may also manifest imagistic and diagrammatic iconicity via depicting (vowels, consonants) and describing (words).

Comparing Iconicity Across Interactions

We need a way to compare all these different manifestations of iconicity. Recall the two main issues with how iconicity

[11]This sign is not exclusively a deaf sign, it is widely known and used by hearing people in Mumbai.

[12]Indeed, the interactional strategies of turn-taking and repairs choreographed by Pradip, and which scaffolded the co-articulation of the three different biscuit icons, are more 'conventional' than the content of what was said, in the sense that Pradip initiates these repairs turn-by-turn and the shopkeeper responds to them by (mis)understanding (see the section 'Signalling by Describing').



FIGURE 10 | Composite utterance produced by a deafblind Mumbai signer (adapted from Kusters, 2017: 405 and reproduced with permission from the author and Taylor and Francis Group, LLC., a division of Informa plc. The letters **p-u** pertain to the original publication).

is defined and operationalised in the section 'Issues With Defining and Operationalising Iconicity': the prominence of form and the prominence of perceptual resemblances. Our aim here was to mitigate these two issues and encourage more faithful comparisons of iconicity across interactions, modalities, and languages. We did this by asking two questions: (i) how does the interaction signal depicting, indicating, and/or describing? (ii) how does the interaction manifest imagistic, diagrammatic, and/or metaphorical iconicity? By applying a neo-Peircean framework to these interactions, we can interrogate how different types of iconicity were created using different bodily articulators (multimodal) and signalled through different combinations of depicting, indicating, and/or describing (polysemiotic) within single forms and across composite utterances. The issue with the prominence of form is solved by recalibrating analyses of iconicity as signalled polysemiotically within multimodal ensembles. The issue with the prominence of perceptual resemblances (i.e., resemblances of quality) is solved by also considering diagrammatic and metaphorical resemblances (i.e., resemblances of relation and/or association). We can now see how the iconicity identified in these examples all differ in fundamental ways. Crucially, none involve depiction alone. Most rely on more than two articulators, and several manifest one other type of iconicity in addition to imagistic iconicity.

The value of this analysis is evident from just some of the many comparisons that can now be undertaken. Consider, for example, the Siwu speaker and Norwegian Sign Language signer, who both made use of imagistic iconicity in their composite utterances. The Siwu speaker created his multimodal, polysemiotic 'gunpowder flame' icon by depicting, indicating (both *placing-for* and *directing-to*) and describing with his two hands and speech. The Norwegian Sign Language signer created her first token of SLEEP by depicting and describing with her two hands and face. She then created her second token of SLEEP by depicting and describing with her hands, head and face, thereby creating an icon that is more closely comparable with manual gunpowder flames depiction than the first token. The second token of SLEEP also manifested diagrammatic iconicity through the sequential multiverb construction depicting the sequence of events as they occurred in the storey. This aspect of the second token further differentiates it from the first token of SLEEP.

Then, there is the hearing archaeologist and the hearing Australian English speaker. Both created speech and manual action ensembles that were analysed as primarily depicting some objects. However, the manual curved tracing action used to depict a feature overlaid on the ground also involved a resemblance of relation between the map and the ground, i.e., diagrammatic iconicity, while the COMPARISON manual action also involved a resemblance of association, i.e., metaphorical

iconicity. The manual curved tracing action done by the hearing archaeologist is more comparable to the outline of a packet of biscuits traced by Pradip into the Mumbai shop counter. As a final comparison, consider the token name sign NS:BROTHER3 co-articulated by the Bay Islands Sign Language signers, and the iconic English words mentioned in the final paragraph of the section 'Analysing Iconicity in Interactions.' All these tokens depict and describe to create imagistic iconicity, but the Bay Island Sign Language example involves using one signer's two hands, head and face, and the other signer's right hand, while the English words in this instance rely on written forms only. In fact, all the examples re-analysed here differ quite substantially from such iconic spoken or written forms used by English speakers. At the very least, tokens that manifest imagistic iconicity through depiction and indication are more comparable with each other than tokens that manifest imagistic iconicity through combinations of depiction, indication and description, although the number of articulators used and the prominence of the different signalling methods is important. As we have demonstrated here, the presence of diagrammatic and/or metaphorical iconicity also needs to be considered.

Recognising Iconicity as Plurifunctional

The analysis and comparison of how iconicity manifests multimodally and polysemiotically across these interactions prompts a deeper and more pervasive question: why do we do it? Much of the literature has focused on the role of iconicity for human cognition, language development and language evolution, typically by analysing how specific iconic forms are created and used (see the section 'The Prominence of Form in Analysing Iconicity'). A primary function of iconic ensembles is to show selective qualities of what one means, such as by drawing or performing a picture and/or by creating resemblances of relation and association, rather than describing these qualities through non-resemblances (see Haiman, 1985; Müller, 2014; Clark, 2016). It has been shown that iconicity supports the development of early languaging repertoires and any subsequent language learning (e.g., Imai and Kita, 2014; Perniss and Vigliocco, 2014; Ortega and Morgan, 2015; Ortega, 2017; Nielsen and Dingemanse, 2021). Iconicity helps us figure out what we want to say and how we can say it (McNeill, 1985; Goldin-Meadow, 2003). It enables us to be creative and improvise meaning, and to communicate expressively and efficiently (e.g., Clark, 1996; Kendon, 2004; Fusellier-Souza, 2006; Hodge and Ferrara, 2014; Slonimska et al., 2021). Iconicity is also important for the negotiation and co-regulation of joint actions within social participation frameworks, such as by aligning our manual actions with those of our interactant (Goodwin, 1986; Rasenberg et al., 2020).

Some types of iconicity are fundamental principles explaining language variation and change, while others are merely an effect of how we communicate within specific (socio)linguistic and cultural contexts (see Haspelmath, 2008; Perlman, 2017). For example, imagistic iconicity has been shown to be central to the evolution of displacement in language, supporting the transition of functionally referential signs to conceptually referential signs (Perniss and Vigliocco, 2014). Some communicative strategies that particularly suit the creation of imagistic iconicity may be useful in specific contexts, such as deaf signers' use of manual depicting actions for talking about referents or processes that do not have a readily available lexical form, or when such a conventionalised form is unknown due to oppressive social and/or educational experiences (Klima and Bellugi, 1979; Fusellier-Souza, 2006; Major et al., 2012; Hodge and Goswell, 2021). Particular types of iconicity can be useful in interactions involving people who have experienced cognitive disruptions such as aphasia (e.g., Neils, 1995; Schveiger, 1995; Wilkinson et al., 2010; Meteyard et al., 2015; Pritchard et al., 2015) and people who are neurodiverse (e.g., Dargue et al., 2021).

These are all valuable lines of investigation, yet there is one more that needs to be considered for the question of 'why iconicity': what is the social role of iconicity, and what power does it afford? As with all other aspects of language and communication, it is necessary to consider the broader socio-functional dimensions of iconicity in addition to the semantico-referential ones (see Silverstein, 1976; Halliday and Hasan, 1989; Bernstein, 2003/1971). As Clark observes, 'How speakers [and signers] make their choices is part of their broader decisions about what they are doing and why' (1996: 186). Interest in the socially indexical and 'beyond referential' aspects of language and communication can be traced back to early scholars concerned with the relationship between people, language and the body politic, or the concept of 'language as dialogue' (Vološinov, 1973; Bakhtin, 1981; see Linell, 2009; Spronck, 2019). The basic tenet of dialogism is that all aspects of language are referentially, contextually, and socially grounded (see Gurdin, 1994). This thread was later taken up by others researching the sociology of language use (e.g., Silverstein, 1976; Halliday and Hasan, 1989; Bernstein, 2003/1971). As mentioned in the section 'Imperatives for Defining and Operationalising Iconicity', it entails recognising the multilingual and multimodal repertoires that different people and communities develop and draw upon in different contexts and for different (socio)linguistic and cultural reasons (Busch, 2012; Kusters et al., 2017).

In order to consider the social functions of iconicity, we also consider indexicality as a dialectic condition, and not solely a referential strategy. Silverstein (1976) contrasts these two notions of indexicality. He defines referential indexicality as overlapping with referential functions, which were the focus of the analyses presented in the section 'Analysing Iconicity in Interactions' (see also Mittelberg, 2008; Kok et al., 2016). He defines non-referential indexicality as signalling elements of the interactional and sociocultural context (i.e., 'the field, tenor, and mode of discourse', Halliday and Hasan, 1989). For example, Javanese speakers use deference indexes to stratify interactions between people of high and low social status, and Dyirbal speakers strategically select everyday vs. mother-in-law lexical items to create and maintain sociological distance in relationships (Silverstein, 1976: 32). An example from signed interactions is how experienced Auslan signers might quickly fingerspell full English sentences to other fluent signers in the presence of people who are

learning Auslan, both to impart some propositional information about the learner pertinent to their acceptance (or not) within the social context, while excluding comprehension for these learners (see also Tapio, 2014). Such socio-functional aspects of language use can be incorporated into a modality-agnostic, comparative semiotics of iconicity (see also Gurdin, 1994; Radwańska-Williams, 1994).

Consider the following example from an investigation of the social meanings of variation in BISINDO (Indonesian Sign Language; Palfreyman, 2020; see **Figure 11**). Here, a young deaf signer Ambar is talking to a deaf friend about her experiences of trying different professions before finding a suitable job. **Figure 11A** provides an English translation of how Ambar recreated an earlier conversation between herself and her elder hearing sister, using visible bodily enactment (i.e., 'personal transfer', 'constructed action', 'reported speech') to depict these earlier utterances. Each utterance involved one of two different variants for negating the predicate '*can*'. Ambar uses the variant TIDAK-BISA for her own utterances, and another variant TIDAK + mouthing '*tidak bisa*' for those of her hearing elder sister (see **Figure 11B**). The two variants impart different social meanings: TIDAK-BISA is a suppletive manual sign that is commonly used by younger deaf signers from the Solo (Central Java) region, whereas the variant TIDAK + mouthing '*tidak bisa*' has its origins in the manual gestures and Indonesian mouthings used by hearing non-signing speakers. There is an implicit BISINDO ideology that 'the suppletive variant is more "deaf" than the mouthed predicate construction, which is more "hearing" because of its gestural associations' (Palfreyman, 2020: 15).

In these composite utterances, Ambar combines depicting, indicating and describing within manual and bodily action ensembles to enact the utterances (and negation variants) previously used by herself and her sister. Altogether, the TIDAK-BISA ensemble manifests imagistic iconicity by depicting (face, head, and hand), indicating (gaze) and describing (hand), while the TIDAK + mouthing '*tidak bisa*' ensemble manifests imagistic iconicity by depicting (face, head, and hand), indicating (gaze) and describing (hand and mouthing). Ambar therefore uses these iconic bodily enactments to reference who is saying what to whom (Ambar; her elder sister), while simultaneously indexing the different social roles of each person, and local ideologies regarding their chosen communication practices (a young deaf local signer; an older, hearing sibling who does not know BISINDO). Thus, Ambar also communicates her epistemic evaluation of the previous conversation between herself and her sister, whereby she selectively imbues her personal values into the depiction to take a stance about it (see Niemelä, 2010). In terms of the participation framework in which these composite utterances unfold, these enactments aid Ambar to 'other' her sister as a hearing outsider within deaf social contexts. Thus, the imagistic reconstruction of a prior conversation indexes both the referential aspects of the interaction and the social dynamics of the people involved, through the lens of one of those people. This aspect of iconicity is vital in every sense of the word, but is often masked in experimental investigations.

There are many socio-functional dimensions of iconicity present in the examples analysed above. Consider the POLICE CATCH THIEF example in **Figure 7**. Johnston (1996) actually provided eight variations of this propositional utterance, all of which vary in the order of signs and/or meaningful use of space. The example chosen for our purposes here most closely reflects the choices made by experienced and highly respected Auslan signers who are proficient in making meaningful use of space. Thus, this particular construction also indexes specific Auslan socialities: people who have signed since birth or early childhood, or who have otherwise experienced maximal opportunities to sign this way (see Hodge and Goswell, 2021). Then, there is the Alice Springs air writing example in **Figure 3**, which indexes the development of English literacy practices used by young and older people in Ngaanyatjarra communities (Ellis et al., 2019: 105). The embodied depictions used by the Providence Island signer (**Figure 8**) and the deafblind Bay Islands signers (**Figure 9**) index specific sociocultural norms regarding how people are physically perceived and known, and how they are identified and named.

Finally, there are the iconic ensembles co-articulated by Pradip and the Mumbai shopkeeper in **Figure 10**. These icons are more restricted in terms of non-referential indexicality, since so much effort is invested in establishing referential common ground, but look closely and it is there: in Pradip's expert labouring and strategic use of iconicity in building mutual understanding, to achieve self-determination and personal agency by connecting directly with someone who has a vastly different sensory embodiment, rather than indirectly through a 'helper' who can rely heavily on describing, such as a signed language interpreter (see also Clark, 2021; Moriarty and Kusters, 2021; Green, 2022). Herein lies the social role of iconicity, and the power it affords: we use iconicity to index our relationships, our experiences, and our socialities. We use it to live our lives. It is therefore just as important to consider the socio-functional aspects of iconicity as the semantico-referential aspects, since much depends on the people interacting and the resources available within specific social and spatiotemporal contexts (see also Sicoli, 2010).[13]

This has implications for how we can expand discussions of iconicity across the language and communication sciences. For example, researchers have highlighted the important role of depicting for efficient referential communication between signers who share a signed language (e.g., Slonimska et al., 2021). Yet when we consider how iconicity manifests between people with sensorial asymmetries such as Pradip and the

[13]Sicoli (2014) later observed that Peirce's most well-known trichotomy of *symbols, indices, icons* may not be the most appropriate tool for analysing iconicity, and that his trichotomy of *rheme, dicent, argument* better highlights the 'joint activity' of languaging in terms of its performativity, recipient design, and interpretability. We agree this is a solid proposal for future consideration, and hope that eventually these frameworks may be united.

A

Token reference number ↓		role: Ambar (deaf)	role: sister (hearing)
1, 2	I said, 'I **cannot**, sorry, I **cannot** sew'.	TIDAK-BISA	
3	I tried to cut someone's hair, I said, 'I **cannot** do this'.	TIDAK-BISA	
4, 5	I said, 'I **cannot** do make-up, and I **cannot** cut hair'.	TIDAK-BISA	
6	I said, 'Yes, because I **cannot** cut hair'.	TIDAK-BISA	
7	I asked, 'Can I go elsewhere?' She replied, 'You **cannot**'.		TIDAK/'tidak bisa'
8	For Rp. 100.000 a month, I **could not** go anywhere.	TIDAK-BISA	
9	I asked, 'Can I have Rp.150.000?' She replied, 'You **cannot**'.		TIDAK/'tidak bisa'
10	She said, 'You could make porridge.' I said, 'I **cannot** do that!'	TIDAK-BISA	

160-second stretch of narrative

B



FIGURE 11 | (A) English translation of Ambar's composite utterances (adapted from Palfreyman (2020): 104 and reproduced with permission from the author and John Benjamins Publishing Company, Amsterdam/Philadelphia, https://www.benjamins.com/catalog/aplv). **(B)** Two sign variants for negating the predicate 'can' recreated by Ambar (adapted from Palfreyman, 2020: 105 and reproduced with permission from the author and John Benjamins Publishing Company, Amsterdam/Philadelphia, https://www.benjamins.com/catalog/aplv).

shopkeeper, it becomes apparent how much effort and labour is often involved in signalling through depicting. This highlights a moral aspect to using iconicity: it can also reflect people's willingness to both understand and make oneself understood, especially during interactions when people must rely on 'far leaner linguistic resources than users of conventional languages' (Green, 2022: 22; see also Goodwin, 1995; Moriarty and Kusters, 2021). Thus, the socio-functional role of iconicity may also change according to the people interacting and the sociocultural context. **Table 1** summarises some multimodal, polysemiotic, and plurifunctional dimensions of the examples analysed here.

DISCUSSION

In this paper, we reconceptualised and operationalised iconicity as multimodal, polysemiotic, and plurifunctional. We end by discussing some implications for the language and communication sciences, and explain how this approach guides us towards a theory of biosemiotics. It is first necessary to assess if this framework is useful and effective. Using Occam's Razor, we determined six criteria against which the framework can be assessed in terms of its explanatory power (see Hossenfelder, 2020): (1) The framework must be able to account for the full range of iconicity observed across human interactions, not just hearing, able-bodied interactions; (2) It must align with known principles explaining language and communication more generally, or at least not contradict them; (3) It must enable continuity across different time frames, e.g., enchrony, synchrony, and diachrony; (4) It must be operationalisable using transdisciplinary methods, e.g., available for experimental methods, corpus annotation, language assessment, pedagogy; (5) It must enable continuity and comparability with nonhuman communication, and compatibility with other life sciences; and (6) It must make us rethink existing paradigms and consider new ones.

So how does our proposal hold up to this assessment? The analyses presented in the section 'Analysing Iconicity in Interactions' demonstrates the framework outlined here does effectively facilitate the modality-agnostic analysis and comparison of iconicity within and across a range of human interactions (1, 3). It does this without marginalising or pathologising anyone, and includes consideration of both semantico-referential and socio-functional aspects of communication (1, 2). The theoretical foundations were

TABLE 1 | Iconicity as multimodal, polysemiotic, and plurifunctional (number of articulators in parentheses and note this summary is not necessarily exhaustive).

	Multimodal	Polysemiotic	Plurifunctional	Iconicity
Hissing, buzzing (English)	Speech (1)	DD	Referential	Imagistic
Tree (ASL)	Hands (2)	DD	Referential	Imagistic
To sleep (Norwegian SL)	Hands, face, and mouthing (4)	DD	Referential	Imagistic
Younger brother (tactile BISL)	Head, face (2)	DD	Referential, social	Imagistic
Sleeping deeply (Norwegian SL)	Hands, face, head (4)	DD	Referential, social	Imagistic, diagrammatic
Biscuit sandwich (tactile signs)	Hands (2)	DI	Referential, social	Imagistic, diagrammatic
Biscuit package (tactile signs, counter)	Hands (2), object (1)	DI	Referential, social	Imagistic, diagrammatic
Biscuit contents (tactile signs)	Hands, other hand (3)	DI	Referential, social	Imagistic, diagrammatic
Alice Springs (Ngaanyatjarra, English)	Hand, speech (2)	DID	Referential, social	Imagistic
Person with cane (PISL)	Hand, body (2)	DID	Referential, social	Imagistic
Catching thief (Auslan)	Hands (2)	DID	Referential, social	Imagistic, diagrammatic
An extra thing (English)	Gaze, hand, and speech (3)	DID	Referential, social	Imagistic, diagrammatic
Gunpowder flames (Siwu)	Hands, speech (3)	DID	Referential, social	Imagistic
Working it out (English)	Gaze, hands, and speech (4)	DID	Referential, social	Imagistic, diagrammatic, metaphorical
TIDAK-BISA (BISINDO)	face, gaze, hand, head (4)	DID	Referential, social	Imagistic
TIDAK + tidak bisa (Indonesian)	Face, gaze, hand, head, and mouthing (5)	DID	Referential, social	Imagistic

established by considering what is known about complex ontogenies of semiosis, language, and communication, as well as broader principles influencing and explaining language variation and change (2, 3). The framework offers tools for quantitative analysis, such as diagnostics for identifying how people depict, indicate, and/or describe; identifying how imagistic, diagrammatic, and/or metaphoric iconicity is manifested; and coding methods that are transferable into machine-readable annotation systems. For example, we have used dotted, dashed, and sharp lines or boxes here for ease of illustration, but this coding schema could easily be operationalised as tiers within time-aligned video annotation software such as ELAN. It also offers tools for qualitative analysis, such as consideration of the sociocultural aspects of specific interactions and how these might influence people's choices for manifesting iconicity, including and beyond any immediate need to establish referential common ground. The framework can therefore be operationalised by researchers using a range of methods (1, 4). But what about continuity with nonhuman communication? The need to strive for a science that unifies the destructive schisms between humans and nature is important to us (5).

It was polymath Thomas Sebeok (1920–2001) who suggested that 'life and semiosis are coextensive', a concept he developed by looking for evidence of semiosis across the life sciences, especially across the animal world (see Barbieri, 2009, for an overview). His insights played a large part in the unification of semiotics and biology—*biosemiotics*—the main purpose of which is to show that 'signs and meaning exist between all living systems' and that 'semiosis is a fundamental component of life' (Barbieri, 2009: 222; see also Deacon, 1997; Favareau, 2015). There is not enough space here to do justice to such a broad and relatively new field, suffice to say that we can draw on Sebeok's approach by asking not what makes iconicity different from nonhuman communication (or the traditional preoccupation with what makes *arbitrary symbols* different). Rather, we ask what makes it the same (see also Perlman, 2017).

The question of whether or not gorillas, for example, use iconicity is a matter of great debate (see Perlman et al., 2014). Perlman and Gibbs (2013) describe the 'iconic gestures' used by Koko, a human-fostered gorilla, with the aim of determining if her token gestures suggest a sensori-motor imagery similar to humans. Five tokens of iconic gestures identified within a corpus of video-recorded interactions between Koko and her two main human caregivers were analysed. All involved re-enactments of embodied actions ('pantomimes') that Koko wanted her caregivers to perform, such using a set of keys to act out unlocking a door (to request an outside walk), or acting out wiping a pair of sunglasses with an imaginary tissue (to request a Kleenex). Perlman and Gibbs (2013) argue these actions were clearly produced for communicative purposes, as they were different in force and effect to how Koko would produce them for instrumental purposes. For example, a back scratch gesture done with instrumental force (to scratch an itch) appeared different to a back scratch done with communicative intent (to request a caregiver scratch a different place on her back). Several actions were also novel or obviously tailored for the specific context. Similar actions have also been observed during interactions between free-ranging chimpanzees (Pika and Mitani, 2006). Perlman and Gibbs (2013) suggest these actions constitute iconic gestures, and we agree with them: with the additional suggestion that Koko's embodied actions could be interpreted as different combinations of depicting, indicating, and describing developed throughout her lifelong experiences of interacting with her human caregivers.

Indeed, such a use of this framework may not be restricted to analyses of iconicity; it could also extend to nonhuman referential indexicality. For example, Vail et al. (2013) describe

the 'referential gestures' used by some coral reef fish (groupers and trout) to 'indicate' the presence and location of hidden prey to cooperative hunting partners such as giant moray eels and Napoleon wrasses. Groupers were observed to use two different signals to initiate and coordinate collaborative hunts with moray eels: (i) a high frequency and horizontal body shimmy that is performed in front of a sheltering moray, which results in the moray accompanying the grouper on a collaborative food hunt; (ii) a vertical, headstand orientation produced with headshakes that have pauses between them, placed over a narrow crevice in which escaped prey fish are hiding, which sometimes resulted in the slender moray eel darting into the crevice to hunt the prey, a possibility not available to groupers since they are too large. The authors suggest these signalling actions share the hallmarks of intentionality, and we agree with them: with the additional suggestion that the indicating signals used by these fish could be interpreted as involving both *directing-to* and *placing-for*.

In other words, it is not a huge stretch to consider that Koko's use of keys to poke at the lock in the door, or use of her fingers to demonstrably scratch her back, might be interpreted as an 'icon' by another human or gorilla, or that the placement of a grouper over a narrow crevice in the context of a collaborative hunt might be interpreted as an 'index' by a moray eel. However, it is obviously a problem if we attribute definitive human interpretations to the possibilities experienced by gorillas, fish and eels within their own umwelts. The main point we want to make here is that the communicative behaviours observed within these cross-species interactions are contiguous with human pathways for signalling through indicating, depicting, and/or describing (5).

Finally, the framework proposed here does make us rethink existing paradigms, simply by the questions it asks us to answer: (i) how do we combine depicting, indicating and/or describing within an interaction? (ii) how does the interaction manifest imagistic, diagrammatic and/or metaphorical iconicity? To interrogate these questions, it is necessary to initially focus on interactions (not individuals) and situated contexts (not languages; see also Kusters et al., 2017). Then, there is the process of analysing, annotating, and comparing iconicity within and across interactions (see the sections 'Analysing Iconicity in Interactions' and 'Comparing Iconicity Across Interactions'). After observing how often speakers make use of improvised bodily actions that are tightly coordinated with conventionalised speech or how often signed depictions also describe, does it still make sense to operationalise binaries such as 'signers vs. speakers', 'words vs. signs', 'spoken languages vs. signed languages', 'verbal modality vs. gestural modality', or even 'convention vs. improvisation' in experimental methods or language theory? Does it still make sense to credit the ease and efficiency of 'drawing a picture' as the main motivation for manifesting iconicity, or can we now consider there may be other, more subterranean forces related to human sociality? As we move further along the path of comparative semiotics, it may be useful to question whether these paradigms continue to serve our understanding in a progressive way. Perhaps some are better characterised as intellectual conveniences (and historically, political necessities) that we can gradually do without. For this reason, we add an overarching coda to the method outlined in the section 'Recognising Iconicity as Multimodal and Polysemiotic': (iii) why are the people in the interaction communicating like this? We may not always discover the answer, but we should certainly ask the question.

There are two broader implications for the language and communication sciences. Firstly, iconicity is more complicated than how it is often conceptualised and operationalised in the literature. This complexity needs to be recognised and accounted for within empirical methods and the interpretation of findings relating to iconicity in language and communication. For example, it is not sufficient to propose that one is 'investigating iconicity'—we need to be specific about what kinds and how it manifests. Secondly, particular thought needs to be given to how the indicating and describing signals of an iconic ensemble may affect the interpretation of results and findings from experimental and other studies. Finally, and perhaps most importantly, deeper consideration of the social functions of iconicity may offer richer or even better explanations for why we do it. This may lead to the reanalysis of some prior claims, while others may be better supported, but at least we will be able to address some of the biases described earlier and compare like with like.

CONCLUSION

In this paper, we argued that iconicity is multimodal, polysemiotic, and plurifunctional. By applying the theory of language use outlined by Clark (1996) to a range of different interactions, and also considering the notion of non-referential indexicality proposed by Silverstein (1976), we illustrated the multidimensionality of iconicity as emerging through the creation of different types of icons, all of which are minimally signalled by depicting, but usually also with indicating and/or describing, and usually with more than one bodily articulator. Analyses from a range of co-present interactions highlight how iconicity often emerges across larger ensembles of joint multimodal actions, in addition to smaller units such as words and signs, all of which can range from concrete to more schematic. These analyses also highlight how imagistic, diagrammatic and/or metaphorical iconicity may manifest within these ensembles. This framework facilitates a more accurate analysis and comparison of iconicity across interactions, modes of communication, and languages. It also facilitates consideration of the question of why we do it, from referential functions through to social functions. By reconceptualising and operationalising iconicity in this way, we can do justice to human social complexity in our efforts to understand how languaging works and why it differs, while advancing

possibilities for a modality-agnostic comparative semiotics that is not limited to our human domains.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

GH and LF conceptualised the study, undertook the literature review, analysed the examples, and detailed the theoretical argumentation. GH wrote 60% of the manuscript. LF wrote 40%. All authors contributed to the article and approved the submitted version.

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Show Me What You've B/Seen: A Brief History of Depiction

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Already at a relatively early stage, modern sign language linguistics focused on the representation of (actions, locations, and motions of) referents (1) through the use of the body and its different articulators and (2) through the use of particular handshapes (in combination with an orientation, location, and/or movement). Early terminology for (1) includes *role playing, role shifting,* and *role taking* and for (2) *classifier constructions/predicates* and *verbs of motion and location*. More recently, however, new terms, including *enactment* and *constructed action* for (1) and *depicting signs* for (2) have been introduced. This article provides a brief overview of the history of enactment and depiction in the sign linguistic literature but mainly focuses on issues related to terminology (and terminology shifts). First, we consider the relation between role shifting and constructed action. We question the idea that these terms can be used interchangeably and rather suggest that they capture different, but related functions. Subsequently, we zoom in on the conceptualization of depicting signs, indicating verbs, pointing signs and fully lexical signs and the relation between these signs and the method of depicting. Where earlier research often associates depicting with the use of specific types of structures, we promote the idea that depicting is a semiotic diverse practice. In doing so, we show that the conceptualization of the different sign types and the terms that are used to refer to these phenomena do not accurately capture the way these signs are used in actual signed discourse and propose a reconceptualization of the different sign types in the lexico-grammar of Flemish Sign Language (VGT) as composite signs that can describe, depict and indicate meaning in various ways. In this way, this article illustrates (1) the risks that may come with the execution of terminology shifts and (2) the importance of making a clear distinction between form and function, i.e., we show that it is important to be careful with assuming a (too) exclusive relation between a certain function and one or more particular forms.

Keywords: semiotics, depiction, role shifting, constructed action, classifier constructions, depicting sign

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Abbreviations: ASL, American Sign Language; Auslan, Australian Sign Language; BSL, British Sign Language; DTS, Danish Sign Language; LSF, French Sign Language; LIS, Italian Sign Language; NTS, Norwegian Sign Language; SSL, Swedish Sign Language; VGT, Flemish Sign Language.

1. INTRODUCTION

Already at a relatively early stage, modern sign language linguistics focused on the representation of (actions, locations, and motions of) referents (1) through the use of the body and its different articulators and (2) through the use of particular handshapes (combined with orientations, locations, and/or motions). Early terminology includes for (1): *role play/playing* (Liddell, 1980; Loew, 1984), *role shift/shifting* (Lentz, 1986; Padden, 1986), *body classifier* (Supalla, 1986), *shifted reference*, *shifted attribution of expressive elements* and *shifted locus* (Engberg-Pedersen, 1993); and for (2): *classifier signs/constructions/predicates* (Frishberg, 1975; Kegl and Wilbur, 1976; Supalla, 1986), but also *verbs of motion and location* (Supalla, 1978), *spatial-locative predicates* (Liddell and Johnson, 1987), *polymorphemic verbs/predicates* (Wallin, 1990; Engberg-Pedersen, 1993), *productive signs* (Brennan, 1992) and *polysynthetic signs* (Takkinen, 1996). As becomes also clear when reviewing the terminology uses, these constructions have been conceptualized as symbolic, i.e., morphologic structures that encode linguistic meaning. More recently, and partly as a result of the rise of Cognitive Linguistics and the increasingly closer links between Signed Language Linguistics and Gesture Studies, new terms have been introduced. The representation of referents through the use of the own body is now also referred to with, for instance, *constructed action* and *enactment/enacting* and the term *depicting signs* was introduced to refer to *classifier constructions*. Evidently there is more to it than simply a new name: many researchers have moved away from the symbolic, morphologic conceptualization of classifier constructions and role shifts and rather suggest that these constructions are (partly) gestural in nature. In doing so, they promote the idea that gesture is an integral part of language (see for instance, Liddell, 2003 for ASL; Vermeerbergen and Demey, 2007 for VGT; Ferrara, 2012; Johnston, 2013; Ferrara and Hodge, 2018 for Auslan, amongst many others, but see – for instance – Garcia and Sallandre, 2020 for a Semiological approach and Lepic and Occhino, 2018 for a Construction Morphology approach).

In this article, we first provide a brief history of the conceptualization of classifier constructions and role shifting, with a particular focus on the terminology. Subsequently, we highlight that adopting new terminology does not always come without risks. When reviewing literature on role shifting, for example, it becomes apparent that it often remains unclear how older and newer terms relate to one another and whether these terms refer to the same concept or function. In part 2 we therefore go into the relation between role shifting and constructed action. In more recent literature, we regularly find statements such as *constructed action, previously known as role shift*. In this article, however, we suggest that these different terms are possibly being used to capture and describe (slightly) different functions in signed language discourse. In part 3, we continue on this line by focusing on the conceptualization of classifier constructions (or depicting signs)[1], indicating verbs and pointing signs, and on the relation between these structures and the method of depicting, i.e., showing. Where researchers traditionally have emphasized a strong relation between depicting and the use of classifier constructions and constructed action, we show that signers have various types of semiotic signs at their disposal when they want to depict meaning. We also question the idea that the main function of a classifier construction or a stretch of enactment is always depiction and we argue that signers can also use these highly iconic structures to mainly describe meaning. In doing so, we show that the theoretical conceptualization of these signs and the terminology used to refer to these mechanisms can be misleading and do not accurately capture how these signs are used in actual signed discourse. In this way, we also show that assuming a (too) exclusive relation between a certain function and a particular form can be problematic. Finally, in part 4 we reflect on the implications of this contribution and put forward some suggestions for future research.

2. THE STUDY OF ROLE SHIFTING AND CLASSIFIER CONSTRUCTIONS: NOW AND THEN

In this first part of the paper, we provide an overview of literature on role shifting/role playing and classifier constructions. Although this review is not exhaustive, it highlights the most important theoretical evolutions, with concomitant terminology shifts, in the field of Signed Language Linguistics and it will provide the necessary theoretical background for parts 2 and 3 of the paper.

2.1. "Role Playing"

Already in the 1970s researchers working on American Sign Language discuss the use of the signer's body to refer to somebody else. According to Friedman (1975) for example, American signers may use their body to mark third person (3P) instead of making an indexic reference. The signer is said to "take on" a third person reference, "in much the same way (conceptually) that the speaker takes on 3P reference in 3P narrative prose in oral language" (1975:950). Friedman points out that this process, i.e., conveying 3P reference by the use of surface 1P forms, is very common in ASL[2] and is most clearly seen when the discourse concerns more than one 3P referent. She presents an example of a mother-child interaction and points out that the signer not only uses the body and/or head to distinguish between the two referents but that he will also "look up (with his head raised) when he assumes the child's role, and will look down (with his head lowered) when he assumes the mother's role" (1975:950).

In publications from the 1970s to 1980s, role playing/role taking/role shifting was mainly associated with reported speech/direct quotation. Somewhat generalized, this is how

[1]We adopt the view that classifier constructions are partly lexical signs (e.g., Liddell, 2003; Ferrara, 2012). However, we use the term "classifier constructions" rather than depicting signs, because part 3 of this article investigates how "depicting" can also be a characteristic of other sign types. We therefore believe that the use of "depicting signs" might be confusing.

[2]See the abbreviations section above for the signed languages that the abbreviations refer too.

it was presented: Like speakers, signers can opt for direct quotation/reported speech to report what someone else said/signed. This implies that the speaker/signer "shifts" in the role of the original speaker/signer and makes the report from the quoted person's point of view. Such role shifting usually involves a shift in body position, facial expression and/or eye-gaze (e.g., Mandel, 1977; Padden, 1986 for ASL). This is then usually illustrated with an example of a dialogue between two people, where "a signer may alternate roles to speak each person's lines in turn, taking one role by shifting his stance (or just his head) slightly to the right and facing slightly leftward (thus representing that person as being on the right in the conversation), and taking the other role by the reverse position" (Mandel, 1977, p. 79). Within the at that time dominant formalist perspective, authors mainly focused on the morphosyntax of the direct quotation and discussed, e.g., agreement markers in verb agreement and the interpretation of pronouns and indexicals.

Liddell (1980), in a chapter on non-manual signals in ASL, introduces "what has been called 'role playing.'" That is, in his example (15) the speaker adopts someone else's point of view when he does this (1980: 25). According to Liddell (1980, p. 25) the following sequence means that Bill *decided* that some other person went to the movies[3]:

	"nod"	
	non-neutral facial activity maintained	
	no eye contact	
(15) BILL	PRO.3	GO MOVIE

This example is highly similar to Liddell's example (16) on p. 26, the only difference being that PRO.3 (third person reference) is replaced with PRO.1 (first person reference). In contrast, however, the latter sentence (with PRO.1) means that Bill decided that *he himself* would go to the movies. This is an interesting example also because it is not a case of reported *speech* in the strict sense, i.e., it is not about what Bill *said/signed* but about what Bill *decided/thought*. Liddell (1980) discusses another example of role playing where the signer takes on the role of a dog. Here "a signer signed DOG, looked from side to side as if checking to see if the coast was clear and then signed FINE, meaning the dog thought, 'fine!' (. . .) (Signed with other non-manual behaviors the sequence could mean, 'The dog is fine')" (Liddell, 1980, p. 56). Liddell refers to Bendixen (1975) who differentiates between the pantomimic "role establishment" and the subsequent "role playing." It is not fully clear to us whether Liddell himself agrees with the analysis that the pantomimic behavior following the sign DOG and preceding the sign FINE is not part of the role playing, as he claims that "adopting a role is common in stories and everyday conversation. It can be used for direct quotation or **for the pantomimic reenactment of an event**" (Liddell, 1980, p. 56, emphasis added).

Despite the frequent linking of role shifting and direct quotation, some of the early publications thus already noted that it is not only about representing the *speech* of a referent but also about thoughts, feelings and (for some authors) actions. Engberg-Pedersen (1993, for DTS), for instance, argues that role shifting is not a sufficiently accurate term, because signers may use the sender locus to refer to one referent, while simultaneously expressing the emotions of another referent. According to Engberg-Pedersen (1993, p. 103), it is important to distinguish between three different functions, i.e.,

- 1. Shifted reference, i.e., the use of pronouns from the quoted sender's point of view, especially the use of the first pronoun 1. p to refer to somebody other than the quoting sender,
- 2. Shifted attribution of expressive elements, i.e., the use of the signer's face and/or body posture to express the emotions or attitude of somebody other than the sender in the context of utterance,
- 3. Shifted locus, i.e., the use of the sender locus for somebody other than the signer or the use of another locus than the locus c for the signer.

Engberg-Pedersen (1993) claims that whereas shifted reference is restricted to reported speech, the other two phenomena can also occur in other types of signing. Building on Tannen (1986), she also indicates that shifted attribution of expressive elements in Danish Sign Language is comparable with the way speakers can change their voice in order to take on characters' voice.

Within the framework of his semiologic model, Cuxac (1985, 2000) distinguishes between two modes of communication: telling without showing (*dire sans montrer*) and telling by showing (*dire en montrant*). Cuxac (1985, 2000) takes the signer's intention as a starting point and argues that if signers want to tell by showing, they can make visible the real life or imaginary experiences and observations through the use of highly iconic structures or transfers. One of these transfers considers the personal transfer (transfert personnel), by which the signer literally takes on the role of the entity he refers to Cuxac (2000, p. 51) proposes the following characterization:

> *Ces structures reproduisent, en mettant en jeu tout le corps du locuteur, une ou plusieurs actions effectuées ou subies par un actant du procès de l'énoncé: humain ou animal le plus fréquemment, mais ce peuvent être aussi des non-animés [...]. Le narrateur "devient," pour ainsi dire, la personne dont il parle, jusqu'à, chez certains locuteurs, lui ressembler physiquement. Pour caractériser ces structures, les Sourds utilisent un signe de leur langue signifiant approximativement "rôle" ou "prise de role."*
>
> (*These structures reproduce, by bringing into play the whole body of the speaker, one or several actions carried out or undergone by an actant of the process: human or animal most frequently, but they can also be non-animate [.]. The narrator* "becomes," *so to speak, the person he is talking about, to the point where, for some speakers, he resembles him physically. To characterize these structures, the Deaf use a sign in their language that roughly signifies "role" or "role-taking"*).

The idea that signers want to show (i.e., depict) actions when physically embodying a referent is also present in literature on American Sign Language. In contrast with Cuxac (1985, 2000), however, the use of the own body to depict actions,

[3]See **Appendix** for transcription conventions.

thoughts or feelings is not conceived as entirely linguistic. When conceptualizing the phenomenon researchers rather also start to consider the role of gesture in signed languages. This becomes, for instance, apparent with the introduction of the notions of *constructed action* and *constructed dialogue* (Winston, 1991, 1992; Metzger, 1995; Liddell and Metzger, 1998). Winston (1991, p. 404), who was inspired by Tannen (1986), considers constructed dialogue as one type of *performative*, i.e., it "shows the actions and persona of the speaker." Performatives include both constructed dialogue and *performance of an action* (1991:400) or *action performatives* (1992:100). In a similar vein, Metzger (1995) suggests that constructed dialogue is one of the various types of constructed action occurring within the discourse. She sees constructed action as a discourse strategy and describes it as "the creative construction of an event described by a signer in ASL discourse" (1995:266).

Liddell and Metzger (1998) and Liddell (2003) conceptualize constructed action within Fauconnier's (1985) Mental Space Theory and the notion of mental space blends (Fauconnier and Turner, 1996). In doing so, they argue that signers can bring referents into real space, i.e., their immediate environment, through the process of blending. When constructing action, signers blend the referent performing the action onto their own body. "Within the context of the blend, the actions of the signer demonstrate the attributes of the character blended with the signer" (Liddell and Metzger, 1998, p. 676). They also suggest that constructed action is gestural in nature and compare this phenomenon with McNeill's (1992, p. 12–14) iconic gestures, i.e., gestures that accompany speech and illustrate concrete actions [see also, for instance, Emmorey (1999, p. 145) on the comparison of constructed action with Clark's (1996) component iconic gestures]. Such approaches illustrate some important developments in the field of Signed Language Linguistics, and in the field of linguistics more generally, i.e., with the rise of Cognitive Linguistics and the introduction of Gesture Studies into the discipline of Linguistics a multimodal and multi-semiotic view of human (spoken and signed languages) was promoted (Garcia and Sallandre, 2020).

Soon after Metzger's introduction of the term "constructed action" in 1995, more and more researchers started to use this notion, often providing their own definition. Some examples are as follows[4]:

- "Gestures intended to illustrate the actions of others" (Liddell and Metzger, 1998, p. 660).
- "Constructed action refers to the gestures that imitate the actions of someone other than the signer at the time of signing" (Johnston and Schembri, 2007, p. 273).
- "Becoming an object"; "the use of the signer's body to depict the actions and movements of an object – whether that object be animate or inanimate" (Quinto-Pozos, 2007, p. 1285).
- "Constructed action thus refers to those gestures and bodily behaviors that are used either (i) at the same time as signing or (ii) instead of signing" Johnston (2013, p. 53).
- "Constructed action (CA, or enactment, also known as role-shift), where the signer uses his or her body (the head, face, arms, and torso) to represent the thoughts, feelings or actions of a referent using the surrounding space on a real world scale" (Cormier et al., 2013, p. 370).
- "That Constructed Action is a stretch of discourse (however, short or long) that represents one role or combination of roles depicting actions, utterances, thoughts, attitudes and/or feelings of referents other than the signer (narrator)" (Cormier et al., 2015, p. 195).

Finally, and also in light of the rise of Gesture Studies, *constructed action* is also often used interchangeably with *enacting gestures* and *enactment*, with the understanding that "*enactment*" includes both constructed dialogue and constructed action (in the narrow sense) (see for instance, Ferrara, 2012; Hodge and Ferrara, 2014). Ferrara (2012, p. 64) defines enacting gestures as "gestures that do (partially) demonstrate actions or events." In a more recent publication, Ferrara and Halvorsen (2017, p. 376) write:

> "Another type of iconic, semiotic action available to speakers (and as we shall see, signers) in their multi-modal communicative repertoire is the practice of demonstrating the thoughts, words, or actions of (real or imagined) referents. These enactments occur when a person recruits any number of articulators, e.g., each of the hands, arms, head, face, shoulders, torso, vocal tract, etc., to produce iconic demonstrations."

From the beginning, there was confusion as to how exactly the term *role-shifting* was understood. Padden (1986) for example, writes: "In a role-shifting structure, third person pronouns are shifted into first person. Role-shifting is marked by a perceptible shift in body position from neutral position (straight facing) to one side and a change in direction of eye gaze for the duration of the *role*" (1986:48). For Padden (1986), body shift and the shifted eye-gaze are ways of marking role shifting rather than (part of) the role shifting itself. For other authors, body posture and eye-gaze do seem to be part of the role-shift and/or changes in body posture are equated with role-shift. The same vagueness can also be found in descriptions of constructed action and enactment. Sometimes these terms seem to concern the specific behaviors/activities of the signers, while elsewhere those behaviors/activities are presented as ways of expressing CA/enactment. Yet other researchers approach CA or enactment more as *stretches of discourse* or as a certain *behavior*.

In the current Signed Language Linguistics literature, (1) *role-shifting*/*role-taking*, (2) *constructed action*/*constructed dialogue* as well as (3) *enactment* are used, sometimes with the same meaning, sometimes not. As shown above, this variety of terms, over the years but also today, is undoubtedly related to different (theoretical) approaches and interpretations. However, the multiplicity of terms also indicates the great complexity of the phenomenon (or phenomena). Cormier et al. (2015, p. 169) note:

[4]An interesting observation here is that some of these definitions also apply to "handling depicting signs," since in the latter constructions too, the signer uses his own hands/arms to refer to actions, often the actions of someone else.

> "Terminology used to refer to this phenomenon varies considerably, and it is often unclear if the same assumptions about its nature are being made by different researchers. It is often not even clear whether these terms are used to refer to the same phenomenon, different aspects of the same phenomenon, or perhaps different phenomena altogether."

In the following sections, we follow up on the ambiguous relation between the concepts of role shifting on the one hand, and constructed action on the other hand. We investigate the relation between the two terms and the concepts they refer to.

2.2. Classifier Constructions

2.2.1. Formalist, Morphemic Approaches: Classifiers

Already in early studies on signed language structures, researchers noted the existence of complex predicates that express a referent's movement and/or location. These constructions have been analyzed in various ways, which in turn has also led to a variety of terms used to identify them, including *classifier*, *classifier predicates,* or *classifier constructions* (e.g., Frishberg, 1975; Kegl and Schley, 1986; Schick, 1990 for ASL; Vermeerbergen, 1996 for VGT), *spatially descriptive signs* (DeMatteo, 1977 for ASL), *verbs of motion and location* (Supalla, 1978, 1990 for ASL), *polymorphemic verbs* (Engberg-Pedersen, 1993 for DTS), *polysynthetic signs* (Wallin, 1990 for SSL), *productive lexicon/productive signs* (Brennan, 1990 for BSL; Vermeerbergen, 1996 for VGT) *depicting verbs* (Liddell, 2003; Dudis, 2004 for ASL), and *depicting signs* (Johnston and Schembri, 2007; Ferrara, 2012 for Auslan). In some of the early studies, these constructions were described as a form of visual imagery, i.e., as non-morphemic, complex, iconic constructions that express referent's movements' and locations (DeMatteo, 1977 for ASL).

However, soon after the start of modern Signed Language Linguistics more formalist, morphemic conceptualizations became dominant. Supalla (1978), for instance, argues that these classifier constructions (or in his words: verbs of motion and location) consist of multiple movement roots combined with movement affixes and possibly also articulator affixes. The movement roots express the existence, location or movement of the noun. Signers can combine these movement roots with movement affixes in order to refer to the manner of movement. In doing so, they can for instance indicate a bouncing movement or a circle path movement. Finally, the articulator morpheme in this model refers to (part of) the signer's hand, which classifies characteristics of the noun referent in the construction, i.e., of the referent that is being located/is moving. In this study, and in other studies that adopt a more formal perspective to the phenomenon, it becomes apparent that the iconic nature of these constructions is downplayed or even ignored. The focus in these studies is rather on the comparability of these classifier constructions with classifiers in spoken languages (see also Schembri, 2003).

2.2.2. Cognitive, Functional Approaches: Morphemic, Yet Iconic Constructions

Engberg-Pedersen (1993 for DTS) approaches classifier constructions, which she refers to with the term *polymorphemic verbs*, from a cognitive, functional point of view. Just like Supalla (1978), she conceptualizes these constructions as morphemic. According to her model, signers combine the verb stem (i.e., the handshape) sequentially and/or simultaneously with multiple movement morphemes, which can express the location, motion, distribution, manner, extension, and/or aspect. Note, however, that there are a couple of important differences in this analysis compared to most of the formalist approaches, including Supalla (1978). First, Engberg-Pedersen (1993) argues that the handshape is the verbs stem, rather than the movement roots (e.g., Supalla, 1978). Second, Engberg-Pedersen (1993) also explicitly argues against the idea that the handshapes (i.e., often referred to as classifiers) are comparable to classificatory verb stems in some spoken languages, like Athapaskan languages. Finally, she also acknowledges the iconic nature of these constructions. In her analysis of the handshape stems, for instance, she distinguishes between different types of stems based on their iconic origins. Whereas whole entity stems iconically represent the entire referent, limb stems refer to the entire referent by presenting its limbs. Moreover, Engberg-Pedersen (1993) also argues that the movement of classifier constructions is often also an iconic rendition of the movement of the referent in the scene talked about. This rediscovery of the iconic nature of classifier constructions becomes also apparent in the work from other cognitive and functional linguists (see also, for instance, Schick, 1990 for ASL; Brennan, 1990 for BSL; Cuxac, 1996, 2000 for LSF; Vermeerbergen, 1996 for VGT).

In the studies discussed so far, researchers have often identified the movement and/or handshape as the basis of the classifier construction. Other parameters (including location, orientation, and non-manual components) are mostly seen as components that can complement the movement and handshape. This is in contrast with the conceptualization of classifier constructions as *'mix' 'n match signs,'* a concept first introduced by Brennan (1990, p. 163):

> (...) mix "n" match involves selecting the component parts and putting them together in appropriate ways in order to create particular kinds of effect.

From this point of view, there are no parameters that lie at the basis of the construction, but rather all parameters are equal to one another. The idea is more that signers create new signs in order to show a particular referent/event. In doing so, they select the parameters they need to prompt that meaning and put them together in the creation of a new sign (Brennan, 1990). From this point of view, classifier constructions are seen as an important part of the productive lexicon and are here also referred to with terms like *productive signs*, *classifier constructions* and *verb/sign constructions* (see for instance, Vermeerbergen, 1996).

2.2.3. Gesture as an Integral Part of Language: (Partly) Gestural Constructions

In more recent studies on classifier constructions, the idea that these constructions are entirely symbolic, i.e., conventional, is questioned. This is parallel to an increased interest in the use of gesture by speakers (see for instance, Goodwin, 1981; McNeill, 1992; Streeck, 1993; Kendon, 2004). Although (some

of the) researchers of the studies mentioned above might have been aware of this evolution, it seems that most of them were initially not eager to adopt a gestural analysis of classifier constructions. One of the arguments was that classifier constructions are by far more complex than gestures and thus these researchers maintained a morphemic conceptualization. The first researchers that adopted a (partly) gestural analysis of classifier constructions were Cogill-Koez (2000 for Auslan), who returns to DeMatteo's (1977) notion of visual imagery and argues that classifier constructions are in fact entirely gestural constructions and Liddell (2003 for ASL) who proposes that classifier constructions, or rather depicting signs, are hybrids of symbolic, i.e., conventional, and gradient, i.e., gestural, properties. We will focus on Liddell's work here, because his conceptualization is – in particular within the group of cognitive and functional signed language linguists – the most widespread and adopted conceptualization today.

Liddell (2003), who takes Mental Space Theory as a starting point (Fauconnier and Turner, 1996; Fauconnier, 1997), suggests that classifier constructions are partly lexical verbs that both encode linguistic meaning and depict meaning. He proposes that signers bring referents, i.e., conceptual entities, into Real Space, i.e., the signer's immediate environment. When using classifier constructions, signers map the referent onto their own hands. Liddell (2003) argues that the handshapes are the more conventional part of the construction, because they can only refer to specific types of entities. The location and/or movement are then seen as the more gradient, i.e., gestural properties of the construction (see however, Ferrara, 2012). Liddell identifies three types of partly lexical classifier constructions: constructions that depict entities at a location, constructions that depict movement and constructions that depict the extent and shape of a referent. In more recent studies, constructions that depict the handling of an object are also added to the list (e.g., Johnston and Schembri, 2007; Ferrara, 2012 for Auslan).

In this section, we have shed light on the most important changes in the thinking about classifier constructions in the last (approximately) 50 years. We have shown that, although initially the iconic character of these constructions was emphasized, soon more formalist, morphemic approaches became more dominant. As a consequence, the importance of iconicity at this level of signed language discourse was downplayed or even ignored. Researchers adopting more formal approaches rather emphasized the comparability of classifier constructions with classificatory verb systems in some spoken languages. Only toward the end of the 1990s, researchers (re)discovered their iconic properties and also questioned the status of the handshapes as morphemes. Finally, as a result of the increased interest in gesture in the study of language, the "linguistic-only" approaches have been replaced with reconceptualizations of these constructions as partly lexical constructions that exhibit both symbolic and gradient properties (but see for instance, Garcia and Sallandre, 2020 for a semiologic approach, Lepic and Occhino, 2018 for a construction morphology approach). This conceptualization of classifier constructions, which is the most wide-spread and adopted approach to date, especially amongst researchers working within Cognitive Linguistics, will also be adopted in this article.

3. ROLE SHIFTING = CONSTRUCTED ACTION?

Part one of this article has shed light onto the different conceptualizations of classifier constructions and role shifting in the literature, thereby also referring to concomitant terminology shifts. In this part of the paper, we further explore the relation between "role shifting" and "role playing" on the one hand, and "constructed action" on the other hand.

In recent literature, we regularly find statements such as the following:

- "CA, or enactment, also known as role-shift" (Cormier et al., 2013, p. 370).
- "A last phenomenon that needs introduction is role shift, or constructed action (CA)" (Boers-Visker, 2020, p. 50).
- "Enactment, also known as constructed action (CA) or role shift; a non-linguistic demonstration of entities and actions; a surrogate real space blend" (Ferrara and Johnston, 2012).

The question we ask here is whether this indeed merely is a matter of modernizing terminology or whether it is possible that these different notions are used to capture (slightly) different phenomena in signed language discourse.

That the notion of *role taking* would be outdated and best replaced by *constructed action* was also suggested in the early stages (around 2013) of the annotation of the Corpus Flemish Sign Language[5]. At a certain point, the team of annotators wondered if it would not be better to create a tier "CA" to replace the tier "role taking." This question was prompted by the adaptation of Johnston's (2011/2013) annotation guidelines for the Auslan corpus, where a tier "CA" is used for the identification of periods of time in which the signer is engaged in constructed action or constructed dialogue. Of course, the proposal to replace the role-taking tier with a CA tier raises the question of whether these two phenomena are truly identical.

As becomes clear from section "Role Playing" of this article, very different definitions exist for these two terms. Given the Flemish perspective of this article, we take the way the phenomena are usually understood in Flanders as a starting point here. The term *rolnemen* (*role taking*) was introduced in Flanders by Van Herreweghe (1995) and Vermeerbergen (1996, 1997). Van Herreweghe (1995, p. 113) uses *rolnemen* (as a translation for *role-taking*) to refer to the ways in which a signer reproduces a previous conversation with someone or reproduces what someone has said. She briefly describes four such "ways": "role-taking by means of body shift," "role-taking through facial expressions and body posture," "role-taking through indexing," and "role-taking through eye-gaze."

Vermeerbergen (1996), who provides the first large-scale corpus study of Flemish Sign Language, starts from Engberg-Pedersen's (1993) three-way division (see section "Role Playing") and suggests to distinguish between *rolnemen* (*role taking*) and *referentiewissel* (*shifted reference*). *Shifted reference* here refers to the organization of spatial grammatical mechanisms as if the referent's location were identical to the signer's actual location while role taking involves "taking over" the role of a referent

[5]www.corpusvgt.be

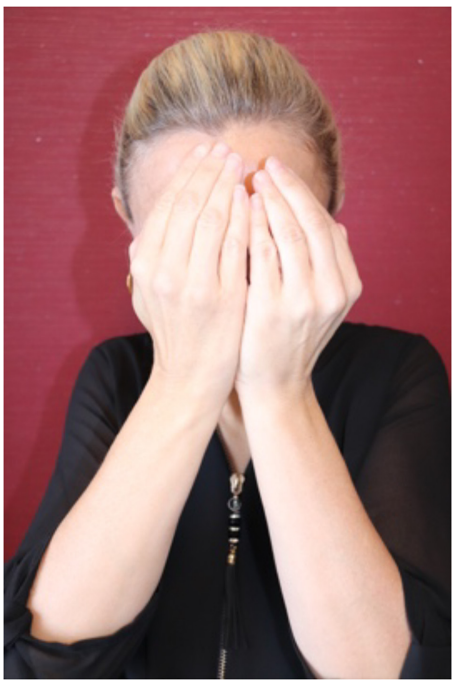


FIGURE 1 | G: COVER-EYES.



FIGURE 2 | G: TAKE-BY-THE-HAND.



FIGURE 3 | G: PUSH-BUTTON.

by means of non-manual behavior. Furthermore, Vermeerbergen (1996, p. 139–140) distinguishes between role taking marked by a body lean in the direction of a previously established locus for the referent (*formal role taking*), and the use of non-manual articulators to adopt a role (*expressive role taking*). She also identifies various degrees of role taking.

In light of her Ph.D. project, Vermeerbergen (1996) also identified the types of gestures that are known as *iconic gestures* (McNeill, 1992 on co-speech gesture) and *constructed action* (Metzger, 1995; Liddell and Metzger, 1998 for ASL). Some examples are: G: COVER-EYES (**Figure 1**), G: TAKE-BY-THE-HAND (**Figure 2**), and G: PUSH-BUTTON (**Figure 3**).

In some cases, these gestures were analyzed as what is now called *depicting handling signs*, i.e., as classifier constructions involving handling classifiers handshapes. When such an analysis was not appropriate, and especially when the gestures were to some extent similar to co-speech gestures, the construction was indeed considered gestural. Within the framework of the Ph.D. research, these were not further analyzed because it was not yet customary to pay too much attention to gesture in (signed) discourse at that time (i.e., beginning of the 1990s). Liddell and Metzger (1998, p. 694) write:

> By the time ASL was demonstrated to be a real human language, virtually all the gesturing done by the hands was considered linguistic and much of the non-manual aspects of the signing were also considered linguistic. Recent analyses of head and body tilts and rotations have also viewed these behaviors as the realization of grammatical elements.

At the start of the annotation of the Corpus Flemish Sign Language manual iconic gestures were annotated in the way proposed in the annotation guidelines of Johnston (2011/2013, p. 34): the capital letter G, followed by a colon and the meaning of the gesture(s). During discussions amongst the annotators, (at least some of) these gestures were referred to by the term *constructed action*, but exactly how the term was interpreted



FIGURE 4 | G: BRICK-A-WALL.

was not entirely clear. At one point it was suggested to make a distinction between CA at the discourse level, where the signer may imitate the expression and/or posture of a certain referent to indicate role, and CA at a lexical level, where gestures and/or bodily behaviors are used instead of signing, e.g., to enact a certain action or posture of a referent and functioning as a predicate, e.g., G: wink [cf., Johnston and Schembri (2007, p. 258–260) on the "carpentry class narrative"] or G: BRICK-A-WALL (**Figure 4**) where the instances of CA might be replaced by lexical or depicting signs. The suggestion further involved calling the first form of CA *role taking*, and the second form simply *gesture* or *enacting gesture* (Vermeerbergen, 2014).

The multitude of definitions and descriptions, with sometimes confusing information as to how exactly the phenomena are understood and analyzed do not make it easier to determine whether role taking and constructed action/enactment are the same or (slightly) different. For example, even within one and the same publication, certain changes in non-manual signals are sometimes called *role shifting* while also being analyzed as "**accompanying** role-shifting," or "**marking** role-shifting" (cf., section "Role Playing"). Below, we present our current approach, bearing in mind that further work and data analysis may reinform our understanding.

First, we propose to distinguish constructed action from constructed dialogue. Then there is the question whether role taking should be distinguished from CA. Central to role taking is, of course, the notion of "role." In older approaches, including discussions of role taking in the literature on Flemish Sign Language from the 1990s, it is argued that body shifts can be used as signaling role (or that body shifts can be interpreted as role shifts), especially when signing about a conversation between two characters. Such episodes/stretches of body shift do not necessarily also involve the use of gestures that demonstrate the actions of the character(s) involved and/or the (re)construction of the facial expression or body position of one or more of the character(s) involved. In other words, in some instances "role shift" is marked by a slight change of the position of the body only, without any form of "enactment." At this moment, i.e., in light of the current state of documentation of VGT, it does not seem appropriate to us to exclude the option that (signaling) role implies only body shift (possibly in combination with shifted reference) and not enactment.

Of course, role taking often involves the signer's use of one or more articulators to "show" ("depict") the actions, thoughts or feelings of a referent, but there are also instances where signers use a gesture/gestures to express a certain action but not necessarily a certain action *of a particular character*. When reviewing the definitions of CA in the literature (cf., "Role Playing"), it became clear that many authors include the idea that the signer is adopting a role. A definition of CA as *"the gestures that imitate the actions of someone other than the signer at the time of signing"* (Johnston and Schembri, 2007, p. 273), for instance, implies that certain gestures can only be interpreted as either actions of the signer at the time of signing or as "belonging" to a character.

We want to suggest that a third interpretation is possible, and that the signer may simply represent a certain action, without assuming a "role" (other than the narrator role). In other words, signers can also use mimetic/iconic gestures as an alternative to an established verb sign or partly lexical classifier construction. This is for example the case in descriptions of recipes or other forms of instructions where signers describe a series of actions to be performed, some expressed by fully-lexical signs, some by partly lexical classifier constructions and some by constructed action or other types of gestures.

A similar three-way split seems possible for CA in combination with speech. Liddell (2003, p. 158) discusses an example [example (11)] where the spoken words "Frank was looking for his keys" are uttered while pressing the palms against shirt pockets, then pants pockets. He writes that "the temporal coordination of the verbal description and the constructed action invites the addressee to interpret the pressing movements of the hands as searching movements. As a result, the message expressed in (11) is much more explicit than provided by the words alone" (Liddell, 2003, p. 158). Liddell continues by stating that in order to understand this example, one must see the speaker's action as Frank's action. "The mental space property 'Frank' has been projected onto the current speaker" (Liddell, 2003, p. 158). We do not mean to claim that this analysis is incorrect but rather that another interpretation is possible. Namely Frank's action is here represented by means of speech and co-speech gesture, without there necessarily being a real-space blend. In other words: the speaker might be using the gesture in order to depict the general action of searching for the keys, without necessarily adopting the role of Frank.

To summarize, we propose to approach role-taking and constructed action as different phenomena, although often

combined. Cormier et al. (2015, p. 195) make a *prima facie* similar suggestion, but they talk about the distinction between constructed action (CA) on the one hand and role shift on the other, and role shift is interpreted as a shift between different roles:

> This may be a shift between a period of narration (narrator role) and a period of non- narrator role (character role) expressed via CA, or between two character roles expressed by CA and determined by the CA articulators.

The importance attributed to "role" or to identifying (character) role in recent studies of CA/enactment may be related to the data that are being analyzed. Very often these concern retellings of picture stories [e.g., *Frog, where are you* (Mayer, 1969)], cartoons (Garfield) or clips from animated movies (e.g., Wallace and Gromit) featuring a limited number of characters actively performing actions. As a consequence, these characters also have a central role in the retellings and it is often (more or less) straightforward to identify the referents that are depicted through, for instance, constructed action. However, in other types of discourse and in particular in more spontaneous conversations, the notions of role and characters might be less prominent and the idea that signers may construct action without necessarily assuming a character role might become apparent more easily.

Finally, although CA is often used to depict actions, postures, attitudes, . . ., signers may also use CA as an alternative for lexical or partly lexical signs with the intention to "simply say" or describe, rather than depict. Imagine a speaker saying "And then he contacted me," while simultaneously imitating holding a phone. Here the gesture adds meaning that is not provided by the spoken message. Especially when there is no simultaneous *shifted attribution of expressive elements*, i.e., no other non-manual articulators that depict some aspect of the action, one might wonder whether the signer aimed to accurately show the action of "calling" or whether he/she rather wants to describe the action, thereby using both speech and co-speech gesture. In other words, the depictive potential of the gesture might be backgrounded. In the next section, we continue on this line and explore the relation between the methods of describing (telling), depicting (showing), and indicating (pointing and placing) on the one hand, and the different sign types in the lexico-grammar of signed languages on the other hand.

4. DEPICTING – FORM OR FUNCTION?

The previous section has illustrated that terminology shifts can come with certain risks. Whereas some authors have used role shifting and constructed action interchangeably, we have proposed that these might be rather two different functions. In this section, we continue on this line by focusing on the conceptualization of partly lexical classifier constructions as "depicting signs" (cf., Liddell, 2003 for ASL) and on how these constructions relate to the methods of describing (telling), indicating (pointing and placing), and depicting (showing). We first provide a brief overview of existing ideas about classifier constructions and constructed action and the relation between those two phenomena and the methods of describing, indicating and depicting. Subsequently, we raise some questions regarding the conceptualization of classifier constructions as depicting signs and their relation with the method of depicting and explore how other sign types (fully-lexical signs, indicating verbs, and pointing signs) can also be exploited to depict meaning. In doing so, we illustrate that some of the current conceptualizations of the different sign types and the terms that are used to refer to these phenomena do not accurately capture the different ways that signers use them in actual language use. Building on insights from, for instance, Ferrara and Halvorsen (2017), Capirci (2018), Ferrara and Hodge (2018), Puupponen (2019) and Beukeleers (2020), we therefore promote the idea that (1) signs in the lexico-grammar of signed languages are best considered as hybrids of descriptive, depictive and indexical properties and (2) that depicting is a semiotic diverse practice and thus that signers can draw on various types of semiotic signs in the construal of depictions.

4.1. Some Early Ideas About Depiction

4.1.1 Classifier Constructions as Depicting Signs

As highlighted in part 1 of this article, Liddell was the first author to reconceptualize classifier constructions as depicting signs, which differ from fully-lexical signs because "in addition to their encoded meanings, these verbs also depict certain aspects of their meanings" (Liddell, 2003, p. 261). In this way, Liddell suggests that these signs are hybrids of descriptive and depictive properties.

4.1.2. Depicting Blends and Surrogate Blends

A second important idea in Liddell's (2003) work is that signers can use partly lexical classifier constructions and/or constructed action in order to create topographical real space blends. On the one hand, signers can create depicting blends, i.e., they can create small-scaled depictions of the event space they refer to in the sign space in front of them. On the other hand, signers can create a life-sized depiction in which they use their own body to depict a referent's actions, thoughts and/or feelings. In this way, signers create a surrogate blend in which they are – in contrast to when they are creating depicting blends – no longer the narrator, but they rather physically become the referent. As such, Liddell (2003) associates the creation of depicting blends with the use of partly lexical classifier constructions and surrogate blends with the use of constructed action, also known as enactment (Metzger, 1995; Liddell and Metzger, 1998; Cormier et al., 2015; see sections "Role Playing" and "Role Shifting = Constructed Action?").

4.1.3. Transfers

Similar ideas with regard to the notion of depiction can be found in studies that adopt a semiological perspective to signed discourse (e.g., Cuxac, 1996, 2000; Sallandre, 2003; Cuxac and Sallandre, 2007; Sallandre, 2007; Garcia and Sallandre, 2019 for LSF). Recall from section "Role Shifting = Constructed Action?" that researchers working within this theoretical framework take the signer's intent as a starting point. They argue that signers can choose between different modes of communication when

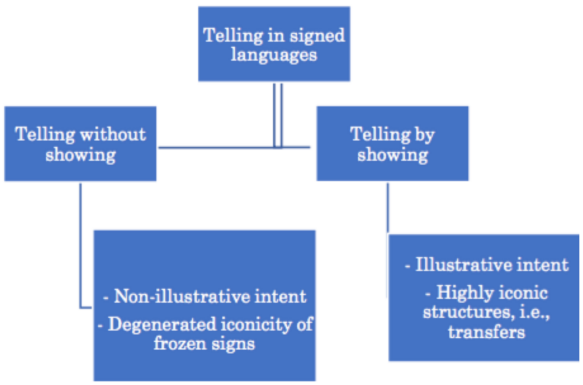


FIGURE 5 | Visualization of the relation between the different modes of communication and different sign types based on Sallandre (2003).

reconstructing experiences through language: telling without showing and telling by showing. With the former, also referred to as the *non-illustrative intent*, signers mainly draw on fully-lexical signs (which they refer to as *standard signs*). When telling by showing, however, signers mainly want to show what a particular referent looks like and therefore rather use different types of *transferts* (transfers), i.e., highly iconic structures through which the signer depicts the referent in the sign space (Cuxac, 1996, 2000; Cuxac and Sallandre, 2007). **Figure 5**, which is based on the illustration of Sallandre (2003), visualizes the relation between the different modes of representation and the different sign types.

Besides the personal transfer discussed in section "Role Playing," Cuxac (2000) also distinguishes between transfers of size and shape and situational transfers. To a certain degree, these types of transfers are comparable to the notion of depicting signs of movement, location, size, and/or shape (Liddell, 2003). Personal transfers, on the other hand, are – to a certain extent – comparable to the concepts of, for instance, bodily enactment (Ferrara and Johnston, 2014 for Auslan) and constructed action (Cormier et al., 2015 for BSL) (see section "Role Playing").

4.2. What About Other Sign Types?

4.2.1. Topographical Use of Signs Space

Although Cuxac (1996, 2000) and Liddell (2003) differ fundamentally in the way they conceive of language, especially with regard to the role of gesture therein, their conceptualizations of the construal of depictions share some interesting similarities. Both researchers mainly associate the method of depicting with the use of classifier constructions and bodily enactment. Both Cuxac and Liddell have had a great impact on the study of depictiopn wihtin the field of signed language linguistics. For instance, when reviewing empirical studies on the construal of depictions, it becomes apparent that most researchers have limited their empirical analyses to the use of partly lexical classifier constructions and/or bodily enactment (e.g., Mulrooney, 2006 for ASL; Perniss, 2007 for DGS; Engberg-Pedersen, 2015 for DTS).

This is striking because there is a large body of research that highlights the topographical use of sign space with other sign types. In other words: researchers working on different signed languages have shown that signers often incorporate topographical information about the referents in the way they structure the sign space with – for instance – pointing signs and indicating verbs, i.e., verbs that are meaningfully directed toward entities, directions, and/or places (Liddell, 2000, 2003; see also Bos, 1990 for NGT; Johnston, 1991, 1996, 2019; De Beuzeville et al., 2009 for Auslan; Engberg-Pedersen, 1993 for DTS; Vermeerbergen, 1996, 2006; Beukeleers and Vermeerbergen, 2017 for VGT; Cormier et al., 2015; Fenlon et al., 2018 for BSL). When modifying the indicating VGT-verb GO-TO, for instance, signers can use the sign space topographically in order to iconically represent the referents' location(s) and movement(s) in the scene under discussion. In this way, they can thus depict the location and/or movement of the referent, i.e., they can show their interlocutor what the event looked like. This supports the idea that signers can also draw on other sign types when they want to depict meaning, i.e., when they want to show what (some aspect of) the referent looks like (see also Vermeerbergen, 2006, 2013, 2016; Ferrara and Halvorsen, 2017; Ferrara and Hodge, 2018; Beukeleers, 2020 for VGT).

4.2.2. (De-)lexicalization Processes

The idea that signers can depict meaning with more conventionalized forms has also been described in terms of (de-)lexicalization processes. It has been argued that classifier constructions and stretches of non-lexical bodily enactment over time can develop into fully-lexical signs (or standard signs), i.e., through repeated use these constructions can acquire an identifiable citation form that prompts the same meaning or set of meanings across different contexts of use (e.g., Engberg-Pedersen, 1993 for DTS; Vermeerbergen, 1996, 2006, 2016 for VGT; Cuxac, 1999, 2000 for LSF; Johnston and Schembri, 1999, 2007, Vermeerbergen, 2016; Johnston and Ferrara, 2012 for Auslan; Shaffer and Janzen, 2002; Janzen, 2012 for ASL). These conventionalized signs, however, do not completely lose their iconic properties and because of that signers can always de-lexicalize them. In other words, they can always re-activate the latent iconicity of these conventionalized signs within a particular context of use in order to show their interlocutors what the referent(s) look(s) like.

The existence of lexicalization and de-lexicalization processes might indeed explain the origins of some of the highly iconic fully-lexical signs and the modification of these conventionalized signs for the purpose of depicting in signed discourse. However, it is not always easy – as an analyst – to determine the degree of conventionalization of a particular token, especially when no extensive lexical databases are available. Moreover, very often there is no historical evidence for all these signs, i.e., there is no empirical data that supports the idea that a particular token over time has developed into a fully-lexical sign (see also Cormier et al., 2012 for BSL, Ferrara and Halvorsen, 2017 for NTS, Beukeleers, 2020 for VGT). So even though (de-)lexicalization processes can often explain how signers use particular signs for the purpose of depiction, it remains difficult to apply this to the actual annotation of signed language data. In this article, we therefore provide an alternative account, i.e., we adopt a

functional, semiotic point of view to the study of signed discourse (e.g., Ferrara and Halvorsen, 2017 for NTS, Capirci, 2018; Ferrara and Hodge, 2018; Slonimska et al., 2021 for LIS; Puupponen, 2019 for FinSL; Beukeleers, 2020 for VGT; see also Clark, 1996, 2003, 2016, 2019; Enfield, 2009; Dingemanse, 2011, 2013, 2014, 2017 for spoken languages). Building on insights from these studies, we suggest that depicting is a method of communication for which signers can draw on various types of semiotic signs. In the following sections, we will elaborate on this recent development by (1) presenting the functional, semiotic framework that has been adopted to the study of depiction and (2) elaborating on the resources that signers can draw on in the construal of depictions.

4.3. Toward a Semiotic Diversity of Depiction: A Functional, Semiotic Account to (Signed) Language

4.3.1. Language as Describing, Indicating and Depicting

Linguists working on both spoken and signed languages have adopted Peirce's (1894, 1955) semiotics to the study of language use. In doing so, they study language as a form of social action in which people rely on a range of different semiotic resources that differ in degree of conventionalization (e.g., Clark, 1996, 2003, 2016; Enfield, 2009; Dingemanse, 2015, 2017; Hsu, 2021 for spoken languages; Ferrara, 2012; Hodge, 2013; Johnston, 2013; Ferrara and Halvorsen, 2017; Ferrara and Hodge, 2018; Puupponen, 2019; Beukeleers, 2020 for signed languages). They thereby consider the different bodily articulators that are at play, such as hands, head and body movements, and eye gaze and analyze how they are brought together in the creation of larger communicative moves, i.e., composite utterances (e.g., Clark, 1996; Enfield, 2009; Ferrara, 2012; Hodge, 2013; Janzen, 2017; Ferrara and Hodge, 2018; Johnston, 2019). This section is limited to a discussion of the methods of describing, indicating and depicting. For recent discussions of Peirce's work itself, we refer the reader to Ferrara and Hodge (2018), Puupponen (2019) and Beukeleers (2020).

Based on the different types of semiotic signs introduced by Peirce (1894, 1955)[6], it has been suggested that people signal meaning through the methods of describing, indicating and/or depicting (e.g., Clark, 1996; Enfield, 2009; Ferrara and Hodge, 2018). When describing meaning, people represent the object categorically, i.e., they communicate by telling. This method has often been described in terms of the use of symbols, such as conventionalized words and fully-lexical signs because they have been associated with their referent by rule and the interlocutor thus needs to interpret the P-sign by decoding its meaning.

The method of indicating entails that people are locating an utterance in space and time by creating an index for the object they refer to Clark (1996, 2003), Enfield (2009), Ferrara and Hodge (2018). The speaker/signer thus uses the P-sign to point toward the object it stands for and, in doing so, he/she anchors the communicative utterance to the real world. Indicating is mainly associated with the use of indices, i.e., partly lexical forms that "glue things together" (Enfield, 2009: 13). People can indicate a referent by means of, for instance, pointing signs and pointing gestures (Clark, 2003; Liddell, 2003; Enfield, 2009; Johnston, 2013), but also with their lips (Clark, 2003; Enfield, 2009), eye gaze and head and body movements (Clark, 2003; Enfield, 2009; Puupponen, 2019 for FinSL).

Finally, the method of depicting allows people to show their interlocutor what the object looks, sounds or feels like (Clark, 1996, 2016, 2019; Enfield, 2009; Dingemanse, 2011, 2014, 2015, 2017; Ferrara and Hodge, 2018; Hsu, 2021). Speakers and signers than create a physical analog of the object in the here-and-now. They thereby combine different elements that stand in for the referents in the depicted scene. Depictions are not interpreted through decoding processes, but rather through the process of imagining: addressees aim to imagine what the object sounds, feels or looks like (Clark, 1996, 2016, 2019; Enfield, 2009; Dingemanse, 2015; Ferrara and Hodge, 2018). The method of depicting is therefore mainly captured in terms of the use of iconic P-signs, such as manual iconic gestures (McNeill, 1992; Kendon, 2004), classifier constructions (Liddell, 2003 for ASL; Johnston and Schembri, 2007, 2010; Ferrara, 2012 for Auslan), and gestural enactment (e.g., Metzger, 1995; Liddell, 2003 for ASL; Cormier et al., 2015 for BSL; McNeill, 1992; Clark, 1996, 2016; Kendon, 2004; Ferrara and Johnston, 2014; Stukenbrock, 2014; Stec et al., 2016 for spoken languages).

As describing, indicating and depicting are methods of communication, they can co-occur within a P-sign. Some P-signs integrate, for instance, the methods of describing and depicting [see Liddell (2003) on partly lexical classifier constructions, Dingemanse (2011, 2014, 2017) and Clark (2019) on ideophones]. Moreover, a large body of research has shown that signers tend to combine different signs of different types in larger communicative moves, i.e., they tend to create larger composite utterances (e.g., Clark, 1996; Enfield, 2009; Ferrara, 2012; Hodge, 2013; Ferrara and Hodge, 2018; see also Vermeerbergen, 1996, 2006 for VGT; Johnston et al., 2007 for Auslan, VGT and ISL, Jantunen, 2008, 2017 for FinSL on the integration of different types of signs in signed utterances). Thus, describing, indicating and depicting are fundamentally different methods of communication, but people tend to combine them in the creation of composite P-signs. In this regard, it should be noted that the co-occurrence of the different methods in various types of P-signs does make it difficult to isolate them and distinguish between them in actual language use.

4.4. Exploring Depicting as a Method of Communication

As highlighted in section "What About Other Sign Types?," depictions are best considered as iconic renditions of the object they stand for, which allow the interlocutor to imagine what the object looks, sounds, feels like (e.g., Clark, 1996, 2016, 2019; Enfield, 2009; Dingemanse, 2015; Ferrara and Hodge, 2018). A review of the Signed Language Linguistics

[6] Peirce (1894, 1955) conceptualizes a semiotic sign as tokens that refer to an object and are addressed to someone. P-signs, i.e., signs in Peirce's understanding of signs, are thus in a tripartite relation between the sign (a form), the object it stands for and the interpretant (the reaction after a sign is interpreted as a P-sign). Based on the relation between the sign and the object, Peirce distinguishes between symbols, icons and indices.

on this topic, has revealed that the construal of depictions has mainly been associated with and analyzed by annotating less conventionalized, less conventional, highly iconic structures, i.e., classifier constructions and constructed action. Indeed, even researchers who take the signer's intent as a starting point analyze depiction by singling out these particular sign types. In this section, we move away from this approach by taking the semiotic framework as a starting point. In doing so, we revise existing analyses of the different sign types and argue that depicting is a property of different sign types (section "Depicting as a Property of Different Sign Types"). In other words, we argue that signers have a range of different semiotic resources at their disposal in order to depict meaning. Moreover, we also question the idea that the main function of a classifier construction, also known as a depicting sign, is always depiction. In section "Describing With Partly-Lexical Classifier Constructions," we rather suggest that these constructions too are best analyzed within their particular context of use because signers can use them to describe, indicate and depict meaning in varying degrees.

4.4.1. Depicting as a Property of Different Sign Types

In this section, we illustrate that signers can use different types of signs in the construal of depictions. While reviewing the different sign types, we show that describing, indicating and depicting are properties of different sign types, regardless of their degree of conventionalization.

4.4.1.1. Fully-Lexical Signs

Ferrara and Halvorsen (2017 for NTS) were the first sign language linguists that have adopted the functional, semiotic framework in the analysis of depictions with conventionalized form-meaning pairings. Building on insights from Dingemanse's (2015, 2017) analysis of ideophones, they propose that iconic fully-lexical signs integrate both descriptive and depictive properties which can be made manifest to varying degrees. Below, we will illustrate their analysis with two different uses of the fully-lexical sign TREE in VGT. This first example is taken from a retelling of the narrative "Frog, where are you?" (Mayer, 1969) in the Corpus VGT (Van Herreweghe et al., 2015). The signer is elaborating on the scene where the boy and the dog find a tree log in the woods.

Example 1

GLOS RH TO-SEARCH+++//TO-HAVE
GLOS LH TO-SEARCH+++//

GLOs RH CL: tree-log TREE
GLOS LH CL: tree-log TREE
#Figure 6

GLOS RH FLS: falling-tree
GLOS LH FLS: falling-tree
#Figure 7

———-

Translation The boy continues searching. There is a fallen tree on the ground.

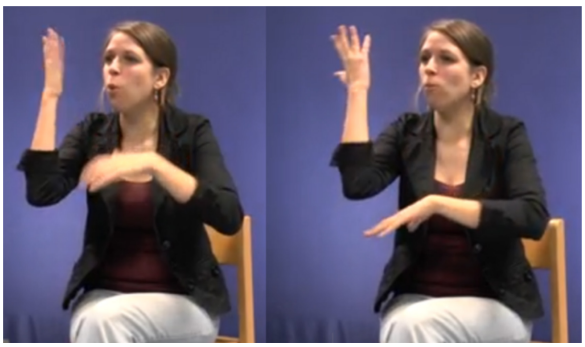


FIGURE 6 | The fully-lexical sign TREE in its citation form, as produced in example 1. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).

According to Ferrara and Halvorsen (2017 for NTS), iconic fully-lexical signs, like the sign TREE, are composites of depictive and descriptive properties. The descriptive properties can be traced back to the fact that they are conventionalized form-meaning pairings. The depictive properties, on the other hand, lie in the iconic nature of these signs. Within a particular context of use, signers can foreground one of both functions. In the first instance of the sign TREE (**Figure 6**), for instance, the signer uses the sign in its citation form, i.e., she produces it on a neutral location in the sign space and with a hand-internal movement only. This manual sign is accompanied by the conventional mouthing "boom," which describes the meaning tree. In the second instance, however, the signer produces the sign with a downward movement that depicts how the tree falls down. Moreover, the signer "adds sound" to the depiction by simultaneously blowing air out of her mouth and bulging her cheeks. From a functional, semiotic point of view, it can then be argued that the signer foregrounds a descriptive reading when using the citation form (**Figure 6**), i.e., she mainly uses the sign in order to tell about the referent. When modifying the token in a way that it depicts the falling movement, however, she foregrounds a depictive reading (**Figure 7**).

Building on these insights, we suggest that iconic fully-lexical signs that can be placed meaningfully in the sign space are also best understood as composites of descriptive, depictive and indexical properties that can be made manifest to varying degrees (cf., Beukeleers, 2020 for VGT). Consider the following example:

Example 2

GLOS RH PS_a DARK//$MOON_a$//
#Figure 8
GLOS LH DARK//
Translation It is dark outside and the moon is out there.

In this excerpt, the signer is setting up the scene. She mentions it is dark outside and subsequently uses the fully-lexical sign MOON in order to say that the moon is already out there. As she thus uses a conventionalized form-meaning

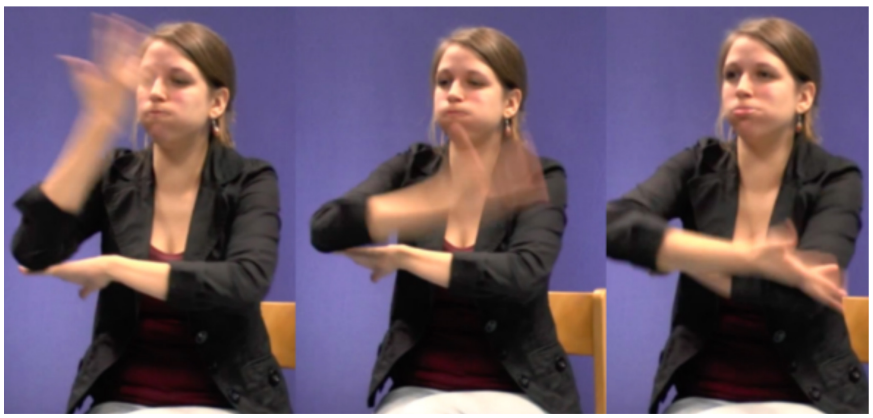


FIGURE 7 | The modified fully-lexical sign FLS: tree-falls-down, as produced in example 1. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).



FIGURE 8 | Fully-lexical sign MOON which is modified in order to indicate and depict its location, as produced in example 2. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).

pairing and combines the manual production of the sign with the conventional word "moon" in Dutch (maan), the signer accurately describes the meaning of the referent she is introducing. However, the sign MOON is also an iconic sign that also depicts its shape. Just like the fully-lexical sign TREE, the sign MOON is thus best conceptualized as a hybrid of depictive and descriptive properties. Within this particular context of use, the signer modifies the sign and places it higher up in the sign space (see **Figure 8**). In this way, the signer does not only depict the referent's shape, but also indicates its location. Hence, the sign MOON is therefore best conceptualized as a composite of descriptive, depictive and indexical properties that can be made manifest to varying degrees. In this setting the signer is setting up the space and in doing so, she is showing what the boy's bedroom looks like. She places MOON higher up than its location in the citation form, and on the right side of the sign space. This locus reflects the position of the moon from the boy's vantage point in the original narrative. Thus, by localizing the moon, she does not only indicate this referents' position, but also depicts its location in the scene. The depictive function of this token becomes also apparent when considering the sign lengthening of MOON. Within this usage event, we therefore suggest that the signer foregrounds the depictive and indexical properties of MOON. This is also supported by the fact that the signer gazes in the direction of the projected referent.

4.4.1.2. Indicating Verbs and Pointing Signs

Continuing on this line, we also aim to explore other sign types that signers can draw on when building a depiction. Based on research on the motivated, often topographical use of sign space in various signed languages, we argue that signers can also use indicating verbs and/or pointing signs to depict movements and/or locations. In doing so, we counter the idea that these sign types are merely hybrids of descriptive and indicative properties, an analysis first proposed by Liddell (2000, 2003). Rather, indicating verbs, just like iconic fully-lexical signs, consist of depictive, descriptive and indexical properties that can be fore- or backgrounded to varying degrees (cf., Beukeleers, 2020).

The example below illustrates how a signer can use a pointing sign in order to create a depiction.

Example 3

GLOS RH BOY TO-SEARCH

GLOS RH CA: searching// TO-

GLOS RH HAVE DS: molehill//
GLOS LH DS: molehill//

GLOS RH SAME FS: M-O-L



FIGURE 9 | DS: molehill – classifier construction that depicts the shape of the molehill. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).



FIGURE 11 | Modified fully-lexical sign HOLE. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).



FIGURE 10 | Modified fully-lexical sign IN. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).



FIGURE 12 | PS_a – pointing sign that traces the shape of the molehill. Figure reproduced with permission from Corpus VGT (Van Herreweghe et al., 2015).

GLOS LH SAME
GLOS RH DS: molehill/
GLOS LH DS: molehill—
Figure 9

GLOS RH BUT INa HOLEa PSa - -
GLOS LH - - - - - - - - - - - - - - -
Figures 10–12

GLOS RH SAME DS: molehill- - - - - -

GLOS RH CA: looking-in-molehill//

Translation The boy is searching for the frog. He looks in a hole in the ground, in a molehill.

In this excerpt, the signer introduces the molehill in the woods. She sequentially and simultaneously combines different types of semiotic signs in order to depict the scene. Toward the end of the excerpt the signer uses a classifier construction that traces the shape of the molehill (**Figure 9**), holds the sign and subsequently modifies the signs IN_a and $HOLE_a$ in relation to the molehill (**Figures 10**, **11**). Finally, she uses a pointing sign that traces the opening of the molehill (**Figure 12**). The signer therefore uses a more conventional index-handshape that points toward its referent. In this way, the pointing sign is simultaneously describing and indicating meaning. However, in this particular context of use the signer produces the pointing sign with a circular movement. In this way, the signer emphasizes the form of the opening of the hole in the original narrative and thus foregrounds a depictive reading.

In a similar vein, signers can use indicating verbs to describe, indicate and/or depict (some aspect of) their meaning. In the following example, the signer is reconstructing the scene where the boy is searching for the frog. In doing so, she also uses a modified token of the indicating verb TO-LOOK-AT.



FIGURE 13 | Modified indicating verb TO-LOOK-AT, as produced in example 4.



FIGURE 14 | Stretch of constructed action (CA: walking-deer), as produced in example 5.

Liddell (2000, 2003) was the first linguist to analyze indicating verbs as descriptive-indexical hybrids. TO-LOOK-AT, for instance, is a verb with a recognizable citation form that prompts the same meaning across different contexts of use, i.e., it accurately describes the meaning of "looking." Signers can, however, modify this verb in order to point toward the entity that is being looked at (e.g., **Figure 13**). Liddell (2000, 2003) therefore argues that these verbs do not only describe meaning, but also indicate meaning. This analysis, however, does not always capture how signers use indicating verbs in signed discourse, like in the excerpt below.

Example 4

GLOS LH OUTSIDE TO-SEE TO-SEARCH
FROG IV: looking-around
#Figure 13————

Translation The boy is outside, searching for the frog.

In this example, the signer is enacting how the boy is searching for the frog. During this period of enactment, the signer also produces a modified token of the indicating verb IV: looking-around (**Figure 13**). Within this context of use the signer thus uses a conventional token that describes the meaning of "looking." In this excerpt, however, the signer does not use the indicating verb to point toward a particular location or entity, but she rather produces the verb with a sideward movement that shows how the boy is looking around in order to find the frog. In doing so, the signer thus accurately describes the action of the boy (i.e., looking), but also depicts the searching trajectory of the boy. The indicating verb IV: looking-around presented in **Figure 13** is thus best understood as a token with descriptive, indexical and depictive properties that is modified in order to foreground a depictive, and to a lesser extent also a descriptive reading. The indicative properties are rather latent.

4.4.2. Describing With Partly Lexical Classifier Constructions

In the previous section, we have shown that the construal of depictions in signed discourse cannot be captured accurately when looking at the use of partly lexical classifier constructions, i.e., depicting signs, and constructed action or enactment only. Rather, signers have a toolbox with different types of semiotic signs which they can manipulate within a particular context of use



FIGURE 15 | Classifier construction that traces a flat surface in the reconstrual of a cliff.

in order to foreground the descriptive, depictive and/or indexical reading. This semiotic account of depiction does then also have certain implications for the analysis of partly lexical classifier constructions. Recall from section "Classifier Constructions" that Liddell (2003) has conceptualized classifier constructions (or rather depicting signs in his terminology) as hybrids of descriptive and depictive properties. According to him, these signs thus differ from fully-lexical signs because they do not only encode linguistic meaning, but also exhibit more gradient properties that depict some aspect of their meaning. In section "Some Early Ideas About Depiction," we have already shown that many researchers have emphasized the iconic nature of these constructions and that they have mainly been associated with the method of depicting.

From a functional, semiotic point of view, however, we may ask the question whether this conceptualization accurately captures the variety in the use of these constructions in signed language discourse. First, it is well-known that signers often place classifier constructions meaningfully in the sign space in order to reflect the position of the referent(s) in the original narrative (e.g., Liddell, 1990, 2003 for ASL; Engberg-Pedersen, 1993 for DTS; Vermeerbergen, 1996; Beukeleers and Vermeerbergen, 2017 for VGT; Johnston and Schembri, 1999, 2007 for Auslan). Within the semiotic account, classifier constructions are then not only describing and depicting, but also indicating.

Second, the question also arises whether signers indeed always mainly want to depict meaning when using these constructions (cf., Vermeerbergen, 2013, 2016; Beukeleers, 2020 for VGT). A first important consideration here is the existence of lexical gaps in, for instance, Flemish Sign Language (Van Herreweghe and Vermeerbergen, 2003; Vermeerbergen, 2013). If a signer wants to describe a referent, but there is no conventionalized form-meaning pair available, he/she will have to rely on other sign types to do so. If he/she then chooses to use a partly lexical classifier construction, does that by definition imply that he/she mainly wants to depict meaning? Or can he/she foreground the depictive properties? Moreover, if a signer does not know a fully-lexical sign for a particular concept, can't he/she then also use a



FIGURE 16 | Classifier construction that traces the shape of the cliff.

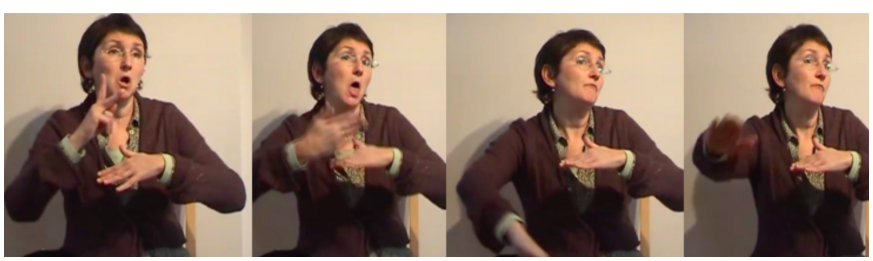


FIGURE 17 | Fingerspelling "K" and repetition of classifier construction that traces the shape of the cliff.

partly lexical classifier construction and foreground a descriptive reading of that token? Finally, when annotating VGT data, it becomes clear that signers use the same or similar classifier constructions in various ways. Moreover, there also seems to be intrapersonal variation in the use of classifier constructions.

Considering these critical remarks, we rather argue that partly lexical classifier constructions are composites of descriptive, depictive and indexical properties that can be fore- or backgrounded within a particular usage event. Signers can thus manipulate these constructions in order to meet their communicative aims. Example 5 below shows how a signer uses a similar partly lexical classifier construction in various ways, i.e., how the signer foregrounds different functions with the various constructions.

Example 5

GLOS LH DEER CA: walking-deer//
GLOS RH DEER CA: walking-deer//
#**Figure 14**- - - - - -
GLOS LH DS: flat-surface-cliff//
GLOS RH DS: flat-surface-cliff//OPEN
#**Figure 15**- - - - - - - -

GLOS LH DS: shape-cliff
GLOS RH DS: shape-cliff
#**Figure 16**- - - - -

GLOS LH FS: K DS: shape-cliff
GLOS RH DS: shape-cliff
#**Figure 17**- - - - -

GLOS LH DEER CA: bowing-down//
GLOS RH DEER CA: bowing-down//

Translation The angry deer is walking toward a vertical rock exposure, toward a cliff. It then throws the boy in the cliff.

In the excerpt above, the signer is reconstructing the cliff in the story "Frog, where are you?" In doing so, she uses different partly lexical classifier constructions that trace the shape of the cliff. First, she uses a flat B-handshape to trace a flat surface, i.e., the onset of the cliff (**Figure 15**). She continues with the fully-lexical sign OPEN and then traces the steep slope of the cliff (**Figure 16**). The classifier constructions contain the more conventional B-handshape and thus describe some aspect of their meaning. Yet, as this is an iconic handshape and it is in both cases combined with a more gradient movement that traces the shape of the cliff, the classifier constructions also depict some aspect of their meaning. The fact that the signer uses two constructions that each depict a different aspect of the rock formation and that these constructions are also sequentially combined with the fully-lexical sign OPEN, might be interpreted as cues that the iconic features, i.e., the shape of the cliff, are foregrounded. In other words, the signer emphasizes what the cliff looks like and thus emphasizes a depictive reading.

This is slightly different for the final classifier construction, presented in **Figure 17**. The signer first fingerspells the letter "K" and subsequently repeats the classifier construction that traces the slope of the cliff, while simultaneously mouthing the Dutch word for cliff (klif). Just like the previous classifier constructions in this excerpt, the token is best understood as a composite, semiotic sign that integrates descriptive, depictive and indicative properties. Within this particular context of use the signer uses both conventional fingerspelling and mouthing in order to narrow down the potential meaning of the construction and thus to specify what the object exactly is. Hence, the signer accurately describes what the construction stands for and she thus foregrounds a descriptive reading.

4.4.3. Summary

In sum, we have shown that the methods of describing, indicating and depicting in the sign linguistic literature have mainly been associated with the use of particular sign types, i.e., fully-lexical signs, indicating verbs + pointing signs, and partly lexical classifier constructions (i.e., depicting signs) + constructed action, respectively. Focusing on the relation between form and function, we have argued that depiction is a semiotic diverse practice (cf., Ferrara and Halvorsen, 2017; Ferrara and Hodge, 2018; Beukeleers, 2020; see also Clark, 1996, 2016, 2019; Dingemanse, 2011, 2014, 2015, 2017; Hsu, 2021 for spoken languages). In other words: we have shown that when signers want to depict meaning, they have different types of signs at their disposal, which they can manipulate in various ways in order to describe, indicate and/or depict to varying, but complementary degrees. Continuing on that line, we have also questioned the idea that the main function of a classifier construction is always depicting (cf., Vermeerbergen, 2013, 2016; Beukeleers, 2020 for VGT) and we have shown that signers can also foreground a descriptive reading of partly lexical classifier constructions, i.e., they can tell about the referent without emphasizing its iconic characteristics in a particular usage event.

In that way, this section thus also indicates that it might be misleading to name particular forms after functions. The researcher(s) introducing a term like "indicating verbs" might be aware of the fact that other types of signs can also be used to indicate meaning or that these signs do not always have to indicate. However, this nuance can easily fade away in later publications and what is mainly left is a term that does not always capture the way signers use these signs in actual signed discourse.

5. CONCLUSION

In this article, we have presented a brief overview of the study of partly lexical classifier constructions/depicting signs on the one hand, and role shifting/constructed action/enactment on the other hand. In the first part of this article, we shed light on the evolutions in the conceptualization of these phenomena and the concomitant terminology shifts. While doing so, we have shown how the symbolic, morphologic conceptualizations of role shift and classifier constructions have been reconsidered and

how more recently, especially in work of researchers working from a cognitive, functional point of view, these constructions have been reconceptualized as (partly) lexical constructions. In doing so, they have promoted the role of gesture in language and rediscovered the importance of iconicity in signed discourse. Along with these theoretical evolutions, we have shed light on the terminology shifts in the literature. In more recent studies, classifier constructions are more often referred to with the term "depicting signs" and role shifting with, for instance, "constructed action" and "enactment." Many authors seem to imply that these older and newer terms can be used interchangeably.

In part 2, we have shown that these terminology shifts can come with certain risks. We pointed out that care should be taken when replacing older terms that have often been taken from studies adopting more formal approaches with newer terms that come from Cognitive Linguistics and Gesture Studies. Do the new terms indeed refer to the same mechanisms and/or functions? And are they thus indeed comparable? Or might it be that the terms refer to different mechanisms and/or functions? We have illustrated the importance of these questions in our discussion of the relation between role shifting and constructed action. Whereas it was sometimes assumed in recent studies that these terms concern the same function, we have shown that signers can take on a character role by (1) means of body and/or eye gaze shifts only, or (2) by means of other non-manual articulators depicting the actions, thoughts, feelings or utterances of a referent, i.e., through constructed action. Signers can thus use constructed action to take a role, i.e., to depict the actions of a particular character. This latter practice is very often reported on in studies on CA and is often integrated as a feature of CA in the definitions. However, we have also highlighted that signers can construct action without actually adopting a character role. Therefore, we have argued that CA and role shifting are different, but related functions.

Finally, we have explored the relation between the functions of describing, depicting and indicating on the one hand, and prototypical forms that have often been associated with them, i.e., (1) fully-lexical signs, (2) partly lexical classifier constructions (i.e., depicting signs) and constructed action, and (3) indicating verbs and pointing signs, respectively. Focusing on the method of depicting, we have argued that signers can use different types of signs in order to depict meaning. In other words, signers can modify fully-lexical signs, indicating verbs and pointing signs in order to foreground the depictive and/or indexical properties in order to show their interlocutor what the (imaginary) event exactly looks/looked like. On top of that, we also showed that the main function of a stretch of enactment or a partly lexical classifier construction does not always have to be depicting. Signers can manipulate these tokens too in order to foreground a descriptive (and indexical) reading. We thus argue that fully-lexical signs that can be modified for movement and/or location, indicating verbs, pointing signs and partly lexical classifier constructions (i.e., depicting signs) exhibit descriptive, depictive and indexical properties that can be made manifest to varying degrees (cf., Ferrara and Halvorsen, 2017 on iconic signs in NTS, Beukeleers, 2020 on VGT). These sign types should thus be analyzed within their context of use in order to accurately capture their main function(s). With these reconceptualizations, we also highlight the importance of making a clear distinction between form and function and we emphasize that is important to be cautious when assuming a (too) exclusive relation between a certain function and particular forms.

We have written this article based on our experience with the analysis of Flemish Sign Language data. It remains an open question whether all our ideas are applicable to all other signed languages. We should keep in mind that signed languages may differ here cross-linguistically [see also Quer (2018) on quotational and non-quotational role shift in different signed languages]. However, we believe that this article provides an important contribution to the field of Signed Language Linguistics as the sign types we discussed, including constructed action and partly lexical classifier constructions, occur in other signed languages as well and it thus opens doors for cross-linguistic comparison. Important questions that arise then are, for instance: Are constructed action and role shift two different functions in all signed languages? Or are there rather signed languages for which it can be argued that they are one and the same function? Moreover, our reconceptualization of depiction also creates opportunities to analyze which resources signers actually use when building depictions and to compare this cross-linguistically.

AUTHOR CONTRIBUTIONS

MV and IB conceptualized the study and wrote part 1 together. MV mainly focused on the literature on role shifting and IB on the literature on classifier constructions. MV took the lead in drafting part 2 of the manuscript. IB took the lead in drafting parts 3 and 4, and conclusion. Both authors have provided feedback on the different parts of the manuscript and worked on the revision.

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APPENDIX

Transcription conventions

WHAT	GLOS, i.e., the English word used to refer to the meaning of a VGT sign.
PS	Pointing signs.
PRO.3	Pronominal pointing sign that refers to a third person.
DS	classifier constructions (i.e., depicting sign).
FLS: leaving-bedroom	Modified fully-lexical sign that depicts movement and/or location.
IV: going-to	Modified indicating verb to depict movement and/or location.
#**Figure 2**	Illustration of depiction in the transcript as shown in **Figure 2**.
/	syntactic or prosodic break in the utterance.
//	End of the basic discourse unit.

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Negation and Negative Concord in Georgian Sign Language

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Negation is a topic that has received considerable attention ever since the early days of sign language linguistics; also, it is one of the grammatical domains that has given the impetus for sign language typology. In this paper, we offer a typological and theoretical contribution to the study of sign language negation. As for the typological side, we add Georgian Sign Language (GESL) to the pool of languages investigated. Our description reveals that GESL displays a number of typologically unusual features: a considerable number of negative particles, including emphatic, prohibitive, and tense-specific particles; specialized negative modals; and a wide range of possibilities for Negative Concord (NC) involving two manual negative signs, including a unique tense-specific instance of NC. Most of the patterns we report—available negative particles, their clausal position, and NC possibilities—are clearly different from those attested in spoken Georgian. As for the theoretical contribution, we investigate how the highly complex GESL negation system compares to existing taxonomies of NC and Double Negation systems, and we conclude that GESL aligns with certain languages that have been classified as atypical NC languages.

Keywords: negation, negative concord, Georgian Sign Language, modality, tense, sign language typology

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INTRODUCTION

Even after 60 years of linguistic study, many aspects of the grammars of natural sign languages still have either not been thoroughly investigated at all, or only for a small number of (mostly Western) sign languages. Clausal negation, however, is a domain of grammar that has been comparably well studied for a fair number of sign languages from different geographical regions, including some so-called village sign languages. Actually, next to interrogatives, negation is one of the domains of grammar that gave the impetus for sign language typology, a young and thriving research field (Zeshan, 2004a,b, 2006; De Vos and Pfau, 2015; Zeshan and Palfreyman, 2017). Notably, clausal negation is also a prominent domain of inquiry in spoken language typology (e.g., Payne, 1985; Dryer, 2005; Miestamo, 2005; Dahl, 2011). Efforts have been made to compare the realization of clausal negation across language modalities, that is, to investigate in how far patterns attested in sign languages (visual–spatial modality) fit, or do not fit, into typological classifications put forward on the basis of a large number of spoken languages (auditive-vocal modality). Despite the use of resources that appear to be modality-specific, such as non-manual markers (for example, brow, head, and torso movements; *cf.* Pfau and Quer, 2010), it has been suggested that typological classifications can be applied to sign languages (e.g., use of negative particles and affixes and French-style split negation (*ne … pas*); *cf.* Pfau, 2008, 2015; Gökgöz, 2021). However, this does not exclude the possibility that we also find

patterns that are either specific to sign languages as a group (i.e., modality-specific patterns) or to a particular sign language.

In this paper, we add to the typological picture data from Georgian Sign Language (GESL), an as yet understudied sign language. On the one hand, we sketch how basic clausal negation is realized in this language, and we conclude that GESL can be classified as a sign language of the manual dominant type. On the other hand, we zoom in on the interaction of negation with other grammatical categories, namely, tense, aspect, and modality. It is the latter domain of inquiry that presents us with some typologically unique features—unique not only in comparison with other sign languages, but also in comparison with spoken languages. Throughout, we include in the presentation various types of Negative Concord that are attested in the language.

In the remainder of the introduction, we briefly introduce GESL and sketch some general characteristics of sign language negation. In "Negation in Spoken Georgian", we describe how clausal negation is realized in spoken Georgian. This is important, as it will allow us to evaluate whether certain patterns that we identified in GESL are possibly the result of language contact. In "Methodology", we explain our methodology. In "Word Order and Basic Negation in GESL", we then turn to a description of word order facts and the realization of basic negation in GESL. The complex patterns of interaction of negation with tense, aspect, and modality, including various types of Negative Concord, are detailed in "On the Interaction of Negation With Tense, Aspect, and Modality". In "Discussion", we investigate how the highly complex GESL negation system compares to existing taxonomies of Negative Concord and Double Negation systems.

Georgian Sign Language

GESL is the sign language used by Deaf and hard-of-hearing people in Georgia. At present, it is unknown how many people use GESL for communication in daily life, but it is estimated that at least 2,500 people use GESL on a regular basis. In the Georgian constitution, GESL is not mentioned as an official language of Georgia. However, in recent years, GESL has received more and more official recognition—also thanks to linguistic research on the language. It is, for instance, mentioned in various governmental documents of the State Language Department and of the Ministry of Education and Science. It is also the official language of instruction at the three deaf schools in Tbilisi, Kutaisi, and Batumi.

Before becoming independent in 1991, Georgia was part of the Soviet Union, and it is therefore not surprising that GESL has been influenced by Russian Sign Language, especially at the lexical level—similar to other sign languages in former parts of the Soviet Union. This influence notwithstanding, the available evidence suggests that GESL is an independent language, which has actually been gaining strength in recent years, emancipating itself from the Russian Sign Language influence—also thanks to activities of the local Deaf community.

To date, only a few linguistic studies on GESL are available. In 2012, an overview of the language, including sociolinguistic information and a sketch of its grammar, has been published (Makharoblidze, 2012), followed by the publication of a GESL-Georgian dictionary with 4,000 entries (Makharoblidze, 2015a; see http://gesl.iliauni.edu.ge/ for the online version). As for studies on aspects of GESL grammar, Makharoblidze (2015b) describes the use of a number of indirect object markers, Makharoblidze and Pfau (2018) address the interaction of negation with tense (which is also part of the present study), and Makharoblidze (2019) provides an overview of verbal morphology.

Sign Language Negation

As mentioned before, the fact that negation is comparably well studied for sign languages—for individual sign languages as well as from an intra-modal comparative perspective—allows us to extract certain recurring typological patterns. We start by noting that all sign languages studied to date employ manual negative markers as well as non-manual markers, mostly a side-to-side headshake, in the realization of clausal negation. The way in which these two types of markers interact, however, has been shown to be subject to language-specific rules (Pfau and Quer, 2002; Zeshan, 2004a; Pfau, 2015, 2016).

First, in some sign languages, the use of a manual negative element is optional. In Sign Language of the Netherlands (*Nederlandse Gebarentaal*, NGT), for instance, the negative particle NOT may be used (1a,b), but clausal negation is more commonly realized by means of only a headshake, which simultaneously accompanies one or multiple manual signs (1c; Oomen and Pfau, 2017, p. 21, 23). In contrast, it is not possible to negate a clause only by means of NOT, i.e., without headshake. The corpus-based study by Oomen and Pfau reveals that the negator NOT mostly follows the verb (1a) but may also precede the VP (1b; Oomen and Pfau, 2017, p. 22). Furthermore, the headshake ("hs") always accompanies NOT, and, in the absence of NOT, at least the verb, but it may also spread onto the object and/or clause-final pointing signs, like the repeated subject pronoun in (1c).[1]

(1) a. INDEX$_1$ POINT UNDERSTAND **NOT** [NGT]
hs
'I don't understand/get the point.'

b. INDEX$_1$ ACTUALLY **NOT** LEARN
hs
'I'm not going to learn (it).'

c. INDEX$_1$ INDEX REACT INDEX$_1$
hs
'I don't react to it.'

Sign languages like NGT, in which the use of a manual negative particle is optional and spreading of the headshake

[1]We adopt common conventions for glossing sign language examples. Signs are glossed in SMALL CAPS; the gloss INDEX represents a pointing sign, POSS a possessive pronoun; when two words are necessary to gloss a single sign, these are separated by a period (e.g., NOT.YET); the symbol "^" indicates cliticization; subscript numbers next to INDEX or a verb sign represent loci in the signing space (1 = on or close to signer's body and 3 = in neutral signing space); and lines above the gloss indicate the presence of a non-manual marker (in all our examples a headshake), the length of the line showing the scope of the marker.

is possible, are referred to as "non-manual dominant" sign languages. Clearly, in sign languages of this type, the headshake carries negative force, as it can negate a proposition by itself, and it has therefore been suggested that examples like (1a, b) exemplify Negative Concord involving a manual and a non-manual negative marker (Pfau, 2016); see "Discussion" for further discussion.

This contrasts with "manual dominant" sign languages, in which the use of a manual negative sign is obligatory. Still, sign languages of this type also employ a headshake (or sometimes a backward head tilt), but this non-manual marker usually only accompanies the manual negator. The examples in (2) show that Italian Sign Language (LIS) belongs to this latter group. Crucially, (2b) is ungrammatical irrespective of the scope of the headshake (Geraci, 2006b: 221), showing that the headshake in LIS does not carry negative force.[2]

(2) a. PAOLO CONTRACT SIGN NOT [LIS]
hs
'Paolo didn't sign the contract.'

b. *PAOLO CONTRACT SIGN
( ) ( ) hs
'Paolo didn't sign the contract.'

Based on the typological dichotomy and syntactic constraints imposed on the scope of the headshake, it has been claimed that in many sign languages, the headshake should be considered a grammaticalized gesture (Van Loon et al., 2014; Pfau, 2015). However, this need not be the case in all sign languages. For instance, based on corpus data, Johnston (2018) has recently argued that the headshake is not a grammatical marker of negation in Australian Sign Language, a manual dominant sign language: in this language, headshakes are observed in just over half of the manually negated clauses (in striking contrast to NGT), and their position and spreading behavior do not appear to be linguistically constrained.

Numerous sign languages have been reported to have at their disposal multiple negative particles, often expressing additional meanings, such as emphatic negatives, negative existentials, or particles with additional aspectual meaning. The NGT example in (3a) involves the negative completive marker NOT.YET (Coerts, 1992, p. 209), whose handshape and movement are different from that of the negative particle NOT. The use of an emphatic negative particle is illustrated by the Jordanian Sign Language (LIU) example in (3b); this particle differs from the basic negator NOT, which is also present in the example, in movement and accompanying facial expression [adapted from Hendriks (2008, p. 79); non-manuals not specified in original example; "//" indicates a prosodic break].

(3) a. AIRPLANE **NOT.YET** $_{3a}$COME$_{1}$ PALM.UP [NGT]
hs
'The plane has not yet arrived.'

b. **NEG.EMPH** SMOKE **NEG.EMPH** // JORDAN NOT [LIU]
'No, of course I don't smoke. That's not done in Jordan.'

In addition, it is fairly common across sign languages to have special forms for negative modals, be it cliticized or suppletive forms (Shaffer, 2002; Zeshan, 2004a; Pfau and Quer, 2007). Such specialized manual negators will play a prominent role in our discussion of GESL negation in "Word Order and Basic Negation in GESL" and "Negative Modals".

NEGATION IN SPOKEN GEORGIAN

In this section, we sketch the realization of sentential negation in Georgian, the spoken language that GESL is in contact with, as we are also interested in possible language contact phenomena. Georgian has two basic negative particles: *ar(a)* "not" (which also functions as negative reply "no") and *ver(a)*, which has a modal flavor and is often translated as "cannot," although the modal meaning may at times be rather subtle. Both particles always immediately precede the lexical verb, as is shown in the examples in (4) and (5). In (5), we also illustrate the difference between the two particles. The version in (5b) is the neutral negative version; it simply implies that no letter writing has taken place, for instance, because the speaker did not want to. In principle, (5c) could receive the same translation, but it implies that there was an intention to write a letter and that specific reasons made it impossible (e.g., lack of time and no stationery available; PREV = preverb and AOR = aorist).

(4) a. chem-s z'ma-s mo-s-c'on-s brok'ol-i
my-DAT brother-DAT PREV-3OBJ-like-3SBJ broccoli-NOM
'My brother likes broccoli.'

b. chem-s z'ma-s **ar** mo-s-c'on-s brok'ol-i
my-DAT brother-DAT NEG PREV-3OBJ-like-3SBJ broccoli-NOM
'My brother does not like broccoli.'

(5) a. me da-v-c'er-e c'eril-i
I PREV-1SBJ-write-AOR letter-NOM
'I wrote a letter.'

b. me **ar** da-v-c'er-e c'eril-i
I NEG PREV-1SBJ-write-AOR letter-NOM
'I did not write a letter.'

c. me **ver** da-v-c'er-e c'eril-i
I NEG(MOD) PREV-1SBJ-write-AOR letter-NOM
'I did/could not write a letter.'

Word order in Georgian is fairly free. The above examples, and the ones to follow, display the common SVO order, but SOV is also attested (alongside other permutations). In both

[2]Other sign languages of the non-manual dominant type are, for instance, American Sign Language, Catalan Sign Language, Finnish Sign Language, and Indopakistani Sign Language, where a manual negative sign never renders a sentence negative by itself; the group of manual dominant sign languages includes, for instance, Hong Kong Sign Language and Jordanian Sign Language. Turkish Sign Language appears to present us with a hybrid type, as a manual negator is obligatory, but the relevant non-manual marker is capable of spreading (Gökgöz, 2011).

orders, the negative particles immediately precede the verb, that is, the standard orders in negated clauses are SNegVO and SONegV, respectively.

When neg-words or negative adverbials are used, Negative Concord (NC) is very common in Georgian, but it is not obligatory. This is illustrated for the neg-word *araperi* ("nothing") in object position in (6) and for the negative adverbial *arasodes* ("never") in (7; VER = marker of version). The (b) examples involve the negative particle *ar(a)*, but NC involving the particle *ver(a)* is also attested, as is shown in (6c) and (7c)—in this case, the neg-word adapts to the negative particle.[3]

(6) a. chem-ma da-m araper-i i-q'id-a
my-ERG sister-ERG nothing-NOM VER-buy-3SBJ
'My sister bought nothing.'

b. chem-ma da-m **ar** i-q'id-a araper-i
my-ERG sister-ERG NEG VER-buy-3SBJ nothing-NOM
'My sister bought nothing.'

c. chem-ma da-m **ver** i-q'id-a veraper-i
my-ERG sister-ERG NEG VER-buy-3SBJ nothing-NOM
'My sister did/could not buy anything.'

(7). a. shen-i megobar-i arasodes sv-am-s lud-s
your-NOM friend-NOM never drink-TH-3SBJ beer-DAT
'Your friend never drinks beer.'

b. shen-i megobar-i arasodes **ar** sv-am-s lud-s
your-NOM friend-NOM never NEG drink-TH-3SBJ beer-DAT
'Your friend never drinks beer.'

c. shen-i megobar-i arasodes **ver** sv-am-s lud-s
your-NOM friend-NOM never NEG drink-TH-3SBJ beer-DAT
'Your friend never drinks / can drink beer.'

Besides the two particles mentioned above, Georgian has an additional negative particle, prohibitive *nu*, which can only be used in the imperative and which—just like the other particles—always immediately precedes the verb; *cf.* (8).

(8) **nu** c'a-x-val ase šors.
NEG(PROH) PREV-2SBJ-go so far
'Do not go so/too far!'

Further phenomena related to negation in spoken Georgian will be introduced in subsequent sections in order to scrutinize the degree in which spoken Georgian has possibly had an impact on the realization of negation in GESL. While it has long been demonstrated that natural sign languages generally do not copy the grammatical structure of the surrounding spoken language (e.g., word order and availability of certain grammatical categories), it is also clear that the spoken language may have an influence on the sign language (Plaza Pust, 2005; Adam, 2012)—and this is a possibility we want to explore for GESL.

[3]An interesting observation that is not well investigated for Georgian and that we cannot go into here, concerns the fact that neg-words in object position prefer the preverbal position (6a), while in an NC structure, they normally follow the verb (6b).

METHODOLOGY

Spontaneous Data

Many of the patterns we describe in this paper were first observed in spontaneous narratives, about 5 h in total, produced by 15 native signers (age 24–65), which have been recorded for the purpose of studying the verbal morphology of GESL, as well as some sociolinguistic properties. All signers are from Tbilisi and are members of the Deaf Union of Georgia. They were asked to share personal experiences and/or anecdotes with a Deaf interlocutor.

The productions of the signers, which vary in length between 5 and 45 min, have been annotated in ELAN with the help of Deaf research assistants and GESL interpreters. All participants produced negative utterances. As for negation, the spontaneous data revealed (i) that GESL features two basic clause negators, which can appear in various positions within the clause; (ii) that, moreover, particles with additional semantics (e.g., emphatic) exist; (iii) that different types of Negative Concord are attested; and (iv) that GESL has specialized negative modals. Note that to date, only manual signs have been annotated, but all negative examples extracted from the data were checked for the presence of a headshake.

Data Elicitation

Subsequently, the patterns concerning negation that we had extracted from the spontaneous data were supplemented by elicited data. Five GESL signers from Tbilisi (age 22–60), who had not been involved in the recording of spontaneous data, participated in an elicitation session, administered by a sign language interpreter, who is also a native signer. These five signers are born and raised in Deaf families and are actually either from the third or fourth Deaf generation within their family. They are also members of the Deaf Union of Georgia and are considered as the best GESL signers among the community members. Four of them teach GESL to other Deaf and hard-of-hearing people at the Deaf Union and/or at Deaf schools.

Data elicitation involved two different approaches. On the one hand, participants were shown negative clauses from the spontaneous data and were asked to repeat them. Each participant saw between 60 and 90 negative clauses, distributed over multiple sessions. If the participant changed the structure during repetition (e.g., different word order and different or additional particle), they were asked why they implemented the change; if the participant repeated verbatim, they were asked whether an alternative structure would be possible. On the other hand, the sign language interpreter presented to the participants affirmative clauses, which were modeled based on negative clauses extracted from the spontaneous data, and participants were asked to negate these clauses. However, some of the model clauses contained time adverbials which were not present in the original example. Each participant saw between 80 and

120 such (modified) affirmative clauses, again spread over various sessions.

The elicited data confirmed the patterns we had previously observed (e.g., basic negation strategy and Negative Concord), but also presented us with additional negation strategies (e.g., additional specific negative particles). In the first elicitation task, signers would, for instance, indicate that another particle could be used or that two manual negators could be combined. The second elicitation strategy confirmed the existence of negative modals and brought to light some further unexpected findings, such as the existence of a tense-specific negation strategy.

Grammaticality Judgments

In a third step, we also obtained grammaticality judgments by the same five signers on pre-recorded sentences, produced by the before-mentioned GESL interpreter, which either mirrored the negation patterns found in the spontaneous and elicited data, or in one way or the other deviated from them. The deviations were implemented to test the (un)grammaticality of certain structures which had surfaced in the spontaneous data and during elicitation. This allowed us to further confirm these patterns and also to identify ungrammatical structures. Deviations involved, for example, a change in word order, the addition of a time adverbial, and/or the addition of another negative particle.

The same five signers who participated in the elicitation tasks also participated in the grammaticality judgment task. Each of them was presented with 120 examples. Judgment did not involve the use of a Likert-scale, but only absolute statements in the form of "acceptable / unacceptable / unclear." Remarkably, judgments of the signers were almost unanimous (97% agreement), in particular regarding the combinatory possibilities of manual negators and the tense-specific strategy which had been identified during elicitation. One has to keep in mind, of course, that all signers participating in the grammaticality judgment task came from Tbilisi. It may well be the case that signers from other regions would offer different judgments for some of the examples.

WORD ORDER AND BASIC NEGATION IN GESL

Word Order in Affirmative Clauses

Similar to what we described for Georgian, word order is also free in GESL. Besides SVO and SOV orders, V-initial and O-initial orders are also attested—albeit less frequently—where the latter order arguably results from topicalization (though information structure has not yet been fully investigated for GESL). Napoli and Sutton-Spence (2014) demonstrate that across sign languages, it not at all uncommon to find both SVO and SOV within a single language, but that generally, the order is less constrained for verbs that allow spatial modification to indicate their arguments, i.e., so-called "agreeing" or "indicating" verbs. In a nutshell, in these verbs, the start point of the verb's movement trajectory typically aligns with the locus in space associated with the subject, while the end point aligns with the locus associated with the object.[4] GESL also distinguishes verbs that can be modified in this way (e.g., TALK.TO, ANSWER, and GIVE) and verbs that cannot be spatially modified (so-called "plain" verbs, e.g., LIKE, UNDERSTAND, and HELP). Interestingly, however, in GESL, word order is free with all verbs, as is shown in (9) for the plain verb LIKE and in (10) for the agreeing verb TALK.TO. Sentence adverbials commonly occupy a clause-initial position (10), but they may also appear clause-finally.

(9) a. POSS_1 BROTHER LIKE VEGETABLE
b. POSS_1 BROTHER VEGETABLE LIKE
'My brother likes vegetables.'

(10) a. YESTERDAY INDEX_1 $_1\text{TALK.TO}_3$ FRIEND^DAT
b. YESTERDAY INDEX_1 FRIEND^DAT $_1\text{TALK.TO}_3$
'Yesterday I talked to a friend.'

Note that GESL has a rich system of manual case markers that only combine with animate arguments and that may cliticize to the noun they accompany. We shall not discuss these markers in detail, as they are not relevant in the present context (see Makharoblidze, 2015b). Still, as some of the examples we present include such markers, and given that some informants judge at least some examples as marked or even ungrammatical when the case marker is omitted, they have to be mentioned. The dative marker in (10), for instance, involves a ☜-handshape, which cliticizes to the noun FRIEND; cliticization is realized by a continuous movement contour from the noun to the case marker, such that the latter loses its syllabicity (cliticization is indicated by "^").

Basic Negation

The basic clause negator in GESL, which we gloss as NEG-1, is articulated with a flat hand (all fingers extended, palm facing forward), which executes a small repeated shaking movement resulting from rotation of the lower arm. This particle usually appears clause-finally, but it may also precede the verb, as is shown by the two examples in **Figure 1**, which express exactly the same meaning. Both examples display OV order, but given that VO order is also possible, other attested orders are SVONeg and SNegVO. Remember from the discussion in "Negation in Spoken Georgian" that of these four orders, spoken Georgian only allows those in which the negative particle immediately precedes the verb (i.e., SNegVO, as in (4b), and SONegV).

Such a variable position of the basic clause negator, without semantic impact, has also been described for other sign languages. For instance, in NGT, a sign language which allows for OV and VO order, the particle NOT also most commonly appears clause-finally, but in contrast to GESL, its alternative position is preceding the entire VP (Oomen and Pfau, 2017); the opposite pattern has been described for American Sign Language (ASL; Wood, 1999). It is not really clear what underlies this variability; while Oomen and Pfau assume that pre-VP placement results from Neg-movement,

[4]We are neglecting many important details here, which have triggered interesting discussions in the sign linguistics literature regarding the proper treatment of the spatial modification of verbs. For different theoretical accounts, see Padden (1988), Meir (2002), Liddell (2003), Lillo-Martin and Meier (2011), Pfau et al. (2018), and Schembri et al. (2018), among others.



FIGURE 1 | Negated transitive clause "I do/did not write a letter," with **(A)** negative particle following the verb and **(B)** negative particle preceding the verb.

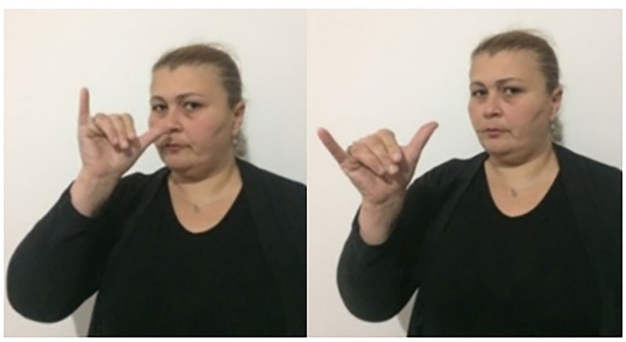


FIGURE 2 | The negative particle NEG-2 ["(can)not"].

Wood argues that sentence-final placement of NOT is derived by VP-movement to a position preceding the negator.

Judgments by all of our informants indicate that GESL has to be classified as a manual dominant sign language. They unanimously agree that examples like those in (11) are ungrammatical—irrespective of word order and irrespective of the exact spreading domain of the headshake (which, in the below examples, is the VP). In other words, the headshake by itself does not contribute negative force, and therefore, a manual negator is required in the expression of clausal negation. Moreover, all the examples we extracted from the data include a headshake, and it appears (i) that the headshake always accompanies at least one manual sign (i.e., it does not appear by itself but may also not be left out), (ii) that the predicate generally falls under the scope of the headshake, and (iii) that headshake on the entire VP is possible. However, further possibilities for and constraints on spreading have not been explored in detail, and therefore, we will not gloss the headshake in the remainder of this article, leaving this issue, that is, the question in how far the headshake is grammaticalized in GESL, for future investigation.

(11) a. hs
*POSS$_1$ BROTHER LIKE VEGETABLE
'My brother doesn't like vegetables.'

b. hs
*YESTERDAY INDEX$_1$ $_1$TALK.TO$_3$ FRIEND^DAT
'Yesterday I did not talk to a friend.'

GESL has a second negative particle which is widely used, and which behaves in exactly the same way as the particle *ver(a)* we described for Georgian [see (5c)]. That is, this particle, which we gloss as NEG-2, has a modal flavor and can often be translated as "cannot" (deontically and epistemically); it is signed with a Y-hand (thumb and pinky extended) which initially makes contact with the nose and moves forward, as illustrated in **Figure 2**. Crucially, this particle cannot combine with modal verbs (see "Negative Modals" for discussion), it always expresses the modal/circumstantial meaning by itself (Makharoblidze, 2019). The use of NEG-2 is illustrated in (12). Similar to what we described for the clause negator NEG-1, different word orders are possible; the particle may, for instance, follow (12a) or precede (12b) the verb.

(12) a. YESTERDAY POSS$_1$ FRIEND VISIT **NEG-2**
'Yesterday my friend didn't/couldn't visit me.'

b. INDEX$_1$ LETTER **NEG-2** WRITE
'I don't/cannot write a letter.'

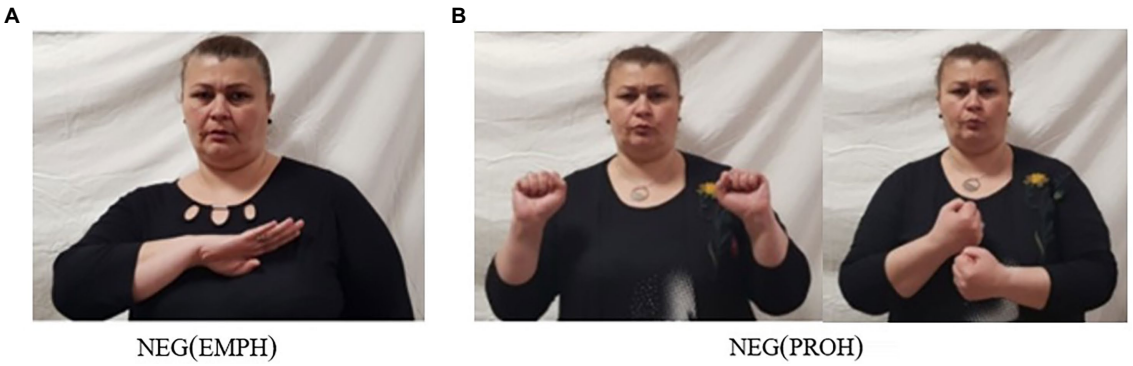


FIGURE 3 | Two specialized negative particles **(A)** emphatic negative and **(B)** prohibitive marker.

Besides the two basic clause negators, GESL employs some specialized negative particles with additional semantics. One of these is the emphatic negator NEG(EMPH), illustrated in **Figure 3A**. This particle, which appears to have grammaticalized from the two-handed sign DEAD, expresses strong negation ("really not"), as shown in (13a). The other one, which we gloss as NEG(PROH) and which is illustrated in **Figure 3B**, expresses a prohibitive meaning and is used in negative imperatives (13b). Both particles follow the verb.[5]

(13) a. INDEX$_3$ EAT MEAT **NEG(EMPH)**
'He really doesn't eat meat.'
b. SMOKE **NEG(PROH)**
'Don't smoke!'

The usage of the particle NEG(PROH) resembles that of the particle *nu* that we described for Georgian in (8). It is thus possible that the existence of a dedicated prohibitive marker is the result of language contact. Remember, however, that while *nu* always precedes the verb, NEG(PROH) must follow the verb [but see (17a) below].[6]

Negative Concord

Having established that GESL is a manual dominant sign language which features two basic negative particles and two negative particles with additional semantics, we now turn to Negative Concord. In GESL, just as in spoken Georgian, NC is attested, but not obligatory, in sentences involving neg-words like NOTHING or NEVER. In (14), this is illustrated for both NEG-1 and NEG-2, occupying a postverbal position in an SOV structure (14a) or a preverbal position in an SVO structure (14b). We even came across examples in which three negative signs are combined (14c). In the remainder of this paper, we will not include patterns with three manual negative elements in our discussion of NC.

(14) a. YESTERDAY INDEX$_1$ NOTHING BUY (**NEG-1/NEG-2**)
'Yesterday I didn't/couldn't buy anything.'
b. POSS$_1$ BROTHER NEVER (**NEG-1/NEG-2**) DRINK BEER
'My brother never drinks / can never drink beer.'
c. HERE NOBODY NEVER STUDY (**NEG-1/NEG-2**)
'Nobody ever studies / can ever study here.'

NEG-1 and NEG-2 can also combine within a clause, but only if NEG-2 precedes NEG-1 (15a–d). The resulting meaning is purely modal and can only mean "cannot." Note further that there is only one postverbal slot for negation; hence a combination of postverbal NEG-1 and NEG-2 is ruled out, irrespective of order. The corresponding combination of particles, that is, of *ar(a)* and *ver(a)*, within a clause is not grammatical in spoken Georgian.

(15) a. WOMAN **NEG-2** SING **NEG-1**
'The woman cannot sing.'
b. WOMAN **NEG-2 NEG-1** SING
'The woman cannot sing.'
c. *WOMAN **NEG-1 NEG-2** SING
'The woman cannot sing.'
d. *WOMAN **NEG-1** SING **NEG-2**
'The woman cannot sing.'

Furthermore, either of the two basic negative particles may combine with the emphatic negative particle NEG(EMPH) within a clause, as shown in (16). In this case, the order of the particles is fixed in that NEG-1/NEG-2 must precede NEG(EMPH).

(16) SATURDAY INDEX$_3$ NEG-**1**/NEG-**2** WORK NEG(EMPH)
'On Saturday, he really doesn't/cannot work.'

[5]GESL has a lexical verb PROHIBIT, which is not phonologically related to NEG(PROH) in any way. Note further that the negative modal MUST.NEG (see **Figure 4C**) can also be used as a prohibitive marker.

[6]For the sake of completeness, let us add that GESL also features two negation strategies that appear to be derivational in nature. First, the sign EMPTY can combine with nouns to yield a meaning comparable to the English negative suffix *-less* (e.g., HEART^EMPTY "heartless"). Second, the sign WITHOUT can combine with signs of various lexical categories to express a meaning similar to the English prefix *un-* (e.g., WORK^WITHOUT "unemployed"). More in-depth study is required, but it appears that both these signs have undergone grammaticalization. Note further that EMPTY may also be used as a negative possessive, as in FATHER HOUSE EMPTY ('Father does not have a house'), suggesting an intermediate stage on the grammaticalization path.

The prohibitive particle NEG(PROH) occasionally combines with the basic clause negator NEG-1, yielding another type of NC. While NEG(PROH) always follows the verb when appearing by itself (13b), when combined with NEG-1, it generally precedes the verb and NEG-1 follows the verb (17a). However, in contrast to NEG(EMPH), NEG(PROH) cannot co-occur with NEG-2, as shown by the ungrammaticality of (17b). In Georgian, both corresponding combinations, i.e., of *nu* and *ar(a)* and of *nu* and *ver(a)*, would yield an ungrammatical sentence.

(17) a. **NEG(PROH)** SISTER PUSH **NEG-1**
'Don't push your sister!'
b. *__NEG(PROH)__ SISTER PUSH **NEG-2**
'Don't push your sister!'

Note further (i) that NEG(EMPH) and NEG(PROH) may not be combined within a clause, and (ii) that both these particles may combine with neg-words—similar to what we described for NEG-1 and NEG-2 (14). Actually, the combination of one of these four negative particles with a neg-word is the most commonly attested type of NC in GESL.

Examples that involve "doubling," that is, the co-occurrence of two phonologically identical negators within a clause, would constitute another possible type of NC. In fact, this type has been reported for other sign languages, e.g., ASL (Petronio, 1993), Brazilian Sign Language (Libras; De Quadros, 1999), and Sign Language of the Netherlands (Van Boven et al., in press)—and at least for ASL and Libras, it has been argued to constitute a focus marking strategy. However, according to all our informants, NC of the doubling type is ruled out in GESL. In (18), this is illustrated for doubling of NEG-1 and NEG-2, but the ungrammaticality of doubling extends to other negative particles and neg-words.

(18) a. *BOY **NEG-1** WAIT **NEG-1**.
'The boy did not wait.'
b. *BOY **NEG-2** WAIT **NEG-2**.
'The boy didn't/couldn't wait.'

Taken together, we observe that GESL optionally allows for various types of NC, involving the basic negative particles (which may also combine with each other), neg-words, the emphatic negative particle, and the prohibitive particle. Yet, not all logically possible combinations are grammatical. We pointed out that NC is also optionally possible in Georgian. However, it is noteworthy that many of the combinations that are attested in GESL are ruled out in Georgian. Further types of NC will be addressed in "On the Interaction of Negation With Tense, Aspect, and Modality", where we will also present an overview table of the attested combinations.

Summary

Word order in GESL is rather free, and this freedom extends to the positioning of negative particles vis-à-vis the verb and object. While GESL shares the former property, flexible word order, with spoken Georgian, the latter property is clearly different from Georgian, where the negative particles must immediately precede the verb. The usage of a manual negative element is obligatory in GESL, that is, the language has to be classified as a manual dominant sign language. GESL has a rich inventory of negative particles. So far, we presented four particles, two of which, NEG-1 and NEG-2, we consider basic (although the latter comes with additional modal meaning), and two, NEG(EMPH) and NEG(PROH), which carry additional meaning. Further particles will be introduced in the next section. Both GESL and Georgian optionally allow for Negative Concord but differ from each other with respect to which negative elements can be combined within a clause.

ON THE INTERACTION OF NEGATION WITH TENSE, ASPECT, AND MODALITY

Having discussed the basic negation strategies of GESL, we now turn to a description of how negation interacts with other grammatical categories, *viz.* tense, aspect, and modality. The fact that negation commonly interacts with modal notions in interesting ways has been described for many spoken and signed languages (De Haan, 1997; Zeshan, 2004a; Iatridou and Zeijlstra, 2013; Homer, 2015, among others). In "Negative Modals", we address dedicated negative modals that we identified in GESL. Subsequently, in Section "Tense- and Aspect-Specific Negative Particles", we turn to the use of tense- and aspect-specific negative particles. Typological studies show that the usage of negators or negation strategies that are specific to certain tenses is not uncommon across spoken languages (e.g., Miestamo, 2005); however, to date, only few such cases have been described for sign languages. Finally, in "A Negation-Modality-Tense Interaction", we address a typologically highly unusual three-way interaction between negation, modality, and tense, namely, a tense-specific occurrence of NC.

Negative Modals

For many sign languages, it has been observed that they employ special forms of modal verbs in the context of negation (Shaffer, 2002; Zeshan, 2004a; Pfau and Quer, 2007). Such negative modals may result from cliticization of the basic clause negator to the modal, or they may be suppletive forms. GESL is no exception in this respect. Besides the basic negative particle NEG-2, which, as pointed out above, may but does not have to introduce modal force, GESL has special negative forms for the modals CAN-1, WANT, MUST, and KNOW.[7] The four modals as well as their negative counterparts are illustrated in **Figure 4**.

The stills make clear that the formational changes observed in the negative forms differ from modal to modal: while

[7]KNOW is a lexical verb in GESL, but—as in many other languages, including spoken Georgian—it is commonly understood and behaves like an epistemic modal: as we show here, it displays partial suppletion in the context of negation, and, as will be shown in "On the Interaction of Negation With Tense, Aspect, and Modality", it also behaves like other modals in past tense contexts.

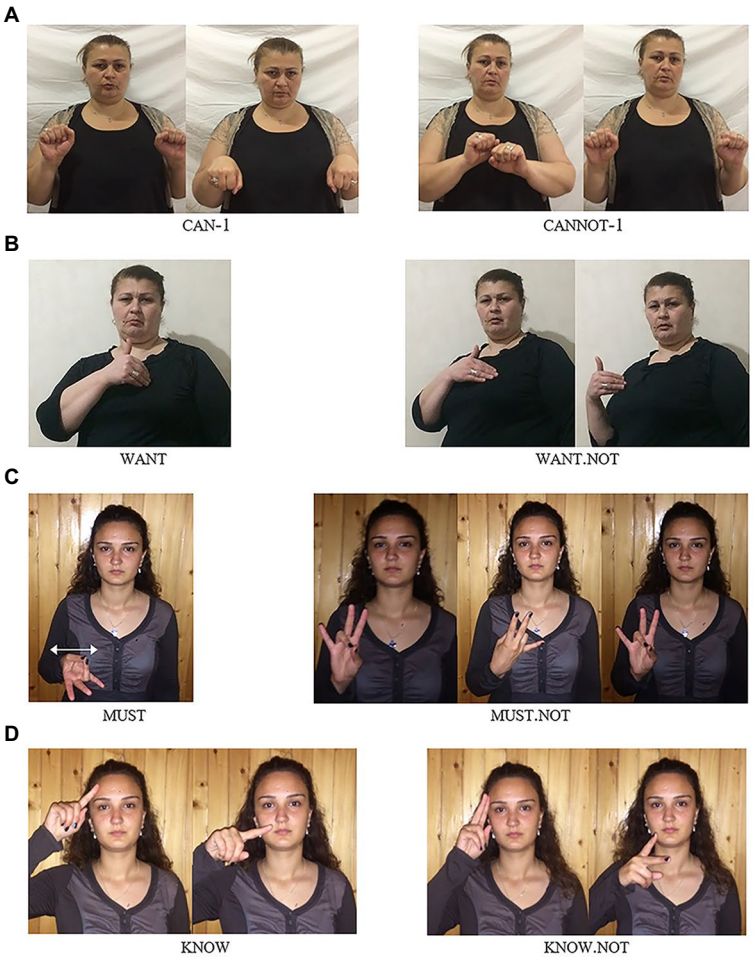


FIGURE 4 | Modals and their negative counterparts in GESL: **(A)** CAN-1—CANNOT-1; **(B)** WANT—WANT.NOT; **(C)** MUST—MUST.NOT; and **(D)** KNOW—KNOW.NOT. (images in **A**, **B**, and **D** from Makharoblidze and Pfau, 2018, p. 141; © John Benjamins, reprinted with permission).

CANNOT-1,[8] WANT.NOT, and MUST.NOT are characterized by different types of movement changes, KNOW.NOT involves a change in handshape. To be precise: CAN-1 involves a downward movement of two 𝄞-hands articulated at the wrist, while CANNOT-1 is articulated with a sideward movement of both hands; in WANT, the fingertips of the hand contact the contralateral side of the chest, while in WANT.NOT, a sideward movement to the ipsilateral side is added; in MUST, the palm of the hand (thumb contacts ring finger) is oriented upwards, and the sign involves a repeated sideward movement on the horizontal plane, while in MUST.NOT, the palm is initially oriented outward, and by rotating the lower arm, it is turned inward, then outward again; and finally, in KNOW, the 𝄞-hand contacts the forehead and then moves downward, while in KNOW.NOT, the 𝄞-hand makes contact and changes into a 𝄞-hand while performing the downward movement.

The forms in **Figure 4** thus neither involve cliticization of one of the basic negators nor are they clear cases of suppletion, as most phonological aspects of the base signs are preserved [see Zeshan (2004a, p. 41–51) and Quer (2012, p. 320–323) for discussion of different types of "irregular negatives" across sign languages]. We therefore consider these as instances of partial suppletion which are characterized by simultaneous, i.e., stem-internal changes. In (19) and (20), we illustrate the use of the first two of these modals by means of glossed examples. Once again, the examples exemplify that different orders are attested. Note, however, that the SOModV order of (19) can also apply to the modal WANT/WANT.NOT and, vice versa, the SModVO order of (20) is also possible for CAN-1/CANNOT-1.

[8]As suggested by the gloss, there are alternative forms of the modal CAN (CAN-2 and CAN-3). These two forms are negated in a different way, i.e., by a combination of the previously introduced NEG-2 with a flat hand. It is likely that this compound form, which occupies a postverbal position, results from a fusion of NEG-2 with NEG-1. We will not include CAN-2 and CAN-3 in the following discussion, but it is worth noting that different variants of the modal verb CAN may combine within a clause (e.g., GIRL CAN-1 DANCE CAN-2 'The girl can dance').

(19) a. INDEX$_3$ DINNER CAN-1 PREPARE
'She/he can prepare the dinner.'
b. INDEX$_3$ DINNER **CANNOT-1** PREPARE
'She/he cannot prepare the dinner.'

(20) a. STUDENT WANT STUDY FRENCH
'The student wants to study French.'
b. STUDENT **WANT.NOT** STUDY FRENCH
'The student does not want to study French.'

The examples in (21a,b) further reveal that NC involving a negative modal and one of the two basic clause negators is impossible. We only illustrate this for clause-final NEG-1/NEG-2, but the ungrammaticality is independent of the position of the negative particle. Crucially, however, we will demonstrate in "A Negation-Modality-Tense Interaction" that, quite strikingly, this ban on NC is lifted for NEG-1 in past tense contexts. Furthermore, while the combinations illustrated in (21a,b) are ungrammatical, negative modals may combine with NEG(EMPH), as shown for WANT.NOT in (21c).

(21) a. *INDEX$_3$ DINNER **CANNOT-1** PREPARE **NEG-1/NEG-2**
'She/he cannot prepare the dinner.'
b. *STUDENT **WANT.NOT** STUDY FRENCH **NEG-1/NEG-2**
'The student does not want to study French.'
c. STUDENT **WANT.NOT** STUDY FRENCH **NEG(EMPH)**
'The student really does not want to study French.'

In clear contrast to GESL, Georgian does not employ specialized negative modals; rather modal verbs are negated in the same way as lexical verbs. In (22), we illustrate this only for the modal verb *dzl* ('can'), but the same is true for other modal verbs. As is evident from (22b), the form of the modal remains the same; the only change observed is the addition of the negative particle. Note that modal verbs can only combine with the negative particle *ar(a)*, as the particle *ver(a)* itself is endowed with modal meaning.

(22) a. c'el-s čven še-gv-i-dzl-i-a ardadeg-eb-ze
this.year-DAT we PREV-1PL.OBJ-VER-can-RM-3SBJ vacation-PL-on
c'a-svl-a
PREV-go-INF
'This year, we can go on vacation.'
b. c'el-s čven **ar** še-gv-i-dzl-i-a ardadeg-eb-ze
this.year-DAT we NEG PREV-1PL.OBJ-VER-can-RM-3SBJ vacation-PL-on
c'a-svl-a
PREV-go-INF
'This year, we cannot go on vacation.'

Tense- and Aspect-Specific Negative Particles

In the data we collected, we also encountered tense- and aspect-specific negative particles, another phenomenon that is not attested in spoken Georgian. The first of these particles is the particle NEG(PERF), illustrated in **Figure 5A**, which is clearly a mono-morphemic form and is used in perfective (or completive) contexts (23a). Crucially, the aspectual interpretation results from the use of the particle alone [*cf.* use of the particle NOT.YET in the NGT example in (3a)]. (23b) shows that, just like other negative particles, NEG(PERF) may also precede the verb, and that it may optionally combine with the basic clause negator NEG-1 (note that the reverse order of the two particles would also be grammatical). However, in crucial contrast to the basic clause negator NEG-1, NEG(PERF) cannot combine with NEG-2 (23c).

(23) a. INDEX$_1$ STEAL INDEX$_3$ BOOK **NEG(PERF)**
'I have not stolen this book.'
b. INDEX$_1$ **NEG(PERF)** STEAL INDEX$_3$ BOOK **NEG-1**
'I have not stolen this book.'
c. *INDEX$_1$ **NEG(PERF)** STEAL INDEX$_3$ BOOK **NEG-2**
'I have not stolen this book.'

Next, to NEG(PERF), we came across the tense-specific particle NEG(FUT), which is only used in the future tense. **Figure 5B** illustrates that NEG(FUT) is a compound form by origin, involving the basic clause negator NEG-1. However, the meaning of the first part is no longer transparent, and the second part has lost the side-to-side movement characteristic of NEG-1. The sign only involves a short outward rotation of the hand during which the handshape changes. Use of this particle alone is sufficient to encode the temporal meaning and thus makes the use of the future tense marker FUTURE unnecessary (24a,b). Alternatively, the marker FUTURE can be used in combination with the basic negator NEG-1 (24c), and also in combination with NEG(FUT), leading to double marking of future tense, as illustrated in (24d). Note further that, just like NEG(PERF), NEG(FUT) may also precede the verb and may combine with NEG-1, but not with NEG-2 (24e).[9,10]

(24) a. INDEX$_1$ FUTURE WRITE LETTER
'I will write a letter.'
b. INDEX$_1$ WRITE LETTER **NEG(FUT)**
'I will not write a letter.'
c. INDEX$_1$ FUTURE WRITE LETTER **NEG-1/NEG-2**
'I will not (be able to) write a letter.'

[9]What we have to leave open for now is the combination of negative modals with either NEG(PERF) or NEG(FUT). Apparently, different modals behave differently in this respect; it seems, for instance, that NEG(FUT) can combine with WANT.NOT but not with CANNOT-1. For this reason, we include a "?" in the relevant cells in **Table 1** in "Summary".

[10]There is a third sign which might be analyzed as a tense-specific negative particle, namely, the sign which could be glossed as NEG(PST). However, in contrast to the two signs in **Figure 5**, this is a transparent combination of two existing signs: the past tense copula WAS and the basic negator NEG-1. We are therefore reluctant to analyze this sign, which in principle might also be glossed as WAS^NEG-1, as a dedicated negative particle. Evidence that suggests that we might indeed be dealing with a more conventionalized form, possibly in the process of being grammaticalized, comes from the observation that the parts can never be separated; that is, a string like DRESS WAS BEAUTIFUL NEG-1 (implied meaning 'The dress was not beautiful') is ungrammatical, and the order would rather have to be DRESS BEAUTIFUL WAS^NEG-1. In other words: in such contexts, use of the conventionalized combination is obligatory. Further research is necessary to determine the exact present status of WAS^NEG-1 / NEG(PST).

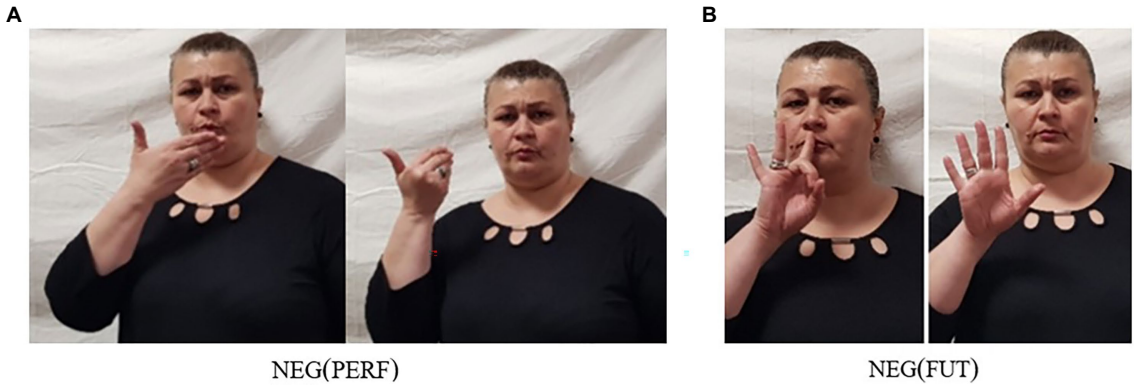


FIGURE 5 | Tense- and aspect-specific negative particles in GESL: **(A)** NEG(PERF) and **(B)** NEG(FUT).

d. INDEX$_1$ FUTURE WRITE LETTER **NEG(FUT)**
'I will not write a letter.'
e. INDEX$_1$ **NEG(FUT)** WRITE LETTER **NEG-1/NEG-2**
'I will not write a letter.'

As already pointed out above, tense-specific negative particles (or negation strategies) are not uncommon in spoken languages. Makharoblidze and Pfau (2018, p. 147), for instance, observe that out of the 297 languages listed in the Appendix to Miestamo (2005), 53 (18%) display tense-specific negation strategies. Yet, when it comes to sign languages, the use of a tense-specific negative particle has to date only been reported for Israeli Sign Language (Meir, 2004). In contrast to the particle we described for GESL, the one identified for Israeli Sign Language carries a past tense meaning and is therefore glossed as NEG-PAST. Yet, similar to what we described for GESL, Meir shows that use of NEG-PAST alone yields the desired past tense reading (e.g., INDEX$_3$ SLEEP NEG-PAST 'He did not sleep at all').

A Negation-Modality-Tense Interaction

In "Negative Modals", we introduced negative modals, and we showed that these modals cannot combine with the basic clause negator NEG-1. However, when studying GESL modal verbs in more detail and eliciting clauses with different tense specifications (as overtly indicated by adverbials) from native signers, Makharoblidze and Pfau (2018) noticed that in past tense contexts, the signers systematically combined the special negative form of the modal with the manual sign NEG-1. In **Figures 6, 7**, we provide examples that illustrate this pattern for the negative modals CANNOT-1 and WANT.NOT, respectively. Once again, different orders are possible but the negative particle NEG-1 must always follow the negative modal [similar to what we observed when it combines with NEG-2; see (15)]. **Figure 6** exemplifies the order (S)–NEG.MOD–NEG-1–VP, while the order (S)–NEG.MOD–VP–NEG-1 is illustrated in **Figure 7**.

The pattern we observe in **Figures 6, 7** is in striking contrast to what we described for present tense examples in (21), where the combination of a negative modal and NEG-1 leads to ungrammaticality. In (25a), we further illustrate this constraint with the present tense equivalent of the example in **Figure 7** (we add an overt subject pronoun in order to make clear that the ungrammaticality does not result from the missing subject). It is thus evident that the ban on NC between a negative modal and NEG-1 does not apply to all tenses.[11] In fact, further discussions with the informants revealed that this type of NC is obligatory in past tense contexts, as shown by the ungrammaticality of (25b).

(25) a. *TODAY INDEX$_1$ **WANT.NOT NEG-1** INDEX$_3$ PAINT
'Today I don't want to paint it.'
b. *LAST NIGHT INDEX$_1$ **CANNOT-1** SLEEP
'Last night I couldn't sleep.'

Makharoblidze and Pfau (2018) also offer a brief discussion of the GESL pattern from a cross-linguistic perspective. On the one hand, they show that NC involving negative modals has been described for some sign languages (e.g., ASL and NGT). Crucially, however, this type of NC is never constrained to a specific tense. On the other hand, they present examples from two spoken languages—Arapesh (a Torricelli language spoken in Papua New Guinea) and Lewo (an Austronesian language spoken on Vanuatu)—in which one tense is negated by a single marker, while another tense requires double marking. These examples, however, do not involve negative modals; rather, it is the basic negation strategy that differs dependent on tense.[12] It thus appears that GESL presents us with a type of NC that has not previously been described for any signed or spoken language: obligatory, tense-specific NC involving negative modals.

Summary

Beyond the basic and specialized (emphatic and prohibitive) negative particles discussed in "Basic Negation", GESL also

[11]In contrast to the ban on NC between a negative modal and NEG-2, which does apply to all tenses.
[12]Moreover, in the spoken languages, present and past tense are grouped together (realis) and distinguished from future (irrealis) in the context of negation, while in GESL, present and future tense align and contrast with past tense.



FIGURE 6 | The negative modal CANNOT-1 used in a past tense context: 'Yesterday it was impossible to go there/one could not go there'; note the combination of the irregular negative form CANNOT-1 with the negator NEG-1 (slightly adapted from Makharoblidze and Pfau, 2018, p. 144; © John Benjamins, reprinted with permission).



FIGURE 7 | The negative modal WANT.NOT used in a past tense context: 'Yesterday I did not want to paint it'; note the combination of the irregular negative form WANT.NOT with the negator NEG-1 (slightly adapted from Makharoblidze and Pfau, 2018, p. 144; © John Benjamins, reprinted with permission).

features two (maybe three) tense/aspect-specific negative particles as well as specialized negative modals, which we analyze as partially suppletive forms. Again, NC is attested, but it is severely constrained: both tense/aspect-specific particles may combine with NEG-1 and NEG(EMPH) but not with NEG-2, and for obvious reasons, they cannot combine with each other; for semantic reasons, NEG(PROH) can only combine with NEG(FUT). Negative modals are particularly interesting in this respect, as they can combine neither with NEG-1 nor with NEG-2 in non-past contexts but must combine with NEG-1 in the past tense. An overview of the combinatorial possibilities is provided in **Table 1**. Let us reiterate that almost all patterns reported in this section are clearly different from spoken Georgian, as Georgian neither features special forms for negative modals nor tense-specific negative particles.

Remember from the discussion above that doubling is ruled out in GESL [see (18)]—in **Table 1**, these are the cells that run diagonally from the top left to the bottom right. The only apparent exception are neg-words (bottom right cell), but crucially, the attested cases are not instances of doubling, as two different neg-words are involved [e.g., NOBODY and NEVER in (14c)].

DISCUSSION

Now that we have given an overview of the rather complex and typologically unusual system of negation in GESL, we are going to investigate how this system compares to existing taxonomies of NC and double negation systems.

Standard NC Systems in Spoken and Sign Languages

Generally speaking, languages vary cross-linguistically with respect to whether they allow NC or not. Dutch is a so-called Double Negation language, a language where every morpho-syntactically negatively marked element also induces a semantic negation. Consequently, in all three examples in (26), the co-occurrence of two neg-words yields an affirmative meaning.

(26) a. Niemand belt niet [Dutch, Double Negation]
NEG.body calls NEG
'Nobody doesn't call.' = 'Everybody calls.'
b. Niemand belt niemand
NEG.body calls NEG.body
'Nobody calls nobody.' = 'Everybody calls somebody.'
c. Suzanne belt niet niemand
Suzanne calls NEG NEG.body
'Suzanne doesn't call nobody.' = 'Suzanne calls somebody.'

In contrast, Czech (27) and Italian (28) are NC languages, where one or more negative elements jointly yield one semantic negation. NC languages are commonly divided into so-called Strict NC languages and Non-strict NC languages (*cf.* Zeijlstra, 2004; Giannakidou, 2006). Czech is classified as a Strict NC language, as every neg-word—be it preverbal (i.e., VP-external) or postverbal (i.e., VP-internal)—obligatorily needs to be accompanied by the negative marker *ne*. In (27a), the neg-word appears in object position, while in (27b,c), it functions as subject and either precedes (27b) or follows (27c) the verb. Crucially, without the negative marker *ne*, all three sentences would be ungrammatical.

(27) a. Milan *(ne-)vidim nikoho [Czech, Strict NC]
Milan NEG-sees NEG.body
'Milan doesn't see anybody.'
b. Dnes nikdo *(ne-)volá
today NEG.body NEG-calls
'Today nobody calls.'
c. Dnes *(ne-)vola nikdo
today NEG-calls NEG.body
'Today nobody calls.'

Italian, by contrast, is a so-called Non-strict NC language, as only postverbal (i.e., VP-internal) neg-words need to be accompanied by a higher negation, yielding an NC reading. Consequently, the examples in (28a) and (28c) pattern with the corresponding Czech examples in (27a) and (27c): both a neg-word in object position (28a) and a postverbal subject

TABLE 1 | Possibilities for Negative Concord in Georgian Sign Language: "+" indicates that NC is attested; "–" indicates that NC involving these two elements is not attested.

	NEG-1	NEG-2	NEG(EMPH)	NEG(PROH)	NEG(PERF)	NEG(FUT)	neg. modal	neg-word
NEG-1	–	+[a]	+	+	+	+	–/+[b]	+
NEG-2	+[a]	–	+	–	–	–	–	+
NEG(EMPH)	+	+	–	–	+	+	+	+
NEG(PROH)	+	–	–	–	–	+	–[c]	+
NEG(PERF)	+	–	+	–	–	–	?[d]	+
NEG(FUT)	+	–	+	+	–	–	?[d]	+
neg. modal	–/+[b]	–	+	–[f]	?[d]	?[d]	–[e]	+
neg-word	+	+	+	+	+	+	+	–/+[f]

[a]*NEG-2 must precede NEG-1.*
[b]*Only in past tense, but then obligatory.*
[c]*We have not attested any such examples, but this is arguably due to the fact that modals are in general unavailable in imperatives (and thus prohibitives).*
[d]*Further research is necessary, as different negative modals appear to behave differently when it comes to these combinations.*
[e]*The minus here refers to combinations of different negative modals as well as to cases of doubling, whereby the same negative modal appears twice in a clause.*
[f]*Different neg-words can be combined within a clause, but doubling of one and the same neg-word is ruled out.*

neg-word (27c) have to be accompanied by the negative marker *non*. However, in contrast to Czech, preverbal (i.e., VP-external) neg-words cannot be accompanied by a negative marker. Inclusion of a negative marker in examples like (28b) thus results in ungrammaticality (under neutral intonation).

(28) a. Gianni (*non) ha telefonato a nessuno
Gianni NEG has called to NEG.body
'Gianni didn't call anybody'. [Italian, Non-strict NC]

b. Ieri nessuno (*non) ha telefonato
yesterday NEG.body NEG has called
'Yesterday nobody called'.

c. Ieri *(non) ha telefonato nesssuno
yesterday NEG has called NEG.body
'Yesterday nobody called.'

Strikingly, all three types of languages can be attested among sign languages as well, showing that the distribution of types of NC/DN languages is not specific to modality.

Like Dutch, LIS is a Double Negation language, where no (manual) negative element is accompanied by another one. Remember from the examples in (2) that LIS is a manual dominant sign language. According to Geraci (2006b), examples involving NC, consisting of a combination of the negative marker NOT[13] and a neg-word, are straightforwardly ungrammatical, as shown in (29a,b). To the extent that a negative marker and a neg-word can co-occur in a clause, only a Double Negation reading is marginally available (29c; Geraci, 2006b; *cf.* also Pfau, 2016).[14]

(29) a. NOBODY CONTRACT SIGN (*NOT) [LIS, Double Negation]
'Nobody signed the contract.'

b. CONTRACT SIGN (*NOT) NOBODY
'Nobody signed the contract.'

c. ?SMOKE CANNOT NOBODY
'Nobody can't smoke.' = 'Everybody must smoke.'

As was shown in (2), a non-manual headshake may accompany negation in LIS. Yet, given that a clause cannot be negated by means of the headshake only, the headshake, by definition, does not count as a negative marker and consequently cannot establish NC relations either.

Things are crucially different in (at least some) non-manual dominant sign languages, where neg-words inside and outside the VP (or more precisely, postverbal and preverbal neg-words) are accompanied by an additional negative marker, *viz.* the headshake. This is the case, for instance, in NGT, a non-manual dominant sign language, where the headshake can negate a clause by itself [see (1c)] and where, consequently, the combination of a neg-word and the headshake constitutes an instance of NC. As the examples in (30) illustrate, neg-words are indeed always accompanied by the headshake, regardless of whether they appear in pre- or postverbal position and regardless of whether they are subjects or objects.

(30) a. INDEX$_1$ CHOOSE NOTHING [NGT, Strict NC]
hs
'I choose nothing.'

b. INDEX$_1$ NOTHING CHOOSE
hs
'I choose nothing.'

c. YESTERDAY NOBODY COME
hs
'Yesterday nobody came.'

Russian Sign Language (RSL), finally, is a language where VP-external subject neg-words, which unlike in most spoken languages appear in a postverbal, sentence-final position, cannot be accompanied by a manual negative marker, but where VP-internal neg-words, subjects and objects alike, must be accompanied by the negative marker, just as is the case in spoken Non-strict NC languages (see Kuhn and Pasalskaya, in press; Kuhn, 2020).[15] In (31), the VP-internal object neg-word NOTHING (31a) or the VP-internal subject neg-word NOBODY (31b) must be licensed by the sentence-final negative marker NOT, whereas a VP-external negative subject as in (31c) may not.

(31) a. IX-1 NOTHING BUY *(NOT) [RSL, Non-strict NC]
'I didn't buy anything.'

b. NOBODY 3-CALL-1 *(NOT)
'Nobody calls.'

c. 3-CALL-1 (*NOT) NOBODY
'Nobody calls.'

Hence, *prima facie*, the same dimensions of variation with respect to negation and NC that apply in spoken language also apply in sign languages, showing again that the latter only differ from the former in terms of their modality of symbolic realization.

Non-standard NC Systems in Spoken and Sign Languages

In recent years, it has turned out, however, that the landscape of NC in spoken languages is much richer than sketched in the previous section. Without doing full justice to the literature, at least three other aspects of variation related to negation and NC are attested among spoken languages. These concern: (i) the optionality of NC; (ii) the co-occurrence of multiple negative markers; and (iii) hybrid NC systems, where only a strict subset of the set of negative elements can participate in NC relations. We discuss (i–iii) in turn.

First, in certain languages, NC is optional. West Flemish is a good example (*cf.* Haegeman, 1995; Haegeman and Lohndahl,

[13]LIS has two negative markers, which are glossed as NON and NEG by Geraci (2006b), and both of which appear in postverbal position. In the examples in (29), we subsume both markers under the gloss NOT. Geraci also notes that the two negative markers cannot co-occur in one clause.

[14]Geraci does not provide examples with NOT and neg-word in object position [i.e., examples that would correspond to (27a) and (28a)] but states that the ungrammaticality of (29a,b) extends to these cases [see Geraci (2006a) for relevant examples and discussion].

[15]Just like Italian Sign Language, Russian Sign Language is a manual dominant sign language when it comes to negation. A negative headshake may accompany a manual negative marker but cannot replace it. Such headshakes cannot render a sentence negative on their own and therefore are not real negative markers.

2010). Whereas neg-words may establish NC relations with both other neg-words (32a) or negative markers (32b) in this language, NC is never obligatory. Consequently, (32c) without NC is just as good as (32b).

(32) a. K een nooit niets gezien [West Flemish]
I have never NEG.thing seen
'I have never seen anything.'
b. Valère ken niemand nie
Valère knows NEG.body NEG
'Valère doesn't know anybody.'
c. Valère ken niemand
Valère knows NEG.body
Valère doesn't know anybody.'

Second, albeit it is a rare phenomenon, in certain languages, neg-words must be accompanied by a negative marker but cannot establish an NC relation with each other. Whereas most spoken and signed NC languages, including Czech, Italian, and Russian Sign Language, exhibit NC constructions in which more than one neg-word participates, in Afrikaans, at least in its more conservative variety, every negative sentence, regardless of whether it contains a negative marker (33a) or a neg-word (33b), ends with the negative marker *nie* (*cf.* Den Besten, 1986; Biberauer, 2008, 2009; Biberauer and Zeijlstra, 2012). This means that Afrikaans allows not only NC between a neg-word and a negative marker (as in most other NC languages), but also between two negative markers.[16]

(33) a. Hy is nie moeg nie [Afrikaans]
he is NEG tired NEG
'He is not tired.'
b. Hy is nooit moeg nie
he is never tired NEG
'He is never tired.'

Third, in languages like French, as in most other NC languages, NC is possible between multiple neg-words, as shown in (34). However, French is exceptional in that any combination of neg-words with the negative marker *pas* gives rise to a Double Negation reading, irrespective of whether the neg-word appears in preverbal (35a) or postverbal position (35b). Note that the same holds for the combination of more than one neg-word with *pas*. In (35c), the two neg-words establish an NC relation to the exclusion of *pas*, and the sentence yields two semantic negations (see Zeijlstra, 2010):[17]

(34) Personne mange rien [French]
NEG.body eats NEG.thing
'Nobody doesn't eat anything.'

(35) a. Personne mange pas [French]
NEG.body eats NEG
'Nobody doesn't eat.' = 'Everybody eats.'
b. Jean mange pas rien
Jean eats NEG NEG.thing
'Jean doesn't eat nothing.' = 'Jean eats something.'
c. Personne mange pas rien
NEG.body eats NEG NEG.thing
'Nobody doesn't eat anything.' = 'Everybody eats something.'

Irrespective of the exact underlying analysis, the examples above show that the landscape of NC is much richer than is generally assumed. This, of course, has strong repercussions for sign languages as well. If such atypical NC systems can be found in spoken languages, and there is nothing modality-specific about them, they should be expected to be manifest in sign languages as well. However, as of yet, such NC patterns have not been explicitly discussed in the literature.

Naturally, the question arises as to what constitutes the landscape of NC such that all the systems described above are possible. We would like to emphasize that, despite appearance, this landscape is not an "ordered mess" but follows from several constraints applying to the realization of negation in general. One such constraint is that negation should at least take structurally higher scope than the VP, and that not every negatively marked element, neg-words and negative markers alike, has to carry semantic negation. A full discussion of these facts is beyond the scope of this paper, but we refer to Zeijlstra (in press) for a detailed description of what are possible NC systems and what not. The crucial fact that is at stake here is that these constraints are not modality-specific and are therefore predicted to be in principle possible in sign languages as well. Strikingly, the above-described atypical instances of NC are indeed attested in GESL, thus confirming this prediction (see Van Boven et al., in press, for NGT).

Toward a Classification of GESL

The discussion of GESL above shows that such non-standard NC properties are indeed attested in sign language. First, as shown in (14), repeated here as (36), NC is not obligatory in GESL, and the language thus patterns with West Flemish in this respect.

(36) a. YESTERDAY INDEX$_1$ NOTHING BUY (**NEG-1/NEG-2**)
'Yesterday I didn't/couldn't buy anything.'
b. POSS$_1$ BROTHER NEVER (**NEG-1/NEG-2**) DRINK BEER
'My brother never drinks / can never drink beer.'
c. HERE NOBODY NEVER STUDY (**NEG-1/NEG-2**)
'Nobody ever studies / can ever study here.'

Second, as shown in (15a,b), repeated below as (37a,b), NC between two negative markers, here NEG-1 and NEG-2,

[16]The only exception to this generalization arises when two negative markers should appear adjacent to one another; in this case, only one *nie* is realized (see Biberauer (2008) for arguments that this scenario involves a real instance of haplology).
(i) Hy kom *nie* (**nie*)
He come NEG NEG
'He is not coming.'

[17]French also has an optional preverbal negative marker *ne*, but as this element never renders a sentence negative by itself, it cannot count as an NC-item (or as a negative element in the first place), and we therefore leave it out from the examples.

is possible as well, yielding a pattern that is reminiscent of the one described for Afrikaans above.

(37) a. WOMAN **NEG-2** SING **NEG-1**
'The woman cannot sing.'
b. WOMAN **NEG-2 NEG-1** SING
'The woman cannot sing.'

And, finally, as discussed at length in "On the Interaction of Negation With Tense, Aspect, and Modality", and shown in **Table 1**, not every negative element may participate in NC relations. The examples in (21), repeated here as (38), for instance, show that negative modals, such as CANNOT-1 or WANT.NOT, cannot be accompanied by the negative markers NEG-1 and NEG-2.

(38) a. *INDEX$_3$ DINNER CANNOT-**1** PREPARE **NEG-1/NEG-2**
'She/he cannot prepare the dinner.'
b. *STUDENT WANT.NOT STUDY FRENCH **NEG-1/NEG-2**
'The student does not want to study French.'

Hence, the outcomes of our investigation into a relatively unexplored sign language, GESL, show that the intricate and marked NC patterns observed in spoken languages like West Flemish, French, and Afrikaans can also be attested in sign languages.

Note finally, that the search for rare NC phenomena, which guided us from spoken languages to sign language, can, in principle, also go the opposite way. As discussed in "On the Interaction of Negation With Tense, Aspect, and Modality", there is one context in GESL where NC is obligatory: when used in past tense contexts, negative modals have to combine with the negative marker NEG-1, as is shown in (39; see also **Figures 6, 7**).

(39) LAST NIGHT INDEX$_1$ **CANNOT-1** SLEEP *(**NEG-1**)
'Last night I couldn't sleep.'

To the best of our knowledge, no such tense-governed instances of obligatory NC have hitherto been observed for spoken languages. Given the discussion above, it should come as no surprise that we take this current absence to be accidental and not to be a principled fact about sign language, spoken language, or linguistic negation in general.

CONCLUSION

In this paper, we made a contribution to sign language typology, a young research field that pursues two, oftentimes related, goals (Pfau and Zeshan, 2016; Zeshan and Palfreyman, 2017). On the one hand, scholars strive to identify structural differences across sign languages, i.e., intra-modal differences, in all domains of grammar—think, for instance, of handshape inventories, patterns of pluralization, and relativization strategies (Perniss et al., 2007). On the other hand, some studies offer a cross-modal comparison, whereby the patterns that are identified are compared to patterns and classifications that have previously been established on the basis of typological research into spoken languages.

In our study on negation and Negative Concord in Georgian Sign Language, we pursued both these goals—following suit of previous studies which compared negation strategies across sign languages (e.g., Pfau and Quer, 2002; Zeshan, 2004a) and/or between sign and spoken languages (e.g., Pfau and Quer, 2002; Pfau, 2016; Gökgöz, 2021). As for the first goal, we established that GESL belongs to the class of manual dominant sign languages, which require the presence of a manual negator—a pattern that has been reported for various sign languages. What makes GESL typologically unusual, as compared to other sign languages, are (i) the availability of a rather wide variety of negative particles, including emphatic and tense-specific particles, and (ii) the multifarious, yet not unconstrained, possibilities for Negative Concord. As for the second goal, the comparison to spoken languages, we showed (i) that the attested negation patterns are clearly different from those available in spoken Georgian, that is, they are not the result of cross-modal borrowing, and (ii), zooming in on NC, that GESL displays some special and unusual characteristics of NC that have also been identified in several spoken languages. A typologically highly unusual characteristic of GESL—both in comparison with other sign languages and spoken languages—is the existence of a tense- and verb-specific type of NC, *viz.* obligatory NC with modal verbs in the past tense.

A component that we neglected in the present study is the non-manual marker involved in negation: a side-to-side headshake. The data allows us to ascertain that a headshake is commonly used in GESL negation and that it cannot by itself change the polarity of a clause. However, we are not yet in a position to say something about its scope, that is, whether it is capable of spreading beyond the manual negative sign. For a manual dominant sign language, the expectation would be that the non-manual marker is confined to the manual negator [*cf.* the LIS example in (2a)]. Yet, the available data suggest that in GESL, the headshake can extend over parts of the clause, e.g., the verb and/or the object. Further investigation of GESL might thus contribute to the typology of sign language negation, as it may reveal that there is also variation within the group of manual dominant sign languages—as has already been demonstrated for non-manual dominant sign languages (Pfau and Quer, 2002). The question would then be whether the headshake is a grammatical marker which is capable of spreading, as has recently been argued for Russian Sign Language (Rudnev and Kuznetsova, 2021), or whether its use is less constrained because it is a co-speech gesture rather than a grammatical element, as has been argued for Australian Sign Language by Johnston (2018).

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: While the participants gave consent for having screen shots from recordings published in the article (as well as for such screen shots being included in conference presentations), they did not consent to having the entire data set made publicly

available. Requests to access these datasets should be directed to Tamar Makharoblidze: tamar.makharoblidze@iliauni.edu.ge.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

TM collected the GESL data by means of elicitation and grammaticality judgements. She wrote "Georgian Sign Language," "Methodology" and Negation in Spoken Georgian," which were revised based on feedback by RP. "Negative modals" and "A Negation-Modality-Tense Interaction" were co-authored by TM and RP. RP wrote "Sign Language Negation" and "Conclusion" as well as first versions of "Word Order and Basic Negation in GESL" and "Tense- and Aspect-Specific Negative Particles," which were revised based on feedback by TM and HZ. HZ wrote "Discussion," which was revised based on RP's feedback. All authors contributed to the article and approved the submitted version.

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Making Referents Seen and Heard Across Signed and Spoken Languages: Documenting and Interpreting Cross-Modal Differences in the Use of Enactment

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Differences in language use and structures between signed and spoken languages have often been attributed to so-called language "modality." Indeed, this is derived from the conception that spoken languages resort to both the oral-aural channel of speech and the visual-kinesic channel of visible bodily action whereas signed languages only resort to the latter. This paper addresses the use of enactment, a depictive communicative strategy whereby language users imitate referents in signed and spoken languages. Reviewing comparative research on enactment, this paper highlights theoretical and methodological shortcomings in prior works. First, a broader set of causal explanations needs to be taken into account when interpreting differences between signing and speaking communities. A more comprehensive conceptual toolbox ensures that differences are not automatically attributed to modality. In particular, less-studied factors of language diversity, like sociolinguistic and cultural ecologies, and how they interact with other factors should be considered. Second, diversity in enactment across signed and spoken languages is shown to be inadequately and insufficiently documented. It is argued that by comparing enactment across more diverse signing and speaking communities and using large, directly comparable corpora, solid analyses can be carried out, enabling a better understanding of how and why different communities use enactment in similar or different ways.

Keywords: enactment, sign language, gesture, depiction, multimodal, comparative linguistics, comparative semiotics

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INTRODUCTION

Enactment is a communicative strategy used in many languaging communities.[1] When enacting, a language user denotes a referent and the latter's actions (bodily behaviour, emotions, thoughts, utterances) using depiction, a method of signaling exploiting perceptual resemblances between communicative forms and their meanings (Clark, 1996; Cormier et al., 2015). This is done by means of bodily movements like the use of gaze, facial expression, torso and hand movements as well as voice (Clark and Gerrig, 1990). The phenomenon has received other labels such as "character

[1]"Languaging" is here defined as the use of a multimodal and composite set of signals involving speech, sign, and speakers' visible bodily actions. Languaging is thus a process that users of both signed and spoken languages engage in.

viewpoint gesture," "role shift" and "constructed action," among others (McNeill, 1992; Herrmann and Steinbach, 2012; Cormier et al., 2015). This terminological multiplicity is paired with a lack of consensus as to how enactment can best be described by linguists. One reason for this lies in the differences in how enactment is used in signed and spoken languages (hereafter, "SLs" and "SpLs").

In the present paper, I start by introducing the framework adopted here to compare SLs and SpLs, i.e., a comparative semiotics of signers' and speakers' signalling repertoires (Kendon, 2014; Ferrara and Hodge, 2018). The paper then focuses on the comparative semiotics of enactment and describes studies that address and compare the phenomenon across SLs and SpLs. Next, I review these works and lay out a research agenda for enactment articulated around Cooperrider's (2019, p. 211) proposal for a double shift in the study of gesture diversity and universals:

> *First, we need better data. We can't afford to overgeneralize on the basis of thin, scattershot descriptions. We need data from culturally and geographically disparate communities, and we need such data to be systematically collected for comparative purposes. And yet data on its own is not enough. The second thing we need is better, more explicit conceptual frameworks. That is, we need intellectual tools to help us make sense of the data we already have, as well as to guide the collection of more data.*

Next, the paper addresses the main approaches taken to account for cross-modal differences. Based on a review of the literature and drawing from like-minded works, I argue that causal accounts of cross-modal differences have been too narrow in scope. I stress the interplay of multiple differences between signing and speaking communities that should be considered when explaining communicative diversity. In addition, I show that comparative research on enactment has been based on small data samples of sometimes monologic, non-spontaneous language use. After arguing that these issues undermine our understanding of enactment across SLs and SpLs, I expand on one way to test claims about the factors which cause cross-modal differences: the use of directly comparable corpora of SLs and SpLs (Johnston, 2013; Hodge et al., 2019). Finally, a summary of the points made in the paper is provided.

Comparing Signed and Spoken Languages

How can signers' and speakers' languaging practices be compared? First, SLs should be compared with speech-gesture ensembles rather than speech only (Vermeerbergen and Demey, 2007). A second step is that of operationalising the comparison on a modality-free basis (Okrent, 2002). Communicative moves in both categories of languages are composites involving different methods of communication that correspond to the uses of Peirce's (1955) three types of signs: symbols, indices and icons (Clark, 1996; Enfield, 2009; Ferrara and Hodge, 2018). Description consists in the use of symbols, i.e., often arbitrary, conventionalised form-meaning pairs, such as lexical and morpho-syntactic constructions or emblematic gestures (Clark, 1996; Teßendorf, 2013). Indicating a referent comes down to anchoring it to a time and place (Clark, 1996). Pointing constitutes one type of indication whereby language users provide an instruction to their audience to look for the referent physically anchored by the extended finger or body part (Clark, 2003). Finally, depiction consists in exploiting the perceptual resemblance between a form and what it denotes to give one's addressee a near first-hand experience of a referent (Clark, 1996, 2016). Depiction is well-studied in speakers' gestures (e.g., McNeill, 1992) but is increasingly recognised as crucial in speech and SLs too (Ferrara and Hodge, 2018). For instance, in languages like Siwu or Japanese, ideophones are lexical classes made up of words which "*depict sensory imagery*" (Dingemanse, 2019, p. 21). Hence, both SLs and SpLs are actioned by means of description, indication and depiction, three methods of communication which rely on different processes. Within a comparative semiotic approach, one can ask: How is the use of these methods distributed across different speaking and signing communities? How are they combined? In what contexts? (Ferrara and Hodge, 2018). Our focus now turns to a comparative semiotics of enactment.

Comparing Enactment in Signed and Spoken Languages

Figures 1, **2** exemplify the use of enactment in LSFB (*Langue des Signes de Belgique francophone*, French Belgian Sign Language)—the SL of the deaf community who lives in the Brussels and Wallonia regions of Belgium—and its ambient SpL—Belgian French. Enactment is exemplified in four utterances drawn from the LSFB and FRAPé corpora (Meurant, 2015).[2]

In **Figures 1**, **2**, both the LSFB signer and the Belgian French speaker take part in a narrative retelling task after watching a cartoon film. Both examples zoom in on a section of the retellings where they describe a woman running to catch a sheet of paper blown away by the wind. Both language users rely on description to talk about the woman ("MS," "WOMAN" in LSFB and "*woman*" for French in a clause preceding the one featured in the example) and the running event ("RUN" in LSFB and "*running*" in French). Simultaneously, they use their bodies to enact the story character's actions. While uttering the lexical sign "RUN", the LSFB signer draws the woman's worried facial expression and rotates their head and torso to the left. The signer's gaze is shifted in the same direction, away from the addressee (see third still). Finally, the signer extends their arms to imitate the catching and draws a relieved facial expression (fourth still). In the Belgian French example, while uttering "*who who's running after a sheet of paper,*" the speaker simultaneously enacts the woman using several articulators: they rotate their head to the right, redirect their gaze upwards and move their arms to enact how the woman tries to catch the sheet of paper (second, third and fourth stills). These examples show that signers and speakers can use enactment to depict the same event (see also Johnston, 2013, p. 118, for an example of similar uses of enactment by

[2]As conventional in signed language linguistics, ID-glosses in SMALL CAPS are used for signers' manual communicative actions. These glosses are arbitrarily based on French words, here translated in English, which are not necessarily translations of the LSFB signs. "CA" stands for "constructed action," another term for enactment. "LH" and "RH" respectively stand for "left hand" and "right hand".



LH	DS:PERSON	DS:PERSON	RUN	CA:WOMAN-CATCHES-SHEET-OF-PAPER
RH	MS.	WOMAN	RUN	CA:WOMAN-CATCHES-SHEET-OF-PAPER

FIGURE 1 | LSFB Corpus, Session 29, S059, Task 12: 00:04:00.002 – 00:04:03.895. Reproduced with permission.
The woman starts running and catches the sheet of paper, relieved.



FIGURE 2 | FRAPé Corpus, Session 10, L019, Task 12: 00:00:20.074 – 00:00:21.681. Reproduced with permission.
[Il y a une jeune dame aussi qui a l'air de partir au travail] qui qui court après un papier.
[There's also a young woman who seems to be leaving for work] who who's running after a sheet of paper.

an Auslan [Australian Sign Language] signer and a speaker in McNeill, 1992).

In **Figure 3**, the signer retells an interaction with their grandmother on a bus. After signing for a while, the grandmother experiences linguistic insecurity due to marginalising attitudes towards SLs (Padden and Humphries, 2006; Hill, 2015). The signer is then told by their grandmother to stop signing. In the example, the signer enacts the grandmother by reorienting their head and breaking gaze address while producing the sign glossed "STOP" (third still). In the remainder of the illustration (fourth and fifth stills, co-occurring with "LOOK" and "WHAT"), the speaker enacts their own reaction by adopting an incredulous facial expression, leaning their head forwards and quoting themselves: "WHAT?"

In **Figure 4**, the speaker discusses lexical variation between Belgian and Canadian French and retells an event where, upon their using the Belgian French word *drache* ("rain"), a Canadian colleague is left wondering what they mean. The speaker first enacts themselves announcing that it is raining (*"it's lashing down"*) (first still). Next, this enactment continues as the signer utters "*so then I see Guillaume*": they turn their head to the right side, lean their upper body towards the left side and redirect their gaze as though looking at their colleague (second still). They then use enactment while uttering Guillaume's words "*it's lashing down?*" to show their colleague's puzzled facial expression (third still). Finally, they enact themselves responding to the colleague, changing their gaze direction, and adopting a smiling facial expression while explaining the meaning of *drache* (fourth still): "*Ok Guillaume so, (it means) 'it's raining lots and lots*'."

In the present paper, "enactment" is used as an umbrella term to refer to all uses of this strategy by both signers and speakers. This is motivated by the assumption that a same phenomenon underlies at least some instances of enactment in both SLs and SpLs and that "enactment" can be used as a label for a comparative concept (Haspelmath, 2010; Hodge and Cormier, 2019). Research has revealed that enactment is part and parcel of the repertoires of both signing and speaking communities (McNeill, 1992; Quinto-Pozos, 2007; Ferrara and Johnston, 2014; Thompson and Suzuki, 2014; Clark, 2016). Linguists and gesture researchers have tried to explore how enactment varies across semantic domains or referential targets, discourse genres, and other factors of variability in language use. Much attention has been given to quotational phenomena. Indeed, enactment often co-occurs with discourse chunks in which language users refer to



FIGURE 3 | LSFB Corpus, Session 29, S059, Task 5: 00:03:47.596 – 00:03:50.587. Reproduced with permission.
We were signing and my grandmother waved at me: "Stop (signing)". I looked at her and was like: "What?".



FIGURE 4 | FRAPé Corpus, Session 10, L020, Task 5: 00:04:27.620 – 00:04:35.071. Reproduced with permission.
"euh il drache euh c'est", donc là je vois Guillaume qui tique: (inintelligible) "il drache ?" "Ok Guillaume en fait, (ça veut dire) 'il pleut très très fort' en Belgique".
"erm it's lashing down erm it's", so then I see Guillaume flinch: (unintelligible) "it's lashing down?". "Ok Guillaume so, (it means) 'it's raining lots and lots' in Belgium".

utterances and, in SLs, it may be the most standard way to refer to a referent's utterances (Quer, 2011; Herrmann and Steinbach, 2012; Hodge and Cormier, 2019). In SpLs, enactment is very frequent in speech reports too (Clark and Gerrig, 1990).[3] Though several have argued that utterance reporting constitutes a sub-kind of enactment, inasmuch as the reported utterance is an action that is depicted (Clark and Gerrig, 1990; De Brabanter, 2017), these two notions are distinguished to easily expose diverging perspectives in the literature. Hence, like Steinbach (2021), I here distinguish between "quotational" enactment, the use of visible bodily articulators and voice to depict a referent whose utterances are reported, and "non-quotational" enactment, the use of the same channels to depict a referent performing actions different from languaging. In **Figures 3**, **4**, two instances of utterance reporting are found in LSFB ("STOP," "WHAT") and three in French ("*it's lashing down,*" "*it's lashing down?*" and "*Ok Guillaume so, [it means] 'it's raining lots and lots'*"). These utterance reports all co-occur with quotational enactment as language users depict the referents whose utterances are reported using their gaze, head, torso, facial expression and voice. The two examples also feature non-quotational enactment where the referents' actions are depicted, but not their utterances. These tokens of non-quotational enactment co-occur with the production of "LOOK" in LSFB and "*I see Guillaume*" in Belgian French.

While both quotational and non-quotational uses involve the perspective-taking of another referent or of the language user in another context (e.g., time or place), researchers have addressed or integrated these phenomena in different ways. On the one hand, some have approached enactment based on Clark and Gerrig's (1990) account of quotation as depiction (e.g., Hodge and Cormier, 2019). This approach sees the "reporting" or "construction" of utterances or thoughts and of other actions

[3]"Utterance reporting" and "quotation" will be preferred to "speech reports" and the like in the present paper because they are less modality-bound. In particular, these terms are used here to refer to what is commonly labelled as "direct speech reports" (notwithstanding that this excludes SLs) where the report features the reported utterer's perspective (Coulmas, 1986). This focus on direct reporting is motivated by the fact that enactment also brings the enacted referent's internal perspective to the fore.

as forms of depiction. Following this account, it is no surprise that these uses present many similarities in SpLs and SLs (e.g., Liddell and Metzger, 1998). On the other hand, other researchers have taken a particular interest in providing formal accounts of the phenomenon. By these accounts, some properties of enactment in SLs cannot be fully explained by an approach treating the phenomenon only as quotation or depiction (Lillo-Martin, 2012). For instance, looking at the behaviour of indexical expressions, researchers have claimed that indexical shifts occur beyond quotational contexts or that some place and time indexicals do not always get a shifted interpretation in enactment (e.g., Quer, 2011). Therefore, they argue, at least some uses of enactment in SLs could rather be likened to (language-specific) conventionalised structures in SpLs.

Moving to the varied discourse genres in which enactment is found, the phenomenon has been widely described for narrations in both SLs and SpLs (Hodge and Ferrara, 2014; Stec et al., 2016; Bressem et al., 2018). One function of enactment in the narrative genre has to do with the liveliness enabled by this referential strategy (Tannen, 2007). Since enactment provides addressees with a seeming first-hand experience of a referent and/or the action(s) performed by the latter, it is particularly useful for what Clark and Gerrig (1990, pp. 793–794) call "engrossment": "*Direct and indirect quotation contrast in whose perspective the addressees are to get engrossed in.* [. . .] *On the addressee's side, to become engrossed in an event is to reexperience it vividly.*" Clark and Gerrig's observations are echoed in research carried out on how enactment can be used as a resource for viewpoint expression and relies on embodied simulation (e.g., Dancygier and Vandelanotte, 2017; Hostetter and Alibali, 2008). For instance, enactment can be used by interactants to display affective or evaluative stance, e.g., distancing themselves, with respect to the enacted referent and/or behaviour (e.g., Niemelä, 2010; Shaffer, 2012; Palfreyman, 2020).

A substantial part of the literature has documented the use of enactment in narration and/or for the expression of stance. It is however clear that enactment is also a useful way to represent referents (Slonimska et al., 2021). As Clark and Gerrig (1990, p. 793) point out, enacting a referent is a good solution to the issue of ineffability (see also Quinto-Pozos, 2007 for a discussion of how enactment can be considered as obligatory for similar reasons in ASL):

> *Many things are easier to demonstrate than describe. Imagine trying to describe how to tie a shoe, parry a lunge in fencing, or knit purl.* [. . .] *It is also generally easier to demonstrate: emotion, urgency, indecision, and sarcasm in tone of voice; gestures, facial expressions, or other body actions;* [. . .]. *If speakers and addressees try to minimize effort in communication, as generally assumed* [. . .], *whether speakers describe or demonstrate an aspect should depend, all else being equal, on which is easier.*

Even though enactment is more frequent in narration than in conversational settings (Puupponen et al., 2022), it is by no means confined to this genre. A growing body of research has shown how enactment can prove a powerful tool to do reference in SLs. In that respect, one aspect that has drawn signed language linguists' attention is the extent to which enactment co-occurs with other semiotics. For instance, Cormier et al. (2015, p. 189) propose a three-way typology of the phenomenon distinguishing between "overt," "reduced" and "subtle" enactment (see also Quinto-Pozos and Mehta, 2010): overt enactment exhibits "*strong intensity,*" the use of "*many articulators*" and does not co-occur with other elements of "*narration.*" When producing overt enactment, language users fully adopt the enacted referent's perspective. When language users produce reduced enactment, by contrast, they resort to few articulators and use "*simultaneous narration (lexical material).*" In such cases, language users' alignment with the perspective of the enacted referent is weak. Subtle enactment lies in between these two categories. While language users are mostly aligning with the enacted referent's viewpoint, their own internal perspective, though less salient, remains active due to the production of "*some simultaneous narration (lexical material).*" While this division has been revised (Jantunen et al., 2020), the recognition of different degrees of enactment has proved informative to document how the phenomenon varies across registers. Indeed, Puupponen et al. (2022) show that, though overt enactment is the most frequent type in both FinSL (Finnish Sign Language) conversational and storytelling settings, the distribution of overt and non-overt enactment varies as a function of discourse genre.

Looking at "clause-like units" in Auslan, Ferrara and Johnston (2014) and Hodge and Johnston (2014) have shown that enactment can be the only strategy expressing core information like the denoted process, the participant (be it agent or patient) involved in the said process, or even the combination of these two pieces of information (see also Jantunen, 2017 on the interplay of enactment and FinSL clauses). Whereas it is clear that less conventional semiotics merge with spoken discourse, making "composite utterances" emerge (Enfield, 2009), the interaction of enactment with SpL structure has received less attention. Some studies have pointed out that enactment can fit within the organisation of clauses in SpLs. For instance, as Clark and Gerrig (1990) show in "*The boy who had scratched her Rolls Royce went [rude gesture with hand] and ran away*." (p. 781), tokens of enactment can function as constituents embedded in SpL utterances (see also De Brabanter, 2010; Ladewig, 2020). Enactment is notably useful when the utterer's intended information is particularly dense (Slonimska et al., 2021). Seeking to single out referential functions of LIS (Italian Sign Language) enactment, Slonimska et al. (2021) use a controlled experimental setting where participants play a director-matcher game in pairs. After one player is asked to describe images varying in the amount of information (ranging from two to five information units) they display, the other player is asked to retrieve the corresponding images based on their description. Slonimska et al. (2021) note that increases in the amount of information found in the images lead to a higher use of enactment, hence suggesting that enactment is used by LIS signers for communicative efficiency. One explanation for this lies in signers' simultaneous use of different bodily articulators, notably for enactment (Quinto-Pozos and Parrill, 2015; Slonimska et al., 2020). As Slonimska et al. (2021, p. 372) exemplify,

> *A signer who tilts their head upwards while depicting a person shaking hands does not only intensify the depiction of the character*

but also provides information in its own right, i.e., that the character is shorter than the person [they are] shaking hands with.

The example provided by Slonimska et al. (2020) puts in the foreground another, related, property of enactment: when enacting referents, language users can also convey information about other referents. Indeed, gaze direction, body posture and other bodily behaviours can index another referent to be construed for addressees. Liddell (2003) coins these referents "invisible surrogates." Using an example from ASL (American Sign Language) where a signer reports an interaction between two referents, Liddell exemplifies how the utterance "KNOW WHERE MY HOME" (translated as "*Do you know where my home is?*") is produced with cues which indexically refer to the addressee being asked the question: "*the signer does not merely recite the signs of the questioner. He directs his eye gaze towards an imagined addressee*" (2003, p. 159). Padden (1986, p. 50) refers to these instances of enactment where two referents are construed as "contrastive role shifting." Herrmann and Steinbach (2012, p. 220) propose that, when DGS (German Sign Language) signers report conversations between two interactants, they position several bodily articulators with respect to locations in the signing space associated with the reported utterer and addressee:

The loci of the signer and the addressee of the reported utterance act as anchors for the respective perspective shifts during quotation. [. . .] *[T]he signers' eye gaze and the head are turned towards the addressee of the quoted situation* [. . .]. *By contrast, the signers' body leans towards the locus of the quoted signer.*[4]

This argumentation resorts to an important body of literature on SLs' spatial reference-tracking systems. For instance, Lillo-Martin and Klima (1990) describe how ASL signers associate specific referents with positions in the space surrounding them, using so-called "referential loci," and subsequently exploiting them in discourse. Puupponen (2019, p. 16) also notes that movements of the head or body can indicate referents, notably in tokens of enactment:

In some movements of the head or the whole upper body, the head moves towards an introduced or previously established location (i.e., an imaginary referent) while the face and gaze may be oriented towards an addressee [. . .] *or to the imaginary referent.* [. . .] *[T]hese movements anchor the simultaneously occurring manually signed contents to the reference point of an imaginary referent.*

Similar indexical properties of enactment are certainly present in SpLs. Comparing the first and the second still of **Figure 4**, it is striking that the speaker shifts from a neutral position to the use of the same bodily articulators (gaze, head, and upper body) to enact themselves looking at their Canadian colleague, thereby indexing the latter's position in the depicted scene.

Summing up, a multifaceted picture of the contexts of use, semiotic functions and forms of enactment across SLs and SpLs has been presented. Despite striking similarities, such as the use of the same bodily articulators and its frequent occurrence in narration and quotational contexts, the comparison of enactment across SLs and SpLs remains a topic of debate. It remains unclear to what extent signers' and speakers' uses of enactment constitute the same phenomenon. These claims are spelled out in more detail in the next section.

CROSS-MODAL DIFFERENCES IN ENACTMENT

Frequency of Use

Researchers have described enactment as highly frequent in SLs, more so than in SpLs. Herrmann and Pendzich (2018, p. 285) claim that one cannot "*find the identical frequency of such comparable strategies in spoken language.*" In a similar vein, the use of enactment in utterance reports has been described as obligatory inasmuch as enactment "*necessarily marks the linguistic report*" (Quer, 2019, p. 225). Despite claims of pervasiveness in SLs, few studies quantify the occurrence of enactment. Hodge and Ferrara (2014)'s study of Auslan narrative text-based and picture-based retellings is an exception. They note that roughly 39% of the discourse time co-occurs with enactment. It is less clear how frequent the strategy is in SpLs. In their study on American English, Stec et al. (2016) find that nearly all 704 (97.4%) tokens of utterance reporting in their dataset of personal narratives co-occurred with enactment.

Studies comparing SLs with their ambient SpLs attest that enactment is more frequent in the former. Rayman (1999) compares ASL and English narrative retellings and reports that ASL signers "*reliably* [used] *role-shifting throughout the story* [while] *English speakers did not enter into the role of either of the characters.*" Marentette et al. (2004) compared narrative retellings by ASL signers and English speakers and also found that productions in ASL exhibited a more frequent use of enactment than the ones in English. Focusing on BSL (British Sign Language) and British English storytellers, Earis and Cormier (2013, p. 340) found that "*depicting characters using expressive elements such as co-speech gesture does not always occur in spoken English, but depicting characters* [. . .] *appears to be a very important element of storytelling in signed narratives.*" Finally, Quinto-Pozos and Parrill (2015) compared how ASL signers and English speakers used depiction relying on either internal viewpoint—enactment—or external viewpoint. Their depictions were elicited by exposing participants to specific events of the same narrative in a retelling task of short cartoon clips. Those events which led speakers to use enactment were also retold by signers using the same strategy. Nevertheless, for those events that speakers depicted from an external viewpoint, signers not only used external viewpoint but also produced enactment. One may thus infer that ASL signers used it more than English speakers overall. Hence, based on those language pairs that have been compared, enactment is more frequent in SLs than in SpLs.

Use of Enacting Articulators and Manners of Articulation

Another cross-modal difference lies in the articulators used for enactment. The most frequently mentioned articulators for

[4]For the sake of clarity, Herrmann and Steinbach's (2012) use of "signer" could be substituted by "utterer." Indeed, signers also enact/report SpL utterances.

SLs are gaze, face, head and torso, often subsumed as "non-manuals." In Herrmann and Steinbach (2012)'s study on DGS utterance reporting, they report the following frequencies for these articulators: face (98%), gaze (86%), head (77%) and body lean (48%). For ASL, Quinto-Pozos and Parrill (2015) code for three categories: "affect" (namely, the use of facial expressions), "torso" and "handling" (i.e., the use of a language user's hand(s) to depict the manipulation of an object). Quinto-Pozos and Parrill report a total of 176 enactment tokens. In 150 (85.2%), face was used whereas torso and signers' hands were used in respectively 113 (64.2%) and 61 (34.7%). While the use of handling is restricted to those events which equally elicit enactment in speakers' renditions, the use of facial expression and torso movements are prevalent in all kinds of events, leading to the conclusion that "*uses of affect and the torso by signers are common and important ways to engage in the retelling or narration of a set of events*" (Quinto-Pozos and Parrill, 2015, p. 27). It is clear that non-manuals play an important role in signed enactment. But this may not be a modality-specific result. In Stec et al. (2016)'s study of American English quotational enactment, non-manuals were found to be more frequent than the enacting use of hands. Posture change (arguably involving both head and torso movements), gaze and face were used in, respectively, 84.7, 71.4, and 47.7% of tokens. In comparison, hands were only used in 20.6% of the tokens. It is also worth noting that Stec et al.'s study addressed a SpL and hence included the analysis of voice, which was used in 55.3% of tokens.

Still, differences across SLs and SpLs are corroborated by studies making cross-modal comparative claims. Rayman (1999, p. 78) notes that "*in contrast* [to deaf ASL signers], *the hearing narrators rarely used facial expression to depict characters.*" Non-manuals, including gaze as well as head and torso, are also cited as more frequent in BSL than British English enactment (Earis and Cormier, 2013). According to Herrmann and Pendzich (2018), in DGS non-quotational enactment too, there are cross-modal differences in the recruited articulators: unlike DGS signers, speakers use their legs to enact referents. Further work may be warranted as the use of the lower half of the body has been attested in other SLs, like ASL, FinSL or LSFB (Quinto-Pozos and Mehta, 2010; Jantunen et al., 2020; Vandenitte, 2021). Hence, though it is not clear which specific articulators are more frequent in SLs and SpLs, prior research suggests that signers resort to specific articulators more systematically than speakers do.

In addition to the use of specific articulators or absence thereof, there have been claims that even when signers and speakers resort to similar articulators, the latter may still be used in different ways. Hence, SLs and SpLs may also differ in the manners of articulation recruited for enactment. Specifically, some uses of enactment, like quotational uses, in SLs have been described as exhibiting more systematic formal characteristics. Quer (2019, p. 225) proposes that enactment "*occurs systematically intertwined with the utterances or thoughts of the reported agent, in a richer and more structured fashion than in co-speech gesture.*" The systematic use of role-shift, whereby language users map referents in the space around them and use that space in enactment, has also been argued to be specific to SLs. Padden (1986, p. 49) says:

> *"Role shift" is perhaps an unfortunate term.* [. . .] *These kinds of descriptions incorrectly suggest that whatever common sense knowledge we have about play-acting ought to apply to understanding how role-shifting works in ASL.*

In several works comparing SLs and SpLs, differences related to role-shift patterns are mentioned. In Earis and Cormier (2013), the use of eye gaze as well as head and torso positioning is reported to be more conventionalised in BSL than British English. Whereas speakers' use of enactment is largely seen as depictive, BSL signers orient their eye gaze, head and torso in order to align with locations in the signing space associated with specific referents. Perniss and Özyürek (2015) compare the use of enactment predicates, i.e., iconic lexical signs denoting manual actions, in DGS with enacting hand movements performed by German speakers when retelling addressees about stimuli consisting in video vignettes. In the same line as Earis and Cormier, Perniss and Özyürek (2015, p. 51) note that

> *DGS signers perform Enactment predicates depicting manual manipulation (e.g., unscrewing the lid of a jar) at the location associated with the referent performing that action nearly half the time* [. . .]. *In contrast, German co-speech gesturers very rarely localize these types of Enactment predicates.*

To sum up, signers and speakers seem to use enactment in different ways. Signers use enactment more frequently. In addition, signers might exhibit more conventionalised enactment practices inasmuch as they may more consistently use certain articulators, locations and/or modes of articulation. In the remainder of this paper, I will come back to these studies, review their methodologies and argue that further work is needed to ascertain that claims on enactment conform with the ways language users enact referents in naturally occurring discourse. Before that, some ways in which these potential differences have been and could be accounted for are laid out.

ACCOUNTING FOR CROSS-MODAL DIFFERENCES

From Modality Effects to a Broader Set of Causal Frames

What is to be made of differences between signers and speakers? How can they be accounted for? Enfield (2014, p. 13) provides a framework to account for linguistic diversity based on six causal frames:

> *Each of the six frames – microgenetic, ontogenetic, phylogenetic, enchronic, diachronic, synchronic – is distinct from the other in terms of the kinds of causality it implies, and thus in its relevance to what we are asking about language and its relation to culture and other aspects of human diversity. One way to think about these distinct frames is that they are different sources of evidence for explaining the things that we want to understand.*

The following sections present the frames deemed most relevant to account for cross-modal differences. I exemplify how these frames have been used to account for cross-linguistic and cross-modal differences broadly (first

addressing languaging phenomena that are separate from enactment). Next, the discussion narrows down to how Enfield's framework can help reframe the interpretation of cross-modal differences in enactment.

The Microgenetic Frame

Microgeny refers to the phenomena usually studied in the fields of psycho- and neurolinguistics, phonetics and kinematics. Enfield subsumes it as the set of processes linked to the ways in which humans process actions. Because speech communities process languages in very similar ways, accounts of differences based on microgenetic causes are rare. Still, Moisik and Dediu (2017, p. 1) use a biomechanical model to examine "*whether variation in human vocal tract anatomy and physiology constitutes a systematic bias or pressure on speech sound systems.*" In particular, this hypothesis is examined by investigating the link between the presence of click sounds in the phonological system of a language and aspects of alveolar ridge morphology. Microgenetic causal explanations have also been used to explain diversity in gesture. For instance, Cooperrider et al. (2018) observe that non-manual pointing is distinctively prevalent in the Yupno speaking community. Some causes offered to account for this prominence are the pressure towards minimal effort or potential long-term effects of speakers' hands being frequently occupied (e.g., performing manual work) during interactions, hindering the use of manual pointing.

The differences between signing and speaking communities are sometimes depicted as owed to so-called "modality" effects. In this tradition, microgenetic factors are invoked: SLs are often described as visually perceived and kinesically produced whereas SpLs additionally rely on vocal production and auditory perception (Meier, 2002). Modality effects are understood as resulting from the fact that "*the language modality—auditory-vocal or visual-gestural—influences linguistic structures in different ways*" (Zeshan and Palfreyman, 2020, p. 531). One clear example of how this microgenetic difference impacts SpL and SL use has to do with their main channels: the motor controls required for the different modalities (e.g., the effort required to move one's hands with respect to one's vocal folds) lead to different articulatory rates (Bellugi and Fischer, 1972).

Another example has to do with the fact that interactions in signing communities take place in contexts that are somewhat different with respect to those of speaking communities. Referring to this as "*the semiotic umwelt of signers,*" Johnston (1996, p. 63) says that "*sign languages are face-to-face languages rooted in the immediate physical situation of the context of utterance to an extent seldom appreciated by non-signers. When signing, one must always be in view of one's interlocutor and stop most non-linguistic behavior.*" Many have asked to what extent the pervasiveness of face-to-face interaction and mutual visual attention for signers may have (dis)favoured the emergence and use of specific symbolic forms with respect to SpLs. For instance, the pervasive reliance on the visual-kinesic modality in signed interaction has an impact on the presence of iconicity in SLs. Johnston (1996, p. 65) continues:

> *The world is primarily temporal, visual, and spatial rather than auditory.* [. . .] *[T]he fact that our experience, as a whole, is visual, temporal, and spatial means that a language that has visual and spatial resources for representation has greater means for mapping onto itself those very visual and spatial qualities.*

Languages are, in part, shaped by the sensory and linguistic experiences of their users (but see Kusters et al., 2017 on how individuals flexibly navigate different interactional contexts using diverse semiotic resources). Interactions within communities lead to the emergence and use of forms that are tailored to their environment and communicative purposes. Though microgeny is an important frame to explain cross-modal differences, it is not the only way SpLs and SLs differ.

The Ontogenetic Frame

Ontogeny is the causal frame in which one looks "*at how a person's linguistic habits and abilities are learned and developed during the course of that person's lifetime*" (Enfield, 2014, p. 14). Ontogenetic explanations have been provided for some cross-linguistic differences. For instance, Trudgill (2009) proposes that morphosyntactic complexity is influenced by social aspects of languaging communities. Of interest here is the impact of ontogeny on what Trudgill refers to as the processes of 'morphological complexification' in a given language, identified by the following criteria: higher degree of "*irregularity*, *allomorphy* [as well as] *redundancy,*" as evidenced in this latter case by "*a growth in the number of morphological categories* [. . .] *and the introduction of repetition of information*" (Trudgill, 2009, pp. 105–108). These processes have been shown to be less prominent in languages characterised by high-contact situations involving late learners of the community's language, i.e., learners who have come in contact with this language after they had "*passed the critical threshold for language acquisition*" (Trudgill, 2009, p. 99). As Trudgill explains, morphological complexity makes it harder for late learners to master a language. Pidginisation then occurs as late language learners integrate into a community, leading to less morphological complexity. Trudgill provides several examples of morphological complexity drawn from traditional dialects of English which contrast with varieties of General English, i.e., those varieties of English involved in many high-contact situations and which count many late learners.

Schembri et al. (2018) propose that signing communities provide a good test case for the preceding ontogeny-related claims. In signing communities like the Auslan, BSL or ASL communities, deaf children are often surrounded by hearing caregivers: Mitchell and Karchmer (2004) report that this applies to more than 95% of deaf individuals. This means that there are very few native signers and that this group is in a community-internal high-contact situation with deaf non-native signers (Schembri et al., 2018). In addition, some of these non-native signers have acquired a SL as a delayed first language. Indeed, as Emmorey (2002, p. 205) states: "*[t]he critical period hypothesis has special import for the Deaf population because if a deaf infant is born to hearing parents who do not sign, then exposure to an accessible natural language will be delayed.*" This unique sociolinguistic situation makes signing

communities heterogeneous groups with important internal variation, including in age of acquisition. Schembri et al. (2018, p. 5) note that following Trudgill's criteria, SLs like Auslan, BSL and ASL can be described as having "*low to moderate levels of morphological complexity*." This could be motivated, at least partly, by the ontogenetic factor, i.e., the "*unique sociolinguistic situation and language transmission patterns of sign languages*" (Schembri et al., 2018, p. 7). Another frame which has been shown to generate cross-linguistic differences is the enchronic frame.

The Enchronic Frame

The enchronic causal frame is the one in which one resorts to social-interactional processes to provide causal accounts of language phenomena (Enfield, 2014). Enchrony involves processes such as "*relevance* [. . .], *local motives* [. . .], *sign-interpretant relations* [. . .], *and social accountability*" (Enfield, 2014, p. 15). For instance, in interaction, language users can enchronically choose to produce utterances depending on what has been said before, on their intentions, and on the modalities and method(s) of communication they decide to use. In making these choices, language users can be held accountable for respecting or deviating from social-interactional norms in vigour in their community. For example, research in gestural pragmatics has shown how diverse multimodal practices can be recruited for interaction. Kita (2009, p. 162) points out that "*cultures may differ in how much gesture is highlighted/foregrounded as a medium of communication.*" For instance, Japanese speakers nod more frequently than American English speakers do in conversation (Kita and Ide, 2007). This diversity has been explained enchronically by foregrounding speakers' observance of distinct cultural norms such as differences in the "*emphasis on cooperation and consideration for others*" (Kita and Ide, 2007, p. 159). The enchronic causal frame has also been invoked to account for differences between signing and speaking communities. For instance, in narrative retelling tasks, Rayman (1999) and Marentette et al. (2004) report that signers take up more time than speakers, producing lengthier and more detailed narrations. This has been attributed to storytelling norms specific to signing communities. This is congruent with Ladd's (2003) claim that storytelling plays a peculiarly prominent role in deaf communities like the ASL one and is considered a prestigious skill, whereby good storytellers are often seen as leaders by their peers.

The Diachronic Frame

Diachrony is the causal frame in which phenomena are explained in terms of "*social/cultural history* [by looking] *at elements of language as historically conventionalized patterns of knowledge and/or behaviour*" (Enfield, 2014, p. 15). Cross-linguistic lexical-grammatical distinctions have been explained resorting to diachronic processes which happen at timescales ranging from years to centuries. For instance, the language-specific processes of lexicalisation and grammaticalisation are used to account for the diversity of constructions in the world's languages (Croft, 2001; Traugott and Trousdale, 2013). Morphological complexification is often described as a process which takes time, potentially accounting for why younger languages are less complex than older ones. This explanation has been used to account for reports that creole languages exhibit less grammatical complexity than older languages (e.g., McWhorter, 2001 but see DeGraff, 2001 for arguments against this view).

SLs are subject to the processes which feed phenomena like lexicalisation and grammaticalisation, just like SpLs (Wilcox and Occhino, 2016). For instance, the ASL lexical sign "STRONG" has undergone a grammaticalisation process whereby the sign is nowadays used as the modal "CAN" (Shaffer and Janzen, 2016). However, SLs are relatively young languages (e.g., Kyle and Woll, 1985), some still being referred to as "emerging" (Adone, 2012). Differences in language age have been provided as an explanation for differences between SLs and SpLs (e.g., Meier, 2002). The impact of SLs' young age is however a debated issue. Aronoff et al. (2005) claim that SLs display high morphological complexity with respect to other young languages, like young creole languages. However, there is no agreement as to what constitutes a morpho-syntactic encoding in SLs and many phenomena previously likened to SpLs' grammatical conventions are increasingly approached in indexical or depictive rather than descriptive, morphosyntactic, terms (see Puupponen, 2019). In the same vein, Schembri et al. (2018) argue that SLs exhibit little morphological complexity, partly because of their relatively young age. Despite the difficulty in determining the time depth of some SLs (de Vos and Nyst, 2018), understanding how SLs' recent history impacts their morpho-syntactic structures will require both theoretical and methodological developments to identify criteria of complexity and the analysis of more SLs of different ages.

On the Interconnectedness of the Frames

Each of the presented frames has been explained in isolation for the sake of clarity. However, causal processes at play in languaging occur simultaneously and are undoubtedly interrelated. To try and make sense of this multiplicity of biases on language, Enfield (2014, p. 17) proposes to ask: "*[H]ow might the outputs of processes foregrounded within any one of these explanatory frames serve as inputs for processes foregrounded within any of the others?*". For instance, the link between ontogenetic factors and morphological complexity discussed above clearly involves many other causal frames. These include the microgenetic frame (e.g., the harder processing of a second language for late learners) and the enchronic frame (e.g., the contact situation which involves the intent to interact and, potentially, streamline language use). As an output, this ontogenetic difference leads to diachronic change (e.g., less complex uses spreading through a community).

Applying this reasoning to the comparison of SLs and SpLs, the sensory microgenetic difference has (only) one direct consequence that, in turn, impacts the languaging practices of signing communities: the easier availability of sound for hearing than for deaf individuals. Hence, one question that linguists interested in cross-modal differences should not miss relates to whether other factors may make signing communities different from other languaging communities. As seen above, these factors

do exist. Another crucial question to ask relates to how this microgenetic factor serves as an input for processes foregrounded in other causal frames. For instance, what is its impact on the distribution of the three basic methods of communication found in all languaging communities (Clark, 1996; Ferrara and Hodge, 2018)? Ferrara and Hodge (2018, p. 12) propose that "*both signers and speakers signal through* [description,] *indication and depiction within the spatiotemporal context of their unfolding interactions, although the exact manifestations of these patterns diverge according to the availability of sound.*"

Bearing the prior considerations in mind, the next section looks at how enactment differences have been explained and rephrases these claims in light of Enfield's terminology. While Enfield's framework does not bring new explanations for cross-linguistic or cross-modal differences, it enriches language researchers' conceptual toolbox by providing them with a new way of framing their explanations of these differences. It provides clear labels for sets of causes traditionally used in different sub-disciplines and research traditions that do not always engage with each other. This lack of interaction means that some accounts of cross-modal differences run the risk of neglecting some causal explanation or of ignoring how the causal frames they invoke interact with other causal processes. While not all frames listed by Enfield may be relevant to explain cross-modal differences, research on enactment can benefit from its innovativeness. The reframing of claims on enactment in light of these causal frames can highlight similarities and differences between different approaches to enactment and facilitate dialogue across researchers. In addition, it will be argued that research on enactment has neglected some causal frames that could help explain cross-modal differences.

Accounting for Cross-Modal Differences in Enactment

Several approaches have been taken to interpret cross-modal differences in enactment. All resort to the well-known microgenetic modality difference. Noting the more frequent localisation of manual enactment predicates in DGS than German, Perniss and Özyürek (2015, p. 20) propose that "*the systematic use of space in the service of reference-tracking and discourse cohesion*" in SLs is due to the fact that "*the visual modality is used unimodally within a linguistic system.*" Signed language linguists have also proposed that patterns reported in studies on SL information packaging can be accounted for by noting that signers fully exploit the affordances of the visual-kinesic modality (e.g., Slonimska et al., 2020). How could this difference evolve in diachronic terms? Perniss et al. (2015, p. 7) propose that "*[i]n comparing sign and (co-speech) gesture from the perspective of conventionalization from gesture to sign, investigation of the degree of conventionalization can reveal new insights into lexicalization, linguisticization, and grammaticalization processes.*" Microgenetic-diachronic accounts postulate that SLs, because of their visual-kinesic modality, conventionalise or grammaticalise communicative actions also found in speakers' gestures. For instance, Quer (2011) and Herrmann and Steinbach (2012, p. 223) offer an analysis of quotational enactment as resulting from a grammaticalisation process specific to SLs: "*[T]he development of role shift into a non-manual grammatical device systematically marking quotations seems to be a modality-specific characteristic of sign languages, which have the unique property of grammaticalizing manual and non-manual gestures.*" This unique property is attributed to the common modality of speakers' gestures and SLs: "*Since gestures use the same articulatory channel that is also active in the production of signs, it is not uncommon for manual and non-manual gestures to become grammaticalized in sign languages*" (Herrmann and Steinbach, 2012, p. 222).

A second explanation for the differences observed between signers and speakers combines the microgenetic modality factor with enchrony. Considering all forms of enactment as depictive, the higher prevalence of this kind of depiction in SLs rather than SpLs could be due to the face-to-face nature of signed interactions and the cultural importance of storytelling in these communities (Marentette et al., 2004; Earis and Cormier, 2013). A similar point is made by Hodge and Ferrara (2014, p. 391): "*[A]s storytelling constitutes a conventional 'script' of expression for many Auslan signers across many communicative domains, we argue that enacted performance is ubiquitous within these signed language ecologies.*" Hence, from this perspective, signers and speakers' differences are rooted in cultural norms about how acceptable and well-received enactment is as a semiotic strategy. A similar explanation has already been used to account for a related depictive phenomenon: the language used when reporting an utterance originally produced in a language not understood by one's interlocutor. Evans (2012, p. 73) reports that one "*contribution of the speaker to the construction of 'direct speech' that we tend to take for granted* [. . .] *is the translation of quotes into the language currently being used by the narrator.*" Evans shows that a narrator reports Dalabon speech in Dalabon in a Kriol narrative, despite the addressee's lack of command of the language. Evans' enchronic account of this difference is reminiscent of Ladd (2003)'s proposal about storytelling prestige for deaf communities: "*In many Aboriginal speech communities* [. . .]*, a good narrator will reproduce the language choice of the characters as accurately as possible, even where the hearer may not understand the quoted language*" (Evans, 2012, p. 73).

What do these causal models predict? If enactment undergoes grammaticalisation in SLs, one may expect paradigmatic differences between standard, depictive uses and their grammaticalised counterpart(s), like quotational enactment. Following grammaticalisation accounts, quotation should co-occur more often (or obligatorily) with enactment in SLs than in SpLs. In addition, signed quotational enactment should exhibit a fixed form-meaning pairing. This form should stand in contrast with its non-quotational counterpart in SLs or any form (quotational or otherwise) of enactment in SpLs. For instance, one could expect a constrained set of articulators, perhaps systematically articulated in specific manners (see Herrmann and Steinbach, 2012; Herrmann and Pendzich, 2018; Quer, 2019). Indeed, Steinbach (2021, p. 356) proposes that

> *[P]rototypical cases of AtRS* [attitude role shift, i.e., quotational enactment] and *AcRS* [action role shift, i.e., non-quotational

> enactment] *have different functional and formal properties: while AtRS is used to report utterances, thoughts, or attitudes and thus includes mainly linguistic material (typically sentences denoting propositions), AcRS is used to report actions and includes mainly gestural demonstrations. Furthermore, both kinds of role shift differ in their non-manual marking.*

In contrast, by the second account, enactment by signers and speakers alike is an act of selective depiction, that is, a form of improvised semiotics (Hodge and Ferrara, 2014). Cross-modal differences can then rather be explained by social-interactional, cultural differences. Variation exists in members of a community's observance of social norms. Enfield (2014, p. 33) refers to Gladwell's (2000) considerations about personality traits:

> *[D]ifferent personality types contribute to the diffusion of innovation in complementary ways. Connectors have a high number of weak social connections, in a range of social spheres. Mavens are actively interested in the market, and want to share their knowledge and opinions. Salesmen are the charismatic, persuasive ones who model innovations and effectively sell them. Innovators are the risk-takers who try things before anyone else does. They are followed by early adopters, the early majority, the more conservative late majority, and finally, the laggards.*

If enactment is one such social norm, one could expect intra- and interindividual variation in its use. No constraints of obligatoriness would be found for either the use of specific articulators or specific manners of articulation. Rather, these characteristics would be driven by context-dependent factors like the nature of the target referent, referential salience, stylistic choices or common ground with one's addressee. Focusing on reported speech, Genetti (2011, p. 73)'s comment on the enacting use of voice adopts a similar view: "*[O]ne needs to consider inter-speaker variation in style. Speakers vary in their interest and proficiency in storytelling and in the degree to which they use a performative style.*" As phrased by Kimmelman and Khristoforova (2018, p. 101), "[*t*]*he optionality of non-manual marking can be explained by the variation in how precise and how expressive the signer decided to be when quoting someone.*" Taking a step further in microgenetic-enchronic predictions, if speakers and signers differ because of social-interactional norms of depiction, one could predict that observed differences hold for both quotational and non-quotational uses of enactment. For instance, taking for granted that utterance reporting is a form of enactment and that enactment is more frequent in some SLs with respect to their ambient SpLs, signers might use utterance reporting more frequently than speakers for the same SL-SpL pairs.

The different causal accounts presented above are not mutually exclusive. It may well be that signers and speakers differ both in their cultural appreciation for enactment and the extent to which this strategy has become conventionalised to express certain meanings in different languages, spoken or signed. Researchers arguing for a conventionalisation phenomenon in SLs acknowledge that teasing apart depictive enactment from its potential conventionalised offshoots is no easy task. Quer (2011, p. 287), for instance, says: "*As a consequence of the language modality, both regularly coexist, either simultaneously or consecutively. Although sometimes the limiting line between the two sorts of elements is hard to draw* [. . .], *I would like to defend that it exists.*" In the rest of this paper, I expand on the idea that, to move the debate forwards, the predictions derived from these claims can and should be tested. Thanks to the creation of comparable SL and SpL corpora, language researchers can now avail themselves of better data to make robust claims on the aspects in which signers and speakers differ and pinpoint those features of enactment which are best explained enchronically and those which could result from a conventionalisation phenomenon. In the next sections, this paper argues in favour of this recent methodological contribution to complement current approaches used to study enactment.

DOCUMENTING ENACTMENT CROSS-MODALLY

Drawing on Stefanowitsch (2020)'s discussion of the criteria of authenticity, diversity and size as well as several remarks on the suitability of corpus linguistics for the study of SLs, the following section addresses shortcomings in the literature and advocates for a corpus-based comparative approach. First, one limitation of some works lies in the absence of data, or reports of the used data, on which the claims are made. Indeed, some statements on the use of enactment seem to draw on researchers' intuitions about speakers' use of depiction. To really understand cross-modal differences, comparable data is needed. Hodge et al. (2019) introduce the Auslan and Australian English archive and corpus, the first directly comparable set of corpora of a SL and its ambient SpL. Thanks to similar sampling frames, the communicative practices of both languaging communities can be directly compared using authentic and diverse language use. The constitution of such multilingual corpora is timely: the corpus-based approach to enactment, as shown in this review, is well on its way and the use of enactment as a comparative concept allows for its operationalisation in corpus studies with well-defined, reproducible, annotation procedures. Guidelines for the study of enactment drawn from Cormier et al. (2015), for instance, have been applied in different studies (e.g., Slonimska et al., 2021; Vandenitte, 2021; Puupponen et al., 2022).

How frequently do users of different languages use enactment? How often do they use specific articulators such as their hands, lower half of the body, non-manuals or voice? What are the manners of articulation of these articulators and how often are they used? What is the impact of modality and how does it interact with the physical properties of the intended referent or action (e.g., quotational vs. non-quotational enactment), culture, genre, register, discourse salience of the referential target or individual style? More specific examples of questions that lie ahead of enactment researchers and could be answered by such corpora, include: What kinds of referents do speakers and signers enact? Could it be that the availability of voice for SpL enactment leads to a different distribution of articulator use with respect to SLs? As a considerable part of descriptive meaning-making relies on different channels for SLs and SpLs, does that have an impact on the articulators they use for enactment? To what extent does

enactment provide core meaning contributions cross-modally? Do speakers also use enactment to make their communication more efficient or is the strategy mostly a narrative and/or evaluative one in SpLs? Are role-shift practices the same in SLs and SpLs? Are they specific to quotational contexts or are they equally found whenever an interaction between two referents is enacted, regardless of whether that interaction involves a languaging event? Studies aiming at answering these questions should strive towards meeting several conditions that are detailed in the next sections.

Sampling Enactment in More but Mostly Diverse Languages

A better understanding of language diversity and its causes can be reached by comparing several language pairs and ensuring diversity in the profiles of the communities who sign or speak these languages. When it comes to cross-modal comparisons of enactment, it may well be that the few SpLs studied by linguists so far, such as American English, are not as gesture-rich as others, e.g., Italian (Iverson et al., 2008). This call for research on diverse languaging communities is in line with Zeshan and Palfreyman's (2020, p. 530) agenda for the emerging field of cross-modal typology, "*typological research in linguistics that takes into account the differences and the commonalities that exist both between languages and across the two modalities of signed and spoken language.*" It is indeed well-known that certain communities and languages have been studied more than others. Henrich et al. (2010, p. 1) have shown that researchers in the fields of behavioural sciences have focused on WEIRD communities: "*Western, Educated, Industrialized, Rich and Democratic.*" Majid and Levinson (2010) argue that linguistics is similarly biased: research in this field has taken for granted that claims that could be made for the languages of WEIRD communities, such as English, could equally be applied to other, non-WEIRD languages. The study of enactment too seems to have been mostly confined to a subset of communities. SpLs in which enactment has been studied include Arabic, English, German, Greek, Japanese, Korean, Spanish, i.e., languages spoken by large communities (Tannen, 1986; Cameron, 1998; Park, 2009; Earis and Cormier, 2013; Thompson and Suzuki, 2014; Quinto-Pozos and Parrill, 2015; Stec et al., 2016; Bressem et al., 2018; Soulaimani, 2018).

Similarly, most research on SLs is restricted to those signed in Europe and North America, particularly languages of signing macro-communities (Fenlon and Wilkinson, 2015, p. 7). These languages "*are transmitted primarily through peers at schools or are learned later in life. They are minority languages surrounded by majority-SpLs, consist of both deaf and hearing signers, and are young languages*" (Fenlon and Wilkinson, 2015, p. 9). Even though macro-community SLs have been the focus of most works in signed language linguistics, they are but one part of the signing communities around the globe. Other communities also use SLs as (one of) their primary languages: these languages are those signed by micro-communities, "*characterized as small labour-intensive economy-based communities, with a much higher incidence of deafness than that seen in developed countries and urban communities*" (Fenlon and Wilkinson, 2015, p. 9). As a consequence, in these communities, there is a "*high number of deaf signers and hearing signers living in close proximity [and] deaf children are much more likely to acquire a signed language from signing parents or from other extended family members and neighbours who can sign*" (Fenlon and Wilkinson, 2015, p. 10). Most SLs in which enactment has been studied are macro-community SLs such as ASL, Auslan, BSL, DGS, DTS (Danish Sign Language), FinSL, Libras (Brazilian Sign Language), LSC (Catalan Sign Language), LSF (French Sign Language), LSFB, LSQ (Quebec Sign language), and SASL (South African Sign Language) (Cuxac, 2000; Aarons and Morgan, 2003; Janzen, 2004; Meurant, 2008; McCleary and Viotti, 2010; Quer, 2011; Herrmann and Steinbach, 2012; Earis and Cormier, 2013; Hodge and Ferrara, 2014; Engberg-Pedersen, 2015; Quinto-Pozos and Parrill, 2015; Parisot and Saunders, 2019; Jantunen et al., 2020).

Progress towards capturing enactment diversity has recently been made by two breakthroughs: the inclusion of less WEIRD communities and the introduction of cross-linguistic and cross-modal studies. The highly diverse profiles of both speaking and signing communities may provide keys to grasp the causes underlying semiotic diversity because they feature different combinations of several factors shaping language use and structure. As Zeshan and Palfreyman (2020, p. 533) suggest, '*it may be argued that sign languages are not different from spoken languages per se, but pattern with particular sub-types of spoken languages*'. For instance, studying micro-community SLs, for which transmission patterns are closer to SpLs where all children acquire at least one directly accessible language from birth, may allow to control for ontogenetic causes in a comparison. Similarly, including SpLs of communities with a strong oral culture helps unravel the impact of enchronic factors on enactment. A striking example that, to the best of my knowledge, has not yet made its way to the signed language linguistics literature, is that of Chantyal, a language from the Tibeto-Burman family found in Nepal. The descriptions provided by Noonan (2006, p. 1) of Chantyal speakers' use of "*direct speech as a rhetorical speech*" are reminiscent of frequent claims on SL enactment. One is that tokens of direct reported speech are frequent in Chantyal (p. 24). Another is that this strategy is crucial in Chantyal discourse. Noonan refers to a potential rephrasing of Chantyal speech that would exclude direct reporting: "*While such a discourse would be fully grammatical, it would be* [. . .] *decidedly unidiomatic. Part of being a fluent speaker of Chantyal involves knowing how and when to use quotatives. Quotatives constitute part of the 'flavor' or 'style' of the language*" (p. 27). Noonan analyses this frequent use of reported speech in enchronic terms: "*The effects that rhetorical styles produce are ultimately social and interactional in origin and not specifically grammatical*" (p. 30). Though empirical comparisons are required, one could be tempted to say that, as far as (quotational) enactment is concerned, Chantyal is a good candidate, to reuse Zeshan and Palfreyman's phrasing, for those sub-types of SpLs with which SLs pattern. Other examples of less WEIRD languages in which enactment has been studied include Murrinh-Patha (Blythe, 2009), ISN (Nicaraguan Sign Language) (Kocab et al., 2015),

as well as ABSL (Al-Sayyid Bedouin Sign Language) and KQSL (Kufr Qassem Sign Language) (Stamp and Sandler, 2021).

Among these, comparative research between SLs with different sociolinguistic profiles have aimed at better understanding enactment diversity. For instance, Pyers and Senghas (2007) compare ISN to ASL, two macro-community SLs which differ in age. ASL is an older language (about 200 years old) whereas ISN is still referred to as "emerging." Pyers and Senghas (2007) note that ASL and ISN enactment are alike in the frequent break in gaze address but differ in the way the upper body is used to enact referents: whereas ASL signers resort to a lateral lean of their shoulders, ISN signers would rotate their torsos. Neither methodological explanations to distinguish between the two movements nor quantitative support for this claim are however provided. Kocab et al. (2015) compared the first and the second cohorts of ISN signers to investigate whether there would be a different use of torso movements across cohorts due to the grammaticalisation of enactment. They note that, "*[c]ompared to the first-cohort signers, second-cohort signers used significantly more [. . .] body shifts*" (Kocab et al., 2015, p. 9). However, no account of how depictive and grammaticalised torso movements were distinguished is provided either. In a more recent study, Stamp and Sandler (2021) compare two micro-community SLs with different network densities, ABSL and KQSL, with a macro-community SL, ISL (Israeli Sign Language). They note that what they consider to be depictive enactment is found across all three communities. They do however differ in the use of conventionalised strategies of enactment, which they classify as "*complex abstract forms*" (Stamp and Sandler, 2021, p. 11), where body positions indicate rather than depict referents. They find that ISL signers use more indicating body shift than ABSL and KQSL signers, who prefer depictive enactment. This difference may be explained by the fact that ISL is a macro- rather than a micro-community SL. Because ISL is a less close-knit community than ABSL and KQSL, Stamp and Sandler propose that it could be under more pressure for conventionalisation. Since these works have relied on the description of short vignettes by participants, it would be interesting to investigate how the ISL, ABSL, and KQSL communities use enactment in spontaneous interactions.

As shown earlier, most cross-modal comparisons of the phenomenon have been limited to macro-community SLs and their ambient SpLs, such as BSL-British English, DGS-German, and ASL-American English (e.g., Earis and Cormier, 2013; Perniss and Özyürek, 2015; Quinto-Pozos and Parrill, 2015). One recent exception is Hodge, Barth and Reed's (under review) comparison between Auslan and Matukar Panau, an Oceanic SpL of Papua New Guinea. Auslan and Matukar Panau are comparable in several respects. Both are face-to-face languages and their communities form tight social clusters. Both languages are also surrounded by another, majority language (Australian English and Tok Pisin). The comparison shows that Auslan signers use enactment about three times more often than Matukar Panau speakers do. Another difference lies in that Matukar Panau speakers mostly enacted referents as speaking or thinking in the study whereas Auslan signers more frequently enacted referents as doing or thinking, and only sometimes dialoguing. In addition, the forms of enactment are partly different in the two communities. Auslan signers used visible forms whereas Matukar Panau speakers preferred to enact referents using their voice. Even when Matukar Panau speakers did use visible bodily forms of enactment, differences arise between the two language groups: they recruited different sets of articulators and Auslan signers tended to use more articulators on average (e.g., using both their head and face rather than using only one of these articulators). In addition to patterns specific to Auslan or Matukar Panau, Hodge et al. also stress interesting variation within each language group. By comparing a SL to a SpL that is not its ambient SpL as well as by addressing individual variation, this study adds to the understanding of enactment in a way not achieved in prior comparisons. Further work is crucial to include signing and speaking communities which differ from each other in ontogenetic, enchronic and diachronic terms. Now that a case has been made for the inclusion of a more diverse sample of languages, specific methodological issues found in the literature are addressed.

Towards Better (Enactment) Data

Size

Most comparative studies of enactment have focused on small-scale, though fine-grained, analyses. For instance, Rayman's (1999) study is based on the use of enactment by 5 ASL signers and 5 English speakers. Both Marentette et al.'s (2004) and Perniss and Özyürek's (2015) comparisons studied enactment as produced by 8 ASL/DGS signers and 8 English/German speakers. In Earis and Cormier (2013), the phenomenon is compared across 2 BSL signers and 2 English speakers. In Quinto-Pozos and Parrill's (2015) study, the number of participants is the highest (23 English speakers and 10 ASL signers). Analysing large samples of data is crucial to study the frequency of use of enactment, the articulators it recruits and their manners of articulation. Large-scale studies may provide solid accounts of variation patterns and their potential causes by distinguishing individual from community patterns (Barth et al., 2022). This is crucial for macro-community SLs because of the unique sociolinguistic ecology of these signing communities and their subsequent highly variable patterns of language use. As put by Fenlon et al. (2015, p. 158),

> *[T]he variability owes much to the fact that SLs exist in unique sociolinguistic circumstances: they are young, minority languages, with few native signers and with an interrupted pattern of intergenerational transmission. As a consequence, it is often difficult even for native signers to be certain about what is and is not an acceptable construction in their language. [P]rocessing* [. . .] *large amounts of annotated texts can reveal patterns of language use and structure not available to everyday user intuitions, or even to expert detailed analysis.'*

A large corpus is more likely to contain many tokens of enactment and hence show potential patterns of variation across different uses of the phenomenon. Large-scale analyses are thus an ideal way to distinguish idiosyncratic variation from

patterns common to larger groups in the community or to the whole community.

Authenticity

Next, taking for granted that authentic data is key to reliable insights on natural language use (Kusters and Hou, 2020; Stefanowitsch, 2020), one can wonder how the experimental setting of some studies impacts enactment and its authenticity. As noted by Stec et al. (2016), authenticity in prior comparisons of enactment could be improved by ensuring dialogic, spontaneous language use by participants with no specific storytelling experience. Participants in Earis and Cormier's (2013) study received a summary of the story to be told in advance and were given time to prepare for their storytelling task. Highly controlled narrative retelling tasks using elicitation materials like cartoons or other visual stimuli may also undermine authenticity with respect to less controlled settings, such as one where topic choice is left to participants. Furthermore, taking for granted that interaction is the natural locus of language use (Clark, 1996), monologic language use, like that produced by participants in Earis and Cormier's (2013), could impact the use of enactment. Indeed, Bavelas et al. (2014) have shown that monologues feature significantly less depiction than dialogues. In a similar vein, having a researcher be the participants' interlocutor, such as in Rayman's (1999) study, might lead to less authenticity.

Representativeness/Diversity

Lastly, another shortcoming in the literature is the lack of representativeness. To make generalisations on communicative phenomena, it is important for the sample to be as representative of language use in its totality as possible. However, as Stefanowitsch (2020) shows, representativity is rarely possible and the best next option is that of diversity. A similar point is raised by Fenlon et al. (2015, pp. 160-161) for SL corpora in particular:

> *[P]articipants are selected as part of a quota sample, according to a set of demographic variables (e.g., gender, age, region, ethnicity, socioeconomic class, and age of SL acquisition) that are considered relevant to deaf communities. Although the resulting data set may or may not be representative of the wider deaf community* [. . .]*, recruiting participants via a quota sample with these demographic variables does take us some way towards capturing the full range of variability in the deaf community.*

Accounts of language use at the community level are thus best achieved by putting the emphasis on the diversity of the data sample. This point bears particular relevance when it comes to deaf signing communities because of the heterogeneous profiles of their members. As enactment has been described as harder to command for late hearing learners of a SL (Gulamani et al., 2020), it is relevant to ask what impact one's language acquisition profile has on one's use of enactment. Future studies could compare how native signers differ from near native and late signers, for instance. Fenlon et al. (2015, p. 164) emphasise that text type constitutes another layer of diversity in the data sample: "*While there are some differences between projects in the type of data collected, there is a clear consensus among projects that different genre types should be sampled in order to maximize representativeness.*"

Fenlon et al. (2015) show that narrative tasks are well represented in SL corpora. Coming back to the study of enactment, more diversity could prove fruitful to see how the phenomenon varies across different discourse genres. Indeed, most works have largely concentrated on narrative data (Slonimska et al., 2021). Participants are often asked to perform a narrative retelling task and, in two cases (Rayman, 1999; Earis and Cormier, 2013), at least some participants or all were known to be highly skilled storytellers. The inclusion of narration is interesting as it is known to be a prevalent discourse genre, potentially more so for signing communities than for speaking ones (Ladd, 2003; Hodge and Ferrara, 2014). However, by focusing almost exclusively on narration, research on enactment fails to meet the diversity criterion as it is left unknown how the use of enactment might compare across different genres, like argumentation or description (see Puupponen et al., 2022 for a recent exception). Because of issues related to intuition-based claims as well as improvable sizes, degrees of authenticity and diversity of the investigated datasets, further comparative research aiming at avoiding these pitfalls is warranted. Ensuring corpus diversity in language users' profiles and in their linguistic activities should help provide a clearer account of intra- and inter-individual variation and better understand why and how they use enactment in specific contexts.

DISCUSSION

Several questions remain open as to the diversity of ways signers and speakers of different communities use enactment. While enactment is more frequent in SLs than SpLs, the amount of idiosyncrasy and conventionality in enactment forms remains unclear: Are some articulators and manners of articulation systematically recruited in community-specific ways and for particular communicative functions? For instance, the distinction between quotational and non-quotational uses of enactment in SLs has yet to be empirically supported. Which are those articulators and articulatory behaviours specific to either SLs or SpLs?

In this paper, I have highlighted conceptual and methodological avenues for cross-linguistic and cross-modal comparative research on enactment. Explaining cross-modal differences should be done by recognising that the modality used by the community is not the only factor at play. In addition, this factor should always be considered in pair with adjacent causal inputs and causal processes for which it serves as an input. What impact do other factors such as time depth of a language (diachrony), community-specific social-interactional norms (enchrony), age of language acquisition (ontogeny), and their interactions, have on the use of enactment?

Main accounts of enactment differences between SLs and SpLs have been reformulated in Enfield's terms. The diachronic grammaticalisation account proposes that a semiotic shift away from depiction occurs, whereby some uses of enactment, like

quotational uses, can be described as fixed form-meaning pairs in SLs. The enchronic account views both uses of enactment as equally depictive, whereby utterance reporting constitutes one sub-kind of enactment where the reported utterance is depicted. The predictions of both these approaches have been fleshed out for further comparative research. On the one hand, the grammaticalisation account predicts that some formal aspect of enactment should be conventionalised for a specific function (e.g., indicating a reported utterer) across discourse genres in a community-specific way. On the other hand, the enchronic account predicts intra- and inter-individual stylistic variation as well as an impact of local factors like discourse genre, intended referent or discourse salience. Following the enchronic approach, quotational and non-quotational uses of enactment should look similar. In addition, if utterance reporting is a sub-kind of enactment, its use could be more frequent in those communities where enactment is generally more appreciated in interaction.

Finally, I have also argued that better enactment data is needed to empirically test these hypotheses. Therefore, comparisons of large datasets of spontaneous, interactional and diverse language use would be fruitful for the study of enactment. These comparisons should address multiple languages of diverse communities featuring different combinations of the microgenetic, ontogenetic, enchronic and diachronic causal factors. Only then will it be possible to spell out data-based accounts of how and why enactment differs across communities.

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What about synthetic signing? A methodology for signer involvement in the development of avatar technology with generative capacity

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Although signing avatar technology seems to be the only option currently available to serve sign language (SL) display in the context of applications which demand generative capacity from the part of the technology like in machine translation to SL, signing avatars have not yet been accepted by signers' communities. One major factor for this rejection is the feeling that technology is developed without the involvement of its actual users. Aiming to invite the signers' community into the process of signing avatar development, we have designed the shell methodological framework for signer-informed technology which is implemented as on-line surveys addressed to signer communities of different SLs. The surveys are communicated *via* focused on-line questionnaires with content of signing avatar performance that allows rating of various aspects of the produced SL synthetic signing by human signers. Here we report on the first survey application with content from the Greek Sign Language (GSL). The analysis of the obtained results is 2-fold: it highlights the significance of signer involvement and the provided feedback in the technological development of synthetic signing; in parallel it reveals those aspects of the survey setup that need fine-tuning before its next distribution cycles. The implementation of the first on-line survey can be found in: https://sign.ilsp.gr/slt-survey/.

KEYWORDS

signing avatar performance, on-line survey framework, signing avatar rating, avatar generative capacity, user acceptance, signer involvement

Introduction

Traditionally, sign languages have been languages which are developed and transferred within the deaf[1] communities of the world. Since SLs are articulated in the three-dimensional space on and in front of the signer's body, video has been

1 Although the standard academic reference d/Deaf is extensively used in the literature as in Kusters et al. (2017), "deaf" is used here as a generalized term to refer to deaf signers, adopting a recent recommendation by the European Union of the Deaf (EUD) (https://www.eud.eu/).

extensively used as a means of SL representation ever since this technology has been made available. The significance of video technology for the representation of signed content also becomes obvious if one considers the lack of a universally accepted system for the written representation of SLs. The use of video has also opened the way to creating sign language corpora, thus enabling the corpus-based linguistic analysis of sign languages and the study of the three-dimensional articulation of signing *via* simultaneous engagement of various articulators (hands, upper body, head, face) on a completely new basis.

However, beyond the revolution that video has brought with respect to SL representation, its use as a means of communication *per se* has several limitations. These include difficulty in editing and lack of signer anonymity. Furthermore, good video quality requires studio infrastructure with proper lighting, capturing devices and video processing equipment, which is neither affordable nor easy to set up. These parameters make it impossible to use video in a manner that would resemble the production of a written document by means of an editing tool or allow easy production of signed messages which, for example, display the result of an automatic translation application like google translate, or modification of a saved file of signing content, as is the case with standard word processors for spoken languages.

In the last two decades, various research attempts to address these problems have focused on developing dynamic sign language representation engines, which use avatar characters for the display of signed utterances. These aims to provide tools that can be used to easily compose, save, modify, and reuse SL content in various education and communication settings, where this lack creates barriers for deaf and hard-of-hearing individuals. Since the earliest attempts for synthetic signing representation, however, deaf communities have received avatar signing with skepticism, if not with complete rejection (Sáfár and Glauert, 2012; Erard, 2017; European Union of the Deaf, 2018; World Federation of the Deaf, 2018). This is partially due to the immature technology underlying SL display, and partially because the signer communities have been kept away from the technology development procedures underlying the synthetic signing performance, which was indeed far from acceptable to technology consumers.

While avatar characters have been developed to be used mainly in gaming, their use was gradually extended to other applications, from film making to various education and communication tools. Sign language synthesis[2] researchers have identified the opportunity to use avatars for the display of signing since the'90s. However, since the very beginning they have recognized the demand to develop enhanced display engines that could provide fine-grained motion capabilities as regards the hands and fingers, the body, and the head, as well as advanced expressivity with respect to all face features, and that SL display sdemand extends far beyond the capabilities of commonly used avatar characters. This demand has been driving dynamic signing avatar technology ever since, and it still poses numerous questions affecting research in the fields of both technology development and SL theoretical analysis, targeting a systematic approach to the incorporation of SL articulation features in synthetic signing environments. Thus, the combination of technological enhancements and SL analysis has proven necessary in view of reaching synthetically composed SL messages that can be recognized as both comprehensible and close to human in respect to signing performance.

In the next sections, we attempt to provide an answer to the question of signing avatar acceptability by showcasing the importance of end-user involvement in the development of the technology. To do so, we developed a methodological framework for involving signers' community in technology development which makes use of a shell environment offered in the form of an on-line questionnaire with the aim to reach as many end-users as possible. The questionnaire underlying structure allows for accommodation of content from different SLs and may emphasize on various aspects of SL articulation. This allows for an iterative process of signers' consultation accommodating content which each time displays the state of technology to be evaluated, thus providing a way of steady communication with and involvement of a wide group of signers during technology development. The goal here is that active involvement of users by means of steady inspection and evaluation of the produced synthetic signing can set the guidelines for the next research goals, while effectively making users participate in the formulation of SL display engines.

Next, we report on the first application of the on-line questionnaire to get user feedback in a survey that intended to identify end-user preferences as regards a specific set of sign articulation features already implemented in two well-known SL avatar technologies. Each of these two technologies represents over two decades of development based on advancements in theoretical research in the last 60 years. These engines, with constant user involvement, may get closer to what signers regard as legibility of the synthetic signed message. In Section Technological and societal background, we present a brief review of the current state of synthetic signing technologies, as well as some societal factors that have incited reticence on behalf of the deaf communities toward avatar signing so far. In Section Methodological framework of the on-line survey application, we present our approach to directly involving deaf individuals in the development of avatar display technology for SL. This is accomplished *via* a series of surveys which use specially designed on-line questionnaires to collect signer preferences regarding various aspects of avatar performance. In Section Results,

2 Although several methodologies have been developed to display SL from sources like video or motion capture data using avatars, here we refer exclusively to signing avatar technologies that can support the dynamic composition of new signed messages in contexts such as SL machine translation or SL editors.

we discuss the results of the first application of the survey, addressing the Greek Sign Language (GSL) community. Finally, in Section Discussion, we provide an overview of the experience gained and our future steps toward further addressing other European SL communities in a steady attempt to enhance the generative capacity of the EASIER SL display engine.

Technological and societal background

Currently, SL display technology can be classified along two distinct dimensions: (a) the appearance of the virtual signer, and (b) the motion of the virtual signer (Wolfe et al., 2021). The quality of these two aspects forms the baseline that determines the degree of user acceptance of the SL message produced by the technology.

A virtual signer's appearance can be of three forms: (i) a video recording of a human signer, (ii) a cartoon character, or (iii) a 3D avatar. As mentioned, although video recordings provide the highest degree of realism, they are extremely difficult to edit (Schödl et al., 2000), despite recent advances toward video reuse (Radford et al., 2016). A cartoon character is a simplified representation of a human form, with the details stripped away to increase its communicative power. But although cartoon characters have been used successfully with children (Adamo-Villani et al., 2013), adults prefer more realism to serve their communicative needs[3] (Kipp et al., 2011). In addition, a 3D avatar offers more realism than a cartoon character and has the flexibility to display signed messages without the need for pre-recorded video (Jennings et al., 2010; Wolfe et al., 2011; Pauser, 2019). In general, appearance should be determined by the targeted audience and communicative setting.

The motion of a virtual signer is far more significant than its appearance (Krausneker and Schügerl, 2021; Wolfe et al., 2021). In SL, the correct motion issue is critical, because motion is essential to understanding the language; when the motion is wrong, the message becomes difficult or impossible to comprehend.

There are three alternative technologies to drive a signing avatar's motion: 1. Motion capture (mocap); 2. Keyframe animation; 3. Procedural animation. Let us briefly go through these technologies. 1. The data acquired by mocap is human motion, which is recorded *via* markers that are placed on the signer's body and face (Brun et al., 2016), or recognized from video by computer vision techniques. Although the motion data obtained in this fashion is natural in quality, this alternative, which is similar to video, lacks generative capacity. The movement in a pre-recorded phrase is natural, but to create a new phrase from it often tends to be very difficult since an enormous amount of resources is required, while the result is not necessarily satisfactory. 2. Keyframe animation is based on the observation of motion in natural signing to communicate its salient features through animation software (Wolfe et al., 2011). The result is a library of signs, or sign fragments, which can be easily used to create new phrases. 3. Procedural animation is an avatar-based technology which creates synthetic signing automatically based on linguistic representations of SL (Jennings et al., 2010) corresponding to a library of motions. The last two techniques have been inspired, in their early steps, by work in speech synthesis. The main working hypothesis is that, if we decompose the signs of a SL in articulation segments and create a library of motions that feeds an avatar with these segments, we can generate the synthetic representation of any sign which is composed of pieces of articulation in the library. Each of the avatar animation technologies mentioned has limitations. Keyframe and procedural avatar animation require considerably fewer computing resources to generate new phrases. But although procedural avatar animation technology is potentially the most powerful one in creating new phrases, the motion in the phrases can look "stiff," "awkward," or "hard to read," according to user assessments.

Recent research attempts to generate new phrases from previously recorded video *via* generative adversarial networks (GANs) (Stoll et al., 2018) have yet a long way to go toward producing results that can successfully portray all aspects of SL including accurate handshapes as well as linguistic and affective processes that co-occur on a signer's face. This is not entirely surprising as machine learning approaches require an extensive number of examples from which a neural network can learn, and unfortunately, the amount available SL data is miniscule compared with the amount available for spoken language translation. Further, due to the over 600 skeletal muscles attached in various ways to 206 bones in the human body, the amount of data necessary to demonstrate every motion in SL would be prohibitive. Currently, this technology is not mature enough to create new SL phrases that are comprehensible. This leaves us with keyframe and procedural avatar animation systems for dynamic synthetic signing.

Previous efforts have placed emphasis on the avatar's appearance, but less attention has been paid to the way the avatar moves (Krausneker and Schügerl, 2021; Wolfe et al., 2021). The quality of the motion is essential for comprehension as SL involves a lot of processes interacting in concert on various parts of the body. The human body moves in coordinated, but asynchronous ways, for example, the eyes and head move before the torso, and the torso will tend to move before the arms (McDonald et al., 2016). Eyebrows can express happiness (up movement) and a WH-question (down movement) simultaneously.

Previous avatars were limited to one scripted motion on each body part and so had to be scheduled sequentially. It was impossible to accurately schedule co-occurring linguistic events

3 A thorough review of the differences between cartoon animation and avatar technology is provided in Wolfe et al. (2021).

(Wolfe et al., 2021) due to limitations in their representations. Furthermore, aspects of SL articulation that are often omitted from avatars include mouth gestures, mouthing, and affect. Thus, the motion representations used as input to the signing avatar are of critical importance. This makes quality of motion regarding the whole set of SL articulators one of the major characteristics that distinguish signing avatars from video game avatars and other computer-generated humanlike characters, also being decisive for the comprehensibility of the avatar's signing.

On the other hand, very little has been reported so far with respect to evaluation of avatar comprehensibility by end-users (Kipp et al., 2011). The best published results to date put comprehension rates at 52% (Pauser, 2019), which, however, is not sufficient for effective communication.

On the user side, lack of successful motion articulation, or even worse, lack of SL representations which incorporate features of the simultaneous multilayer articulation of natural signing, has been one of the main reasons which have led deaf communities to reject SL avatars (Sáfár and Glauert, 2012; Erard, 2017; European Union of the Deaf, 2018; World Federation of the Deaf, 2018). To date signing avatars presented as working solutions to signers' community "have exhibited robotic movement and are mostly unable to reproduce all of the multimodal articulation mechanisms necessary to be legible, comparable to early speech synthesis systems which featured robotic-sounding voices that chained words together with little regard to coarticulation and no attention to prosody" (Wolfe et al., 2021). Display of sign language requires precision in communicative power, to be able to achieve the required comprehensibility and naturalness in signing, which would make it acceptable by human signers.

Apart from robotic motion, there are additional factors that have fueled the negative attitude of deaf communities toward signing avatars. In many cases, deaf signers identify themselves as members of a minority group to which language is the main carrier of cultural heritage and identity, rather than persons with a disability (De Meulder et al., 2019). As such, they need to continuously struggle with policy making issues on local, national, or even global level to establish their right to use their SL for all communication purposes and have the right to face a hearing majority (Branson and Miller, 1998) who is not familiar with SL user communities' reality. Thus, barriers of distrust are also added to the language barrier between deaf and hearing communities. In this context, various already proposed machine translation systems that exploit signing avatars for the display of the signed translation output are far from satisfactory. Thus, instead of been viewed as an assistive tool, the technology is perceived as an unsatisfactory replacement for human interpreters (European Union of the Deaf, 2018; World Federation of the Deaf, 2018; DeMeulder, 2021). Many proposed solutions have been developed by hearing researchers who have little if any at all connection with the signing culture (Erard, 2017). Given this, the poor quality of sign language display is one of the major reasons for the skepticism or even hostility against avatar technology (Sayers et al., 2021).

The direct involvement of deaf users in the development and evaluation of signing avatars is imperative in order to eliminate skepticism, raise trust, and move forward with technologies acceptable by their consumers. A paradigm of constructive cooperation between researchers and the deaf community is the EASIER project[4], where user driven design and technology development have already started producing results. One of the major goals of the project is the direct involvement of SL users at every stage of development of the project avatar. As developers wished to consider every parameter of SL articulation including affect and prosody, it was necessary to develop a steady communication channel with a wide public of SL users, who act as evaluators and provide guidance throughout research steps. To this end, we have developed a questionnaire-based methodology, which enables researchers to reach signers of different SL communities on-line and collect their preferences on various aspects of research work. In the next section, we report on the methodology behind the application of the EASIER evaluation framework for end-user guidance in signing avatar development.

Methodological framework of the on-line survey application

To identify how human signers perceive and evaluate the performance of an avatar's synthetic signing we have developed a shell environment which allows creation of on-line questionnaires to be addressed to various signer groups and question different aspects of synthetic signing performance. The first questionnaire application supported a survey on the preferences of signers regarding the display of affect, hand movement, hand and finger configuration accuracy in isolated signs and in fingerspelling, and smoothness of transition in short phrases, as performed by two synthetic signing engines. The questionnaire was distributed among members of the Greek Sign Language (GSL) community (the questionnaire of the survey can be found at: https://sign.ilsp.gr/slt-survey/).

Next, we present the survey questionnaire's structure along with the decisions and the methodological approaches adopted toward common and uncommon biases that occurred at every phase of its development.

Starting from the design of the shell methodological framework, we tried to create an as possibly unbiased environment which would maintain user-friendly characteristics. To do so we considered various parameters regarding the overall layout of the questionnaire, how the

4 https://www.project-easier.eu/

questionnaire would be distributed and the profile of the participants it would be addressed to, along with our need to regularly address end-users while proceeding with different stages of technological development. With all these parameters in mind, decisions on questionnaire content led to focused, short lasting questionnaire implementations. From a statistical point of view, an exhaustive questionnaire in terms of categories and items would provide a global view of the users' preferences. However, it would demand that the participants devote a significant amount of time and effort to complete it, which would turn its application prohibitive.

One of our main concerns was to balance between a reasonable questionnaire duration (maximum 20 min) that would not cause discomfort or fatigue to the participants, and adequate content to provide clear data on the intended head-to-head comparisons of synthetic avatar signing instantiations for which we needed user feedback. By setting up a viable and reproducible on-line survey we opted to engage into a steady dialogue with signers' communities with respect to various enhancements in the signing avatar technology.

For this first survey the questionnaire was divided in two parts. In the first part, the selection of signs that were generated by the two avatar engines was weighed upon the criterion of complexity with respect to handshape formations, manual movements and basic affect features. In the second part, isolated signs are mixed with short phrases focusing on motion of the upper body, the head, the eyes, and the mouth.

The exploited avatar technologies

The survey involved a head-to-head comparison between two signing avatars, Françoise, and Paula, representing the two most advanced avatar engines with generative capacity currently available. The two avatars use different strategies to create a display of signing performance including the manual element formations as well as the non-manual expressive markers. However, they both use the same original reference recording of productions in GSL that are part of the POLYTROPON bilingual lexical database (Efthimiou et al., 2016), currently comprising ~8,600 entries for the pair GSL-Modern Greek. All lemmas in the database are enriched with phonetic transcriptions according to the HamNoSys coding system (Hanke, 2004). This transcription enables synthetic signing productions *via* animation through an avatar character (Efthimiou et al., 2019).

Françoise was developed by the University of East Anglia (UEA) (http://vh.cmp.uea.ac.uk) in the framework of the Dicta-Sign project. She is animated by a SiGML script deriving from the HamNoSys notation strings which is stored on the SiS-Builder server (http://sign.ilsp.gr/sisbuilder/index.php), a tool that enables the creation and interrelation of SL lexicon entries with the HamNoSys features necessary to drive their synthetic signing and animation (Goulas et al., 2010).

Paula is an avatar developed at DePaul University (http://asl.cs.depaul.edu/) following 20 years of research on synthetic signing animation. Paula's design aims to produce linguistically correct signed outcomes that are convincingly natural in appearance and easy to understand.

The survey entails an experiment based on a selection of signs from the POLYTROPON GSL dataset; the original GSL videos and their accompanying HamNoSys notations were used for the signed productions on both avatar engines.

Greek sign language demographics

In Efthimiou et al. (2014) the demographic data about the Greek Sign Language (GSL) are presented as follows: "*GSL is used by 1% of the 10 million people of the overall Greek population (Facts about Greek Deaf Population 2002), with several thousands of native and non-native signers. In 2000 GSL was approved by the Ministry of Education, as the official language for schooling of deaf persons, following recognition of GSL by the Greek Parliament as one of the official national languages of the Greek State (Legislative Act 2817/2000).*"

Outreach of the first on-line survey

Over the past 10 years the Greek Sign Language and the Greek Deaf Community have been at the epicenter of research performed in various academic fields, such as psychology, education and educational policies, sociology, and linguistics. As a result, the Greek Deaf Community have been targeted as potential participants in multiple surveys, which for various reasons—that are not in the scope of the present article—were not adapted properly in the three-dimensional modality (i.e., questions presented in written text) nor were their outcomes fully disseminated for the wellbeing of the Community. Hence, the members of the Deaf Community have become reticent in participating in such surveys; being aware of this fact allowed us not only to adapt our survey in a fully accessible manner but also circulate our questionnaire *via* collaborating institutions from within the Deaf Community.

The sample of the population to which the survey was conducted, consisted of Greek Sign Language signers who can be broadly categorized in two groups; "L1 signers" including deaf, hard of hearing or hearing signers that acquired GSL from their immediate family environment from early childhood, and "L2 signers" including deaf, hard of hearing or hearing signers that acquired GSL *via* educational procedures (Costello et al., 2006).

The research team, composed of deaf and hearing GSL experts, has collaborated over the years with a significant number of partners with expertise in GSL and Deaf Studies; for the purpose of the present study, we addressed the on-line

questionnaire to the following bodies with the request to forward it to their GSL signer members:

1. The Department of Special Education of the University of Thessaly, with deaf and hearing GSL expert staff.
2. The Deaf Association of North Greece (Ένωση Κωφών Βορείου Ελλάδος).
3. The Association of Greek Sign Language Teachers (https://sdideng.gr/), having as members all deaf teachers active in Greece.

Due to GDPR issues and research ethics guidelines and regulations, responding to the questionnaire was anonymous. Moreover, we restricted personal information to a minimum set of metadata concerning demographic information on gender, age group, education level and GSL manner of acquisition (L1 vs. L2) that were necessary for the analysis of the results. No additional information regarding hearing condition, social and educational status was requested.

During the 3-week period that the questionnaire was circulated among GSL signers before we calculated the results, 91 distinct IP addresses were identified as having visited the questionnaire. By the end of the 3-week period, only 32 out of the 91—one third—had completed the questionnaire, while the rest had stopped responding at various parts of it. One can think of a variety of factors for the questionnaire drop out, including the extremely hot weather conditions during the period, little interest for the topic of the survey or interest decreasing gradually over time, or a combination of all. This indirect feedback will allow us to revisit the overall design of the survey framework including the timing of future distributions.

Regarding the analysis of results, we have taken into account only those questionnaires for which the participants provided data for all questionnaire pages, and hence were considered completed.

Questionnaire instructions display

One of our main concerns was to provide a survey shell fully adapted to the three-dimensional language modality. Considering that language is the principal factor for interaction, we ensured that all questionnaire parts and items could be accessible with the use of sign language only. Hence, in every stage of the questionnaire participants were provided with instructions as to what they were expected to evaluate and how they could interact with the questionnaire environment (i) *via* GSL videos recorded by a L1 signer of GSL, (ii) *via* written text (Greek) available to be viewed if selected, in a text box below each instructive video, and (iii) *via* screen capture videos demonstrating the requested action by the user.

An introductory video presented the scope of the questionnaire, the identity of the research team and a brief description of the EASIER project.

All questionnaire instructions were recorded in the premises of ATHENA/ILSP, in a recording studio that qualifies the highest recording standards. For these recordings, a L1 GSL signer presenting instructions was captured by a High Definition (HD) camera. All videos were rendered with the Advanced Video Coding (AVC) H.264 (MPEG-4) format.

The total duration of the two parts of the survey, including the duration of the video instructions, did not exceed 20 min.

Structure of the first on-line survey questionnaire

The first on-line questionnaire was structured in two parts. In Part A, both avatars were presented to participants on the same screen in a head-to-head manner, while in Part B, participants viewed one avatar at a time. Special care was taken so that in those questionnaire pages where both avatars appeared, these were presented in similar body and face dimensions subject to display settings of the two distinct avatar technologies and against a similar background to minimize bias.

The adopted structure allowed for the collection of information on a variety of aspects, which are analyzed in Section Results.

The linguistic content of the questionnaire was distributed in the two parts as follows:

Part A: participants were presented with both avatars head-to-head, and they were asked to evaluate:

(i) Avatar expressivity *via* inspection of still images of avatar face pairs, while depicting the emotions of JOY, FEAR, ANGER, SURPRISE, and SORROW (Figure 1),
(ii) Pairs of avatar productions of the following signs: TOMORROW, LAKE, INTERPRETER, TRAIN, MILK, HISTORY, BREAK (Figure 2),
(iii) Pairs of avatar performance while fingerspelling the proper names MANOS, NASOS, MARIA,
(iv) Pairs of avatar productions of a set of four short phrases including the previously evaluated signs along with other signs not yet viewed by participants.

In total, 19 signing instances, grouped into 4 categories, were examined as illustrated in the first two columns of Table 1. The presentation order of the two avatars was randomized to avoid bias in the responses. Viewers had to mark their preference, but also rank the performance of the two avatars.

Viewer preference between the two avatar displays in Part A was indicated by color code (red frame in Figure 1), while viewers had to also provide their ranking regarding signing performance of both avatars (boxes marked in yellow in Figure 1) before they could move forward to the next page of the questionnaire. This was a checkpoint of special interest since it could reveal further information regarding viewer attitude than the indication of preference only.

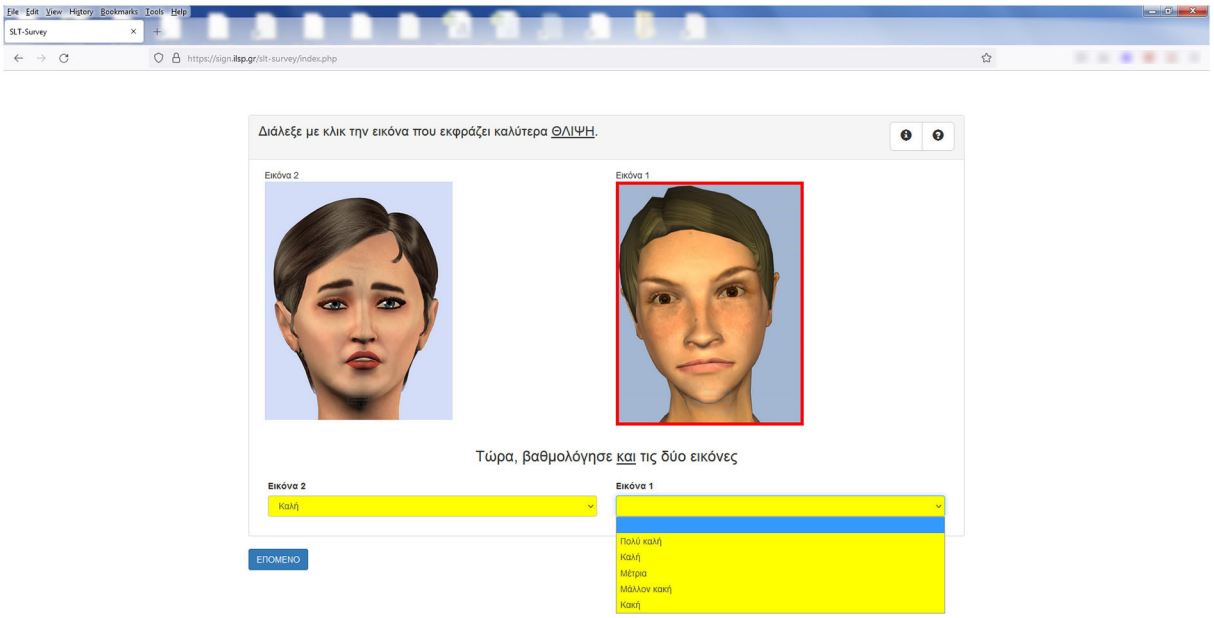


FIGURE 1
Head-to-head inspection regarding the expression of sorrow (Paula on the left, Françoise on the right), red color code indicating viewer preference, yellow color code indicating obligatory ranking of both avatars before moving to the next page.

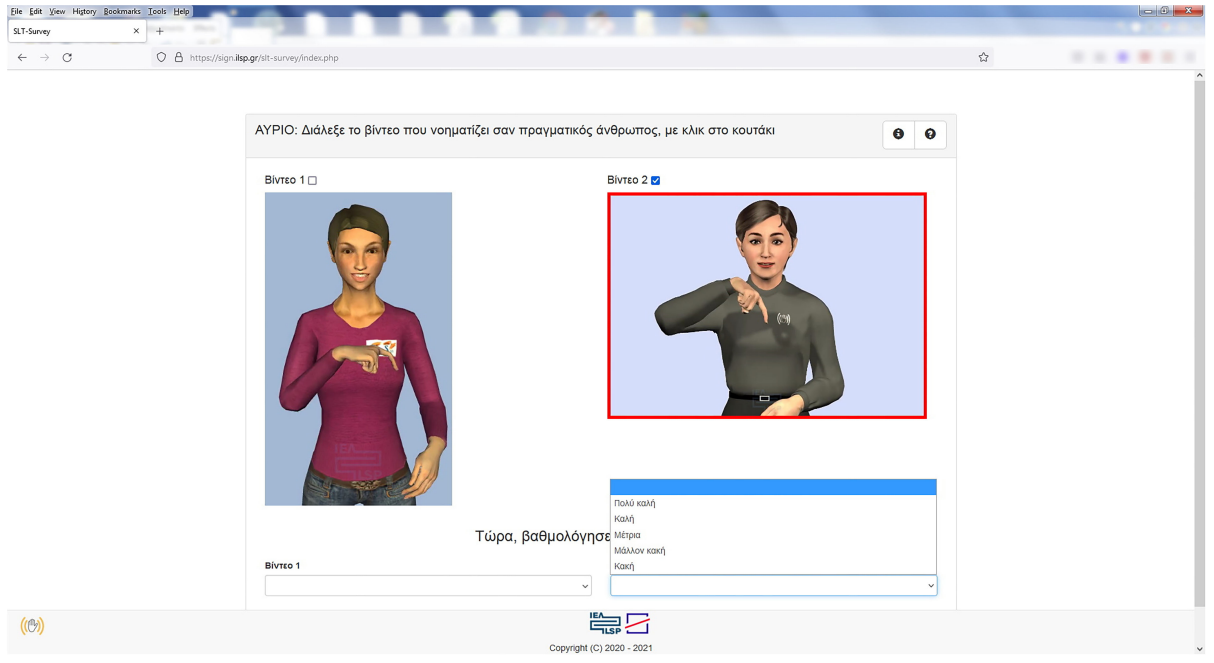


FIGURE 2
Display of the same sign by the two avatars in part A of the questionnaire (Paula on the right, Françoise on the left).

TABLE 1 Analytic overview of median, minimum, maximum, and quartile values for all signing occurrences presented to the participants for both avatars in Part A.

Groups	Signing occurrences	FRANÇOISE					PAULA				
		Min	1st quartile	Median	3rd quartile	Max	Min	1st quartile	Median	3rd quartile	Max
Emotions	Joy	1	3	3.5	4	5	1	3	4	4	5
	Sorrow	1	2	3	4	5	2	4	4	5	5
	Surprise	1	3	3	4	5	2	3	4	4	5
	Fear	1	1	2	2	5	1	4	4.5	5	5
	Anger	2	4	4	5	5	1	3	4	4	5
Lemmas	Tomorrow	1	2	3	3	5	2	4	4	4	5
	Lake	1	2	3	3	4	2	4	4	5	5
	Interpreter	1	2	3	4	4	3	4	5	5	5
	Train	1	3	3	4	5	1	3	4	4	5
	Milk	2	3	3	4	5	2	4	4	5	5
	History	1	3	3	4	4	3	4	5	5	5
	Break	2	3	3	4	5	2	4	4	5	5
Fing/ling	Manos	2	3	3.5	4	5	2	4	4	5	5
	Nasos	2	3	4	4	5	3	3	4	5	5
	Maria	2	3	4	4	5	3	4	4	5	5
Phrases	Phrase 1	1	2	3	3	5	3	4	4	5	5
	Phrase 2	2	3	4	4	5	2	3	3.5	4	5
	Phrase 3	2	3	3	4	5	3	4	4	5	5
	Phrase 4	1	3	3	4	5	3	4	4	5	5
Total		1	3	3	4	5	1	4	4	5	5

The wording of the tasks posed to the participants was a subject of study and discussion among the research team. It was decided to avoid questions of the form "*which avatar do you prefer?*" since they could possibly lead to judgements regarding the external appearance of the avatars, while the aim was to gather data about specific avatar performance features. This led to the decision that the most suitable task formulation for this specific questionnaire would not include the term "avatar" and would neither be phrased as a question but would focus on the signing/emotion production instead. Hence, for the three stimuli categories which were presented head-to-head including lemma, fingerspelling and phrase productions, the viewers were given the task "*choose the video in which the signing performance is similar to human signing by clicking on the box*." For the stimuli category of still avatar images expressing emotions the viewer task was "*choose the image that expresses [EMOTION_TYPE] best by clicking on it*."

In Part A after choosing the closer to human avatar performance, participants also provided a ranking of the performance of both avatars. Ranking of avatar performance was based on a Likert scale from 1 to 5 corresponding to Bad/Rather Bad/Average/Good/Very Good. In order to guarantee that participants go through all protocol steps they had to complete all ratings on a screen before being able to move to the next screen (yellow color indication in Figure 1).

In Part B participants were presented with one avatar at a time. Each avatar performed a set of signs and short phrases. In this part each of the two avatars displayed different content (Figure 3). The aim of this part was to lead viewers to focus on specific features of interest in each avatar performance directly linked to the underlying driving technology. Tasks included rating each avatar separately in respect to:

(i) overall hand motion performance,
(ii) overall body motion performance,
(iii) head and eyes movement,
(iv) mouth movement.

Thus, in this part participants responded only by providing a ranking of each avatar with respect to tasks such as: "*how do you evaluate the hand motion performance?*" Ranking avatar performance was based on the same Likert scale as in Part A, ranging from 1 to 5 and corresponding to Bad/Rather Bad/Average/Good/Very Good.

The survey was accessed by GSL signers *via* the online questionnaire available in https://sign.ilsp.gr/slt-survey/, in which participants were able to watch avatar productions in the form of embedded videos. Regarding software technologies, the questionnaire was created using the open-source Cascading Style Sheets of the Bootstrap Framework. Bootstrap is a framework that allows the creation of responsive, mobile-first

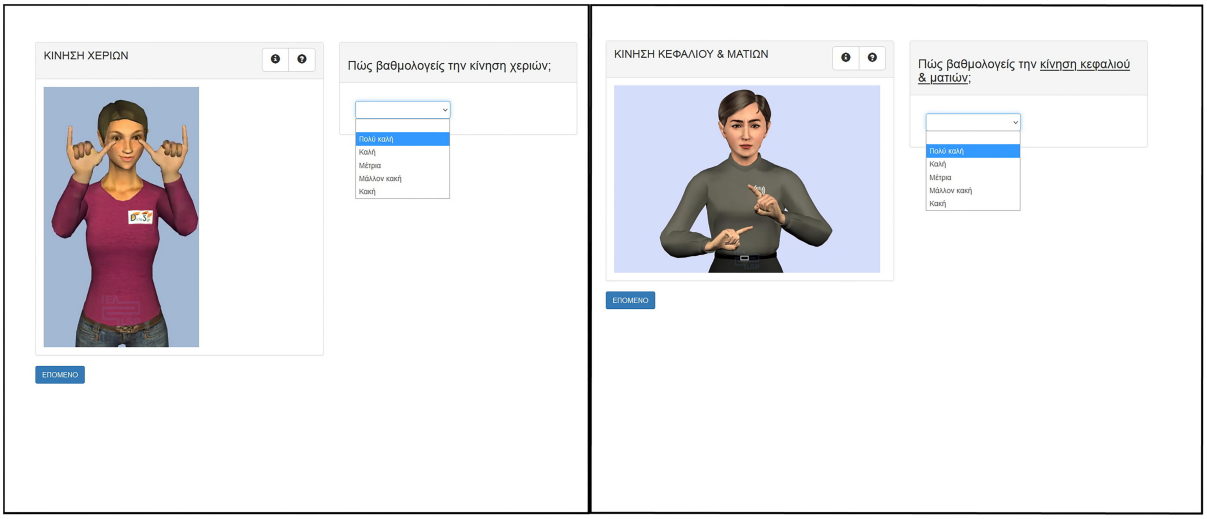


FIGURE 3
Performance observation and ranking in different screens for Françoise (picture on the left) and Paula (picture on the right) avatars in Part B of the questionnaire.

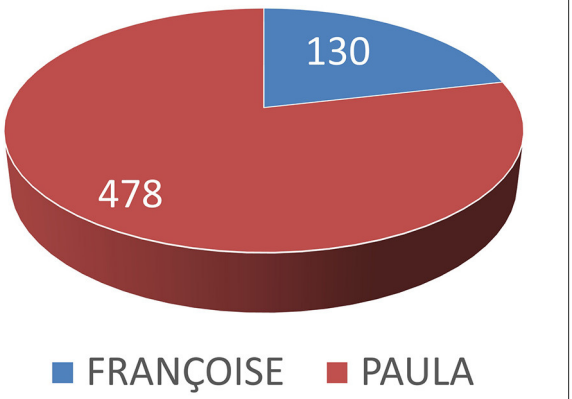


FIGURE 4
Overall avatar preference. PAULA and FRANÇOISE were selected in 478 and 130 answers, respectively.

web applications. Thus, web applications created by Bootstrap Framework can be executed by most desktop as well as mobile browsers. However, due to the considerable number of images and videos in the application, participants were encouraged to use Firefox or Chrome for optimum performance. The user interface was created using HTML5 and JavaScript (jQuery). The database in which participants' answers are stored is MySQL. Php is used to store the data in the database.

Results

Participants' profile

Ninety-one GSL Signers Participated in the Survey in Total, but Only 32 of Them Completed the Questionnaire. Thus, Only the Data From Those 32 Have Been Accounted for in the Result Section.

According to the metadata information provided by the participants at the beginning of the questionnaire, 17 among the 32 participants identified themselves as L1 signers, having learned GSL in their immediate family environment and 15 as L2 signers, having learned GSL in an educational setting later in life.

Among the 32 participants, 21 were female and 11 were male. They were all adults with an age distribution ranging from 18 to 61 years. Due to the restricted number of participants, it was not attempted to perform statistical tests with respect to the metadata parameters. However, within the scope of the overall survey framework, we envisage that future distribution of the questionnaire will be able to provide us with data that will satisfy the statistical requirements for such statistical analysis.

As mentioned above, participation in the survey was voluntary. This fact implies that we did not select a random sample of the targeted population. Thus, no statistical tests were carried out to show significant statistical comparisons between the two avatars, but only descriptive statistics are presented.

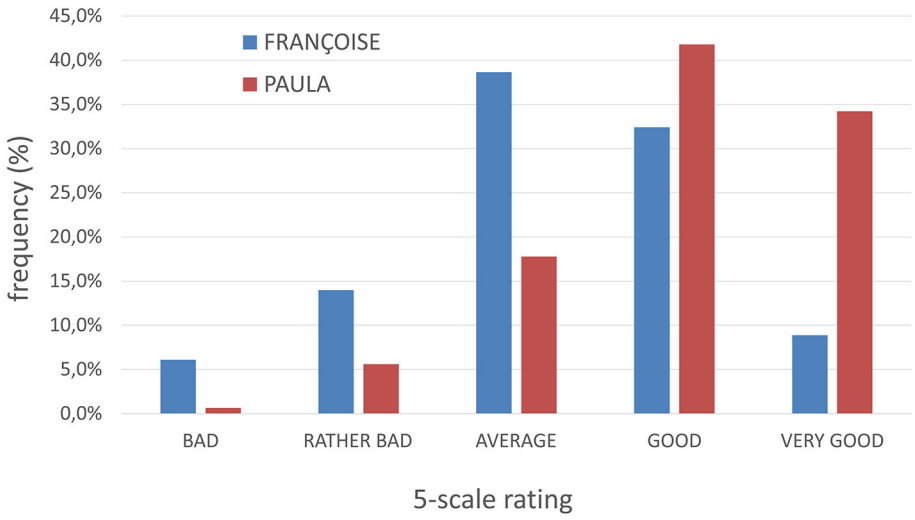


FIGURE 5
Frequency distribution (%) of avatar preference for all signing occurrences (bar plot).

Part A results

In the context of part A, each participant was asked to select the avatar that signed closer to a human in each of the 19 occurrences, grouped within the questionnaire in the following four categories: i. Emotions: 5 images, ii. Lemmas: 7 videos, iii. Fingerspelling: 3 videos and iv. Phrases: 4 videos. Out of the obtained 608 answers (32 participants*19 sign occurrences), PAULA was selected in 478, while FRANÇOISE in 130 (see Figure 4).

In addition to the closed question, participants were asked to rate the performance of each avatar in each signing occurrence in a 5-scale rating (Bad/Rather Bad/Average/Good/Very Good). To get an overview of the obtained data from this 5-scale rating, the frequency distribution in percentages is illustrated in the following bar plot (Figure 5).

By observing the graph above, we conclude that

a) The mode (i.e., the most frequent response) for the totality of the signing occurrences is "Average" for FRANÇOISE and "Good" for PAULA.
b) PAULA's frequency distribution is more right skewed than FRANÇOISE's one.

Both these findings are consistent with the participants' judgment on the binary question which of the two avatars signs closer to a human; the participants preferred PAULA over FRANÇOISE.

To visualize the central tendency and the spread of the collected data (per signing occurrence and in total), we sorted the data in an increasing order, calculated the minimum, maximum, median (i.e., midpoint of the distribution of the ordered dataset) and quartiles values for all signing occurrences presented to the participants within the four groups (see left column) of content for both avatars (see Table 1), and generated the boxplots depicted in Figures 6, 7.

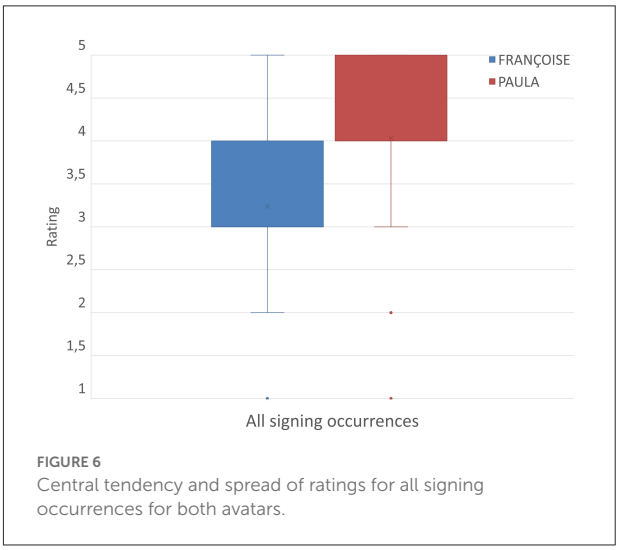


FIGURE 6
Central tendency and spread of ratings for all signing occurrences for both avatars.

In almost all cases, the median value equals either to the 1st quartile and thus the median line in a boxplot coincides with the lower boundary of the box/rectangle, or to the 3rd quartile and thus the median line coincides with the upper boundary. There are four cases in which the median values do not seem meaningful (e.g., 3.5 or 4.5) but these results are due to the even number of the evaluators (i.e., 32). The obtained data from

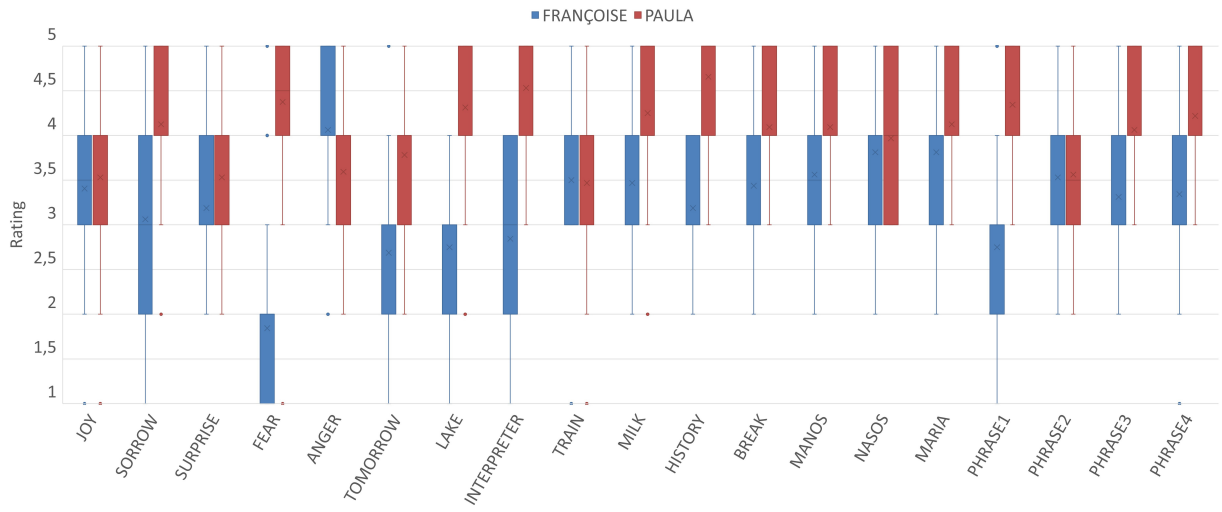


FIGURE 7
Central tendency and spread of ratings per signing occurrence for both avatars.

the 5-scale rating are ordinal, hence the mean value cannot be computed. However, a light "X" in each box has been added, arbitrarily, at the position of the mean value, with the purpose of helping readers who are used to numerical data, to interpret our data. In Figure 6, the boxplots present the central tendency and spread for all signing occurrences for each avatar (see last row of Table 1).

Regarding ratings for all signing occurrences, the median for FRANÇOISE is 3 (Average) while for PAULA is 4 (Good). Based on the blue box's height and position, we observe that the answers for FRANÇOISE's performance are concentrated at 3 and 4 (Average – Good) while PAULA's ones (see red box's height and position) are concentrated at 4 and 5 (Good – Very Good). Moreover, the blue whiskers visualize the spread of the answers given for FRANÇOISE on both sides on the main "lobe," show that rates for FRANÇOISE range from 2 (Rather Bad) to 5 (Very Good) and 1s (Bad) are considered outliers (see blue dot). Respectively, the answer's for PAULA's performance range up to 3 (Average), considering 1s and 2s outliers (red dots).

The following figure (Figure 7) is more explanatory of the performance of each avatar as it presents the central tendency and spread for each signing occurrence the participants were exposed to and illustrates their preferences.

We observe that in most signing occurrences PAULA obtained a higher rating than FRANÇOISE. The most interesting findings from this illustration concern the still images for "JOY" and "SURPRISE," the lemma "TRAIN" and the utterance "PHRASE2." For these signing occurrences the participants evaluated the performance of both avatars as similar, even though the median values for all these occurrences is 3 (Average) for FRANÇOISE and 4 (Good) for PAULA and is consistent with the general tendency as seen in the previous figure.

The first two occurrences are images expressing emotions, those of "JOY" and "SURPRISE." The lemma "TRAIN" (means of transportation) received similar evaluation for both avatars. The signing occurrence "PHRASE2" is the phrase that signifies "*In the train there are many seats*." Interestingly the still image for "SORROW" and the lemma "INTERPRETER" as performed by FRANÇOISE received responses that have significant variation; the ratings for FRANÇOISE are more disperse 2–4 (Rather Bad – Good), while the great majority of PAULA's rating for the same signing occurrences are 4 or 5 (Good – Very Good). Contrary to almost all other cases in which the median line of a boxplot coincides with either the lower boundary of the box/rectangle (i.e., the 1st quartile equals to the median value), or the upper boundary (i.e., the 3rd quartile equals to the median value), in these two cases the 1st quartile, median and 3rd quartile equal to 2, 3, and 4, respectively (see the horizontal line in the middle of the respective box).

Finally, the image expressing the emotion of "ANGER" as expressed by FRANÇOISE received higher ratings than the one expressed by PAULA.

Part B results

In the second part of the questionnaire, the participant task was to provide ratings on the individual performance of each avatar with respect to four movement parameters: i. hand(s) movement, ii. body movement with emphasis on the movement of the shoulders, iii. head and eyes movement and iv. mouth movement. For each of these parameters the participants watched different video compilations that consisted of two lemmas and two phrases. We selected videos in which each avatar was performing best regarding these parameters. Hence,

the created compilations included different content regarding the two avatars. Participants provided their ratings of the signing performance of each avatar on the same 5-scale (Bad/Rather Bad/Average/Good/Very Good).

To get an overview of the obtained data from this 5-scale rating, the frequency distribution in percentages is illustrated in the following bar plot (Figure 8).

By observing the graphs in Figure 8, we conclude that the mode (i.e., the most frequent response) for both avatars, FRANÇOISE and PAULA, is "Good." This is an interesting finding as it indicates that the overall impression of the signing performance of both avatars is equally satisfying the participants.

To visualize the central tendency and the spread of the collected data, we generated the boxplots in Figure 9. The boxplots present the central tendency and spread overall, for all movement parameters for both avatars. It is obvious that the values of 1st and 3rd quartiles are equal to 3 (Average) and 4 (Good), respectively.

Moreover, the whiskers show that the ratings vary from 2 (Rather Bad) to 5 (Very Good) while 1s (Bad) could be considered outliers. In addition, we mention that median values for both FRANÇOISE and PAULA are equal to 4 (Good).

Figure 10 illustrates participants' ratings for both avatars in the four parameters. We observe that in three out of four movement parameters FRANÇOISE obtained a stable rating, between 3 and 4 (Average – Good). PAULA's ratings on the other hand varied more.

More specifically, with respect to "HAND(S) MOVEMENT," PAULA performed better than FRANÇOISE. The ratings for "BODY MOVEMENT" are concentrated at 3 (Average) and 4 (Good) for both avatars. However, further analysis shows that the median value for FRANÇOISE coincides with the lower boundary of the rectangle, in this case 3 (Average), and the median for PAULA coincides with the upper boundary, in this case 4 (Good). Regarding "HEAD & EYES MOVEMENT" the median values are 4 (Good) for both avatars. However, we observe that for PAULA there are also higher ratings ranging up to 5 (Very Good). The "MOUTH MOVEMENT" is the only parameter in which FRANÇOISE obtained higher ratings than PAULA. The median for FRANÇOISE is 4 (Good) and 3 (Average) for PAULA.

Discussion

Statistical results interpretation

Regarding the first part (Part A) of the survey and the head-to-head presentation of the two avatars, for which participants were asked to choose the avatar that had a signing performance closer to the performance of a human, results showed that Paula was the avatar of preference.

Out of the total 608 signing occurrences (19 stimuli of images and videos multiplied by 32 participants), Paula was chosen in 428 of them. Moreover, for each head-to-head instantiation, participants ranked the signing performance of each avatar; the statistical analysis showed that the most frequent response for the totality of the signing occurrences for PAULA is "Good" and for FRANÇOISE is "Average" (Figure 5). This finding is consistent with the obtained results from the head-to-head viewing task for deciding "*which of the two avatars signs closer to a human*" for which the participants expressed a preference for PAULA over FRANÇOISE.

The analysis of per-signing occurrence results showed that in most cases PAULA was the one that participants rated as closer to human.

Even though a larger amount of data is necessary in order to safely draw conclusions, we here attempt to interpret the results for these occurrences that stand out of the general tendency which favors PAULA's signing over FRANÇOISE's one.

Still images expressing emotions

"JOY" and "SURPRISE**":** These images were rated in a similar way for both avatars. This finding allows us to assume that the expression in both avatars is equally satisfying for the viewers.

ANGER": This is the only signing occurrence -still image- for which FRANÇOISE gets higher ratings. Although a lot of research work still needs to be carried out in the domain of embedding emotion expression in synthetic signing, analysis of the expressive means of FRANÇOISE will provide significant insights as regards a complex set of implementation parameters, starting from the facial characteristics of FRANÇOISE in this emotion and the reasons why they were perceived as more convincing in comparison to those of PAULA's.

"SORROW": The image of the emotion as performed by FRANÇOISE received responses that presented significant variation ranging from Rather Bad to Good. PAULA on the other hand received more stable ratings (Good – Very Good). Participants in general preferred PAULA over FRANÇOISE, while the variation in FRANÇOISE's ratings presents a further interesting point for research.

Overall, findings generate interesting research questions with respect to the facial articulators (i.e., eyes, eyebrows, mouth etc.) that participate in the creation of emotion expression in signing avatars. Additionally, we need to investigate intensity and width of facial features and the way they combine in the expression of various emotions. Answering such questions will allow us to incorporate signers' feedback in signing display technology.

Fingerspelling

For all three fingerspelling videos the participants expressed an explicit preference for PAULA over FRANÇOISE. Further testing is needed to validate this finding with more complex

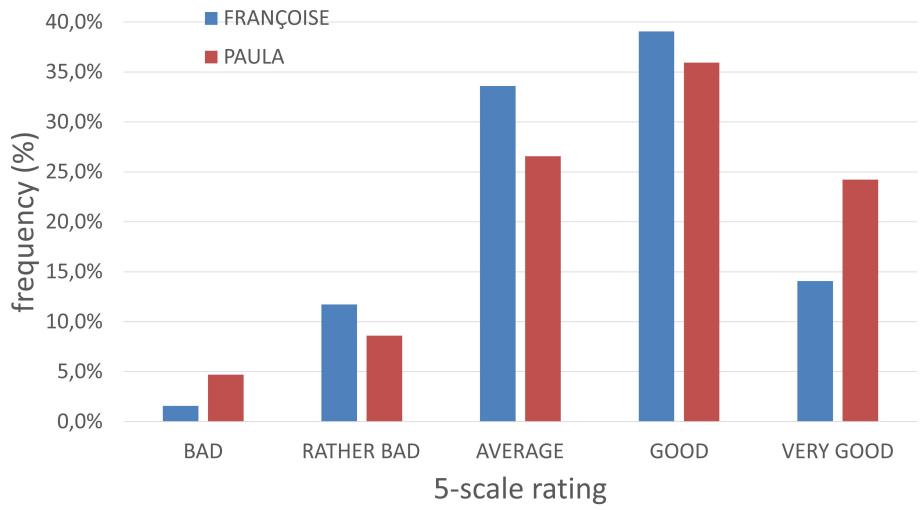


FIGURE 8
Frequency distribution (%) of rankings for all movement parameters (bar plot).

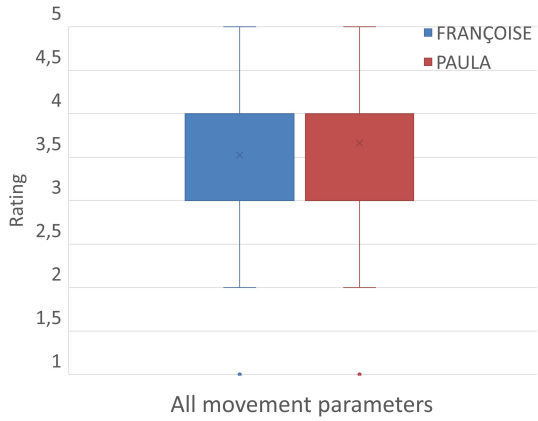


FIGURE 9
Central tendency and spread of rankings for all movement parameters for both avatars.

strings of fingerspelling in isolated strings as well as within linguistic context.

Isolated lemmas

"INTERPRETER": This GSL lemma as performed by FRANÇOISE received responses that had significant variation ranging from Rather Bad to Good. PAULA's ratings for the same lemma varied from Good to Very Good. Like with the emotion image for SORROW, the significant variation in the participants' responses indicates that the performance of this lemma needs to be reevaluated.

"TRAIN": The lemma TRAIN was chosen in this questionnaire for the complexity of the hand movement it involves. Our goal was to receive feedback on the articulation capacity of the two avatar engines regarding performance of this specific sign, the production of which involves technically difficult movement and requires coordination of both hands. According to the participants' judgment and their ratings, this lemma was equally well-performed by the two avatars (Average – Good). This finding becomes significant when combined with the respective findings from "PHRASE2" (see below).

Short phrases

"PHRASE2": The second GSL phrase in the questionnaire roughly corresponds to the English translation "*There are many seats in the train.*" This phrase -similar to all others used in this questionnaire- is a small phrase containing some basic components of GSL phrase formation. However, a certain complexity level is noticed, as it only contains lemmas that are performed with both hands (two handed signs). The ratings of the performance of this phrase for both avatars were similar, and they ranged from Average to Good. The most interesting finding is that the phrase, which in purpose contained the lemma "TRAIN," was rated in a similar way as the lemma "TRAIN" in the isolated lemmas section (see above). Initially, this finding allows us to presume an overall consistency on the participants' ratings. However, to safely claim the validity of this finding, we need to extend testing in the future to a larger pool of stimuli that will involve rating of individual lemmas in isolation and in context.

In the second part of the survey (Part B), each avatar was individually rated for its signing performance with respect

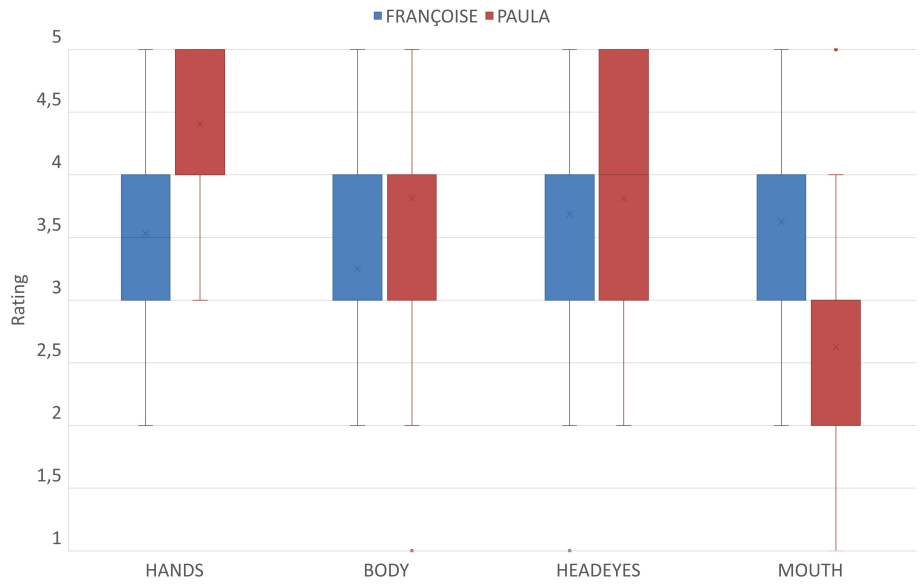


FIGURE 10
Central tendency and spread of rankings per movement parameter for both avatars.

to a compilation of signing occurrences consisting of isolated lemmas and phrases. The overall inspection of the collected data for Part B attests that both avatars performed equally well. An investigation of their performance with respect to the four movement parameters that were evaluated (hand movement, body movement, head and eye movement, mouth movement) led to the findings in Figure 10. PAULA received higher rankings for hand movement and eyes movement, while FRANÇOISE was preferred over PAULA for her mouth movement. Both avatars were equally evaluated with respect to their body movement. These are important findings that need to be investigated in more signing occurrences, within context as well as in isolated instantiations.

Our data in terms of number of participants is sufficient for an initial descriptive analysis as the one performed above. However, in order to further investigate the participants' choices and their respective ratings with respect to gender, age and SL manner of acquisition (L1 vs. L2), we need to extend our survey aiming at a broader randomly selected pool of participants.

Conclusion

The here reported findings from an on-line survey provided significant feedback not only with respect to the targeted aspects of avatar performance, but also regarding the structure of the follow-up surveys, currently under preparation, to address different SLs in the framework of the steady signer consultation strategy on avatar development as implemented in the EASIER project.

The first implementation of the on-line survey has demonstrated its effectiveness in achieving the human-in-the-loop factor in the development of signing avatar technology. Based on the analysis of the collected data, it also proved to make use of a methodologically sound environment in respect to both survey structuring and the display of survey material.

Among the most noticeable findings that allow us to presume an overall consistency on the participants' ratings is the fact that the latter rated similarly lemmas in their individual appearance and within context. Noticeable variation in ratings of a single avatar should be further investigated with respect to factors like age, gender, L1 vs. L2 status and educational level. However, overall good signing performance seems to be equally perceived by all signers.

Future research

The aim being to involve signers in signing avatar technology, we have developed a methodological framework which makes use of a shell environment that can take the form of on-line questionnaires of varying content. Planned accommodation of content from different SLs on various aspects of SL articulation will provide guidance to avatar technology development work, based on experience gained from the first application of the proposed survey methodology as reported here incorporating content from GSL.

The research team's goal is to open a steady communication line with signers in Europe, which will enable the active involvement of deaf European citizens in signing avatar technological enhancement.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

A-LD, KV, and AV contributed to the design of the evaluation protocol and the definition of the tested linguistic content. VP contributed to the statistical analysis of the results of the study. TG developed the on-line questionnaire used in the study and contributed to the creation of the displayed GSL content. S-EF and EE contributed in the design of the evaluation protocol and the development of the user interface. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Role-taking in two micro-community sign languages: Phylogenetic insights

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This study aimed to examine the use of role-taking constructions in two micro-community sign languages (SLs): Yucatec Maya SL (YMSL), and Soure SL. Various role-taking types were quantified and changes in gaze direction were annotated on data regarding these two SLs. The results showed (i) a greater diversity of role-taking produced in YMSL, including complex role-taking (i.e., multiple perspectives or role-taking produced alongside lexical units), and (ii) changes in gaze direction before and after the production of role-taking constructions in both SLs. First, this suggests a phylogenetic development between the two SLs partly observable from the study of role-taking through the conceptual lens of bifurcation of the signer's intent. More broadly, an analysis of the phylogenesis of SLs would benefit from this kind of examination using analytical concepts relevant to SLs. Second, results seem to indicate that the phylogenesis of SLs would share similarities with the ontogenesis of SLs. Indeed, the less socially integrated and analyzed SL (Soure SL) displayed a less advanced degree of bifurcation since few complex role-taking constructions were observed. This is in line with the way these structures are acquired late by SL learners. Further studies on other micro-community SLs would be needed to validate the results of this study.

KEYWORDS

Yucatec Maya SL, Soure SL, non-institutional SL, enactment, embodiment, constructed action, eye gaze, Semiological Approach

Introduction

Role-taking corresponds to the possibility for a signer to embody a character or an entity in sign language (SL). As illustrated in Figure 1, during the realization of this linguistic structure, one or more articulators are involved (for example, the head, facial expression, eye gaze, shoulders, and torso).

Today, several sets of categories coexist to refer to different role-taking in sign languages (SLs) depending on the authors' theoretical framework (see Supalla, 2003, and Lillo-Martin, 2012 for formalism; Cormier et al., 2015; Jantunen, 2017, and Liddell, 2003 for cognitive-functionalism; and Cuxac, 2000 and Sallandre, 2003, 2014 for the Semiological Approach). For instance, "constructed action" (CA)—the most widely used today—"constructed dialogue," "role shift,"



FIGURE 1
An example of role-taking (Martinod, 2019).

"point of view predicate," "personal transfer," "double transfer," or "shifting reference"[1].

Several studies showed that (i) role-taking constructions are narrative devices that are particularly rare in conversations (Ferrara and Johnston, 2014 for Auslan, and Jantunen, 2017 for Finnish SL), (ii) the production of complex role-taking constructions would require a high degree of language proficiency (Morgan, 2002; Slobin et al., 2003; Cormier et al., 2015; Sallandre et al., 2016b; Martinod, 2019), and (iii) a change in eye gaze is a marker for role-taking (a.o. Cuxac, 2000; Cormier et al., 2015; Sallandre et al., 2016b).

Ferrara and Johnston (2014) and Jantunen (2017) indeed report that the narrative register concentrates a high proportion of role-taking: 44% of the units for the frog story in Auslan (Ferrara and Johnston, 2014) and 65% for the same elicited story in Finnish SL (Jantunen, 2017).

Regarding the mastery of some role-taking constructions, Cormier et al. (2015, p. 26) suggest following the acquisition patterns, based on previous studies:

- Overt CA > Overt CA quotative > Reduced CA > Subtle CA[2]
- CA > Role Shift[3]

According to the authors, these trajectories could also stand for historical ones during an SL emergence (p. 33).

In addition, Mixed CA, also termed "multiple perspective constructions" (Aarons and Morgan, 2003), "double-perspective construction" (Perniss, 2007), or "double transfer" in the Semiological Approach (Cuxac, 2000 a.o), seems to be the latest acquired construction (Morgan, 2002; Slobin et al., 2003, p. 291–293).

Concerning the change in gaze direction, some authors consider it to be a marker of role-taking: Cuxac (2000), Fusellier-Souza (2006, 2012), Cuxac and Sallandre (2007), Sallandre and Garcia (2013), Cormier et al. (2015), Sallandre et al. (2016a,b), Garcia and Sallandre (2020), among others.

However, other recent studies suggest that eye gaze patterns vary and might not always be a key criterion in the production of role-taking: Ferrara and Johnston (2014), Jantunen et al. (2018, 2021); and Beukeleers and Vermeerbergen (2019a,b). For instance, Jantunen et al. (2018) observed eye gaze shift occurring with 81% frequency at the beginning of overt CA, but with only 58% frequency at the beginning of subtle CA. According to Beukeleers and Vermeerbergen (2019a,b), during enactments, signers frequently alternate their gaze between the enacted character and the recipient.

Like many phenomena in SLs, role-taking has been described for institutional SLs: presumably American SL according to Cormier et al. (2015) quoting Metzger (1995). Concerning micro-community SLs, although they are described increasingly for the past 30 years, role-taking in these SLs is often mentioned but rarely studied in depth nor in a comparative way. Therefore, there seems to be a gap in the literature on this subject while these languages are supposed to have different structures than the national SLs. Indeed, some authors refer to them by focusing on their diachronic evolution: they would become conventionalized over time (Zeshan, 2003).

Among other things, authors also specify their semantic utility as a representation of referents (Horton, 2020 a.o.). Concerning the gaze during the production of role-taking, Haviland (2020) speaks of "gaze to nowhere" in Z signing[4].

1 See in particular, Cormier et al. (2015) for a critical review of these terms.

2 The features of abovementioned CAs are as follows: Overt CA: clear role-taking without lexeme; Over CA quotative: clear role-taking with reported speech; Reduced CA: the role-taking is reduced and some narration is involved through comments; Subtle CA: differs from Reduced CA by the number and/or intensity of involved articulators (e.g., only eye gaze is enacting the eye gaze of the character).

3 For the authors, "unlike CA which is a stretch of discourse (however short or long) that represents one role or a simultaneous combination of roles, Role Shift is characterized as a shift between roles".

4 Z signing refers to "Zinacantec family homesign", a SL emerging over the past three decades in a family from a remote Mayan Indian village (Haviland, 2015).

This is reminiscent of the "inexpressive gaze" described by Cuxac (2000, p. 55) for the role shift between two role-takings in French sign language (LSF). For YMSL, in particular, Le Guen et al. (2020a) pointed out that the perspective character used in role-taking is also widely used among Yucatec Maya hearing people of the region. Thus, role-taking might represent a privileged means of communication between deaf signers and hearing speakers. In line with this assumption, Safar (2019, p. 39 and 49) detailed two examples where role-taking was used to include two hearing men from the village of Chicán in a conversation between deaf female signers from another village, Cepeda Perraza. The author considered role-taking as part of translanguaging strategies between people (deaf and hearing) from different villages whose SL may differ.

Given the small number of studies devoted to role-taking in non-institutional SLs, this research provides an exploratory study on this topic. Our goal is to enrich typological knowledge about this linguistic phenomenon by examining possible structural differences between the types of role-taking used in two micro-community SLs. We focused on a comparative analysis of role-taking constructions in two sociolinguistically diverse SLs: Yucatec Maya SL (YMSL), used by several generations of signers including hearing signers in Yucatán, Mexico (a.o. Le Guen, 2012; Safar, 2019; Le Guen et al., 2020b), and Soure SL, which is a combination of former homesigns now in the process of social integration, used mostly by deaf signers on Marajó Island, Northeast Brazil. Soure SL is a very little studied SL, with the only existing studies to date being: Martinod (2013, 2019, 2022), Carliez and Fusellier (2016), Carliez et al. (2016), Garcia and Martinod (2017), and Martinod et al. (2020a,b). Using data collected in 2015 and 2017, an analysis was conducted to assess the proportion of role-taking constructions produced according to the type of speech and the diversity of role-taking used by each signer (Martinod, 2019). The current study focuses on YMSL data but Soure SL's data served as a basis for comparison.

After presenting our methodology in Section Methodology (Section Conceptual and analytical tools, Section Data, and Section Annotation), we present the results (Section Results). This section focuses on the impact of the type of discourse on the types of role-taking used (Section The impact of discourse type) and their frequency (Section Frequency of role-taking). We then examine the diversity of role-taking types between signers of the same SL (Section Diversity of role-taking: variation between signers of the same SL) and between SLs (Section Diversity of role taking: variation between SLs). Finally, we assess the role of the gaze (Section Eye-gaze and role-taking constructions) and conclude with our analysis based on the contributions of our study. These reflections concern the role of eye gaze (Section Eye gaze change as a marker of role-taking), the lack of terminological consensus (Section The lack of consensus on terminology: the case of Mixed CA/Double Transfer), which is a possible obstacle to future studies, the phylogenesis of SLs (Section Toward the hypothesis of a phylogenetic evolution between SLs and between signers of the same SL), and the links between phylogenesis and ontogenesis (Section Possible links between phylogenesis and ontogenesis).

Methodology

Conceptual and analytical tools

As mentioned above, the terminology used to refer to role-taking varies from one theoretical framework to another and sometimes even from one author to another. For this reason, in line with Cormier et al. (2015), it is essential to provide clear definitions, avoid confusion, and allow future comparisons on a common basis. The categories for designating role-taking are therefore defined below as well as a still-unknown analytical tool: the bifurcation of the signer's intent.

Categories referring to role-taking

Table 1 shows the seven categories used in the analysis to refer to role-taking and their closest counterparts in the terminology most used in the field. They have been developed by Sallandre (2003, 2014) based on Cuxac's research (2000)[5]. This choice is based on the accuracy these categories provide to describe semantically the possible range of role-taking in SL.

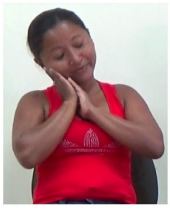
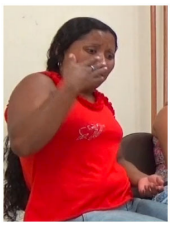
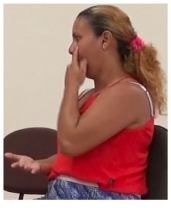
Some categories either do not appear to have an equivalent in the literature (e.g., Prescriptive PT) or correspond to several categories in the literature (e.g., Reported speech w/gesture).

Concept of bifurcation of the signer's intent

An analytical tool developed in the Semiological Approach is also used to bifurcate the signer's intent into two structural branches (Cuxac, 2000; Fusellier-Souza, 2006, 2012; Cuxac and Sallandre, 2007; Garcia and Sallandre, 2014, 2020). This process would occur during the emergence of SLs when the first productions' iconicity of a deaf individual isolated in a hearing environment is gradually structured into two ways of saying:

5 The reader can also refer to Sallandre (2003, p. 139–159) and Martinod et al. (2020a, p. 207) for more illustrated examples.

TABLE 1 Set of analytical categories for role-taking and examples in Soure SL[a].

Label	Definition	Counterpart in the literature	Example
Classic personal transfer (PT)	The signer embodies another individual or entity. All the parametric components, both manual and non-manual, are invested. In the figure, the signer embodies a cat drinking milk.	Overt/pure CA (Cormier et al., 2015) Strong CA (Jantunen et al., 2021)	See Figure 1
Prescriptive PT	This PT has a prescriptive function: the signer shows how to execute an action by accomplishing it himself/herself. Here, the signer shows how to pour milk.	–	
PT w/stereotype	The signer refers to an attitude culturally associated with a certain mental or physical state of the character that is transferred. Here, the signer is embodying a sleeping character by using the typical position associated with this activity.	–	
Semi-PT (PT w/lexeme)	The signer produces a lexeme while performing a PT. Often, this lexeme constitutes a commentary on the action that is performed or on the feeling of the embodied character. Here, the signer realizes the sign for EAT while embodying a character.	Reduced CA (Cormier et al., 2015)	
Reported speech (RS) w/gesture PT	This PT is realized within the framework of a reported speech where the signer uses a co-verbal gesture element of the surrounding culture. Here, the signer holds out her finger in a threatening manner toward the interlocutor of the character she is incarnating.	Over CA quotative, Subtle CA (op. cit.)	
Reported speech (RS) w/lexeme PT	This PT is realized within the framework of a reported speech where the signer uses a lexeme from the SL. Less investment is observed. Here, the signer uses the sign for watch while embodying a character that says "I'm watching you!"	Over CA quotative, Subtle CA (op. cit.)	
Double Transfer (DT) (PT + Situational Transfer)	The signer embodies another individual or entity (=PT) and produces at the same time an element from a Situational Transfer (=signer's perspective). Here, the signer is embodying a character swinging on a hammock while representing the hammock with her two hands.	Multiple Perspective (Aarons and Morgan, 2003) Double-perspective construction (Perniss, 2007) Mixed CA (Cormier et al., 2015)	

[a]Another category (PT with proform) has not been included in the analysis because of the confusion it might raise. Sallandre (2014) already pointed out this issue.

- an ***illustrative*** one, based on highly iconic structures (i.e., transfer structures, including role-taking presented in Table 1) recognizable from a formal characteristic: the breaking of eye gaze toward the addressee,
- a ***generic*** one, with no illustrative intent, based mostly on lexical units (LUs). An advanced degree of bifurcation, as observed in institutional SLs, would thus consist of a fine mastery of the production of

TABLE 2 Analyzed data.

SL	Elicited stories	Spontaneous discourse	Story in front of the camera	TOTAL
YMSL	28 min 45 s	1 h 39 min 05 s	42 min 20 s	2 h 50 min 10 s
Soure SL	11 min 01 s	17 min 13 s	-	28 min 14 s
Total	39 min 46 s	1 h 56 min 18 s	42 min 20 s	3 h 18 min 24 s

TABLE 3 Participants' metadata.

Signer	Sex	Age	1st or 2nd generation of deaf signers
YMSL signer 1	Man	46 years old	1st generation
YMSL signer 2	Woman	±50 years old	1st generation
YMSL signer 3	Woman	20 years old	2nd generation
YMSL signer 4	Man	70 years old	1st generation
YMSL signer 5	Woman	36 years old	1st generation
YMSL signer 6	Woman	±50 years old	1st generation
YMSL signer 7	Man	±50 years old	1st generation
YMSL signer 8	Woman	±50 years old	1st generation
YMSL signer 9	Woman	19 years old	1st generation
Soure signer 1	Woman	37 years old	1st generation
Soure signer 2	Woman	37 years old	1st generation
Soure signer 3	Woman	24 years old	1st generation
Soure signer 4	Woman	±30 years old	1st generation

LUs as well as complex and diverse transfer structures (such as role-taking) and specification of eye gaze (see Sallandre et al., 2016a for a study on seven institutional SLs).

Data

Spontaneous conversations and elicited data from both YMSL and Soure SL were analyzed as summarized in Table 2.

As presented in Table 3, data from 9 YMSL signers and 4 Soure SL signers were analyzed. For YMSL, only one signer out of 9 was a second generation signer. For Soure SL, all signers were first-generation deaf signers.

Annotation

Concerning YMSL data, annotations (segmentation of meaning units, preliminary identification of role-taking) were first made by two research assistants from Yucatán. While one research assistant was deaf, the other assistant was a child of a deaf adult (CODA) with a native command of YMSL. Then, annotations concerning the more precise delimitation of role-taking, labeling of role-taking, and change in the direction of eye gaze were made by the author (see Table 4 below, where the use or not of controlled vocabulary is specified). These were monitored and discussed regularly by Olivier Le Guen, a researcher on YMSL for about 10 years.

Data for Soure SL were referred from the author's thesis work (Martinod, 2019). Fully annotated by her, they were then checked and edited by two deaf signers from the North of Brazil and a Brazilian hearing SL user.

TABLE 4 Annotated elements[a].

Annotated element	Controlled vocabulary
Meaning unit	-
Role-taking	-
Type of role-taking (label)	-
Role-taking between lexemes	-
Eye gaze	Toward the addressee On the signer's hands That of the embodied entity Anticipating the end of the movement Vague
Sequence of eye gaze	(1) toward the addressee_that of the embodied entity_toward the addressee; (2) toward the addressee_on the signer's hands_toward the addressee; (3) back and forth starting and finishing with eye gaze toward the addressee; (4) another sequence pattern.

[a]Moments where eye gaze was impossible to analyze were excluded from the analysis (for e.g., when the signer wore a cap that hid his.her eyes or when s.he turned his.her back momentarily to the camera). The gaze pattern was annotated only for role-taking performed between two lexemes or at the beginning/end of the utterance (i.e., role-taking where the signer's gaze was directed toward the recipient at the beginning and end of the role-taking production).

Results

The impact of discourse type

For both SLs, elicited discourse was the most likely to contain role-taking (19.55% for YMSL, and 21.60% for Soure SL). It is noteworthy that a similar proportion was observed even though the stimuli used for elicitation differed between SLs. YMSL signers had to transpose video stimuli made to elicit ditransitive constructions (e.g., a video showing a man giving

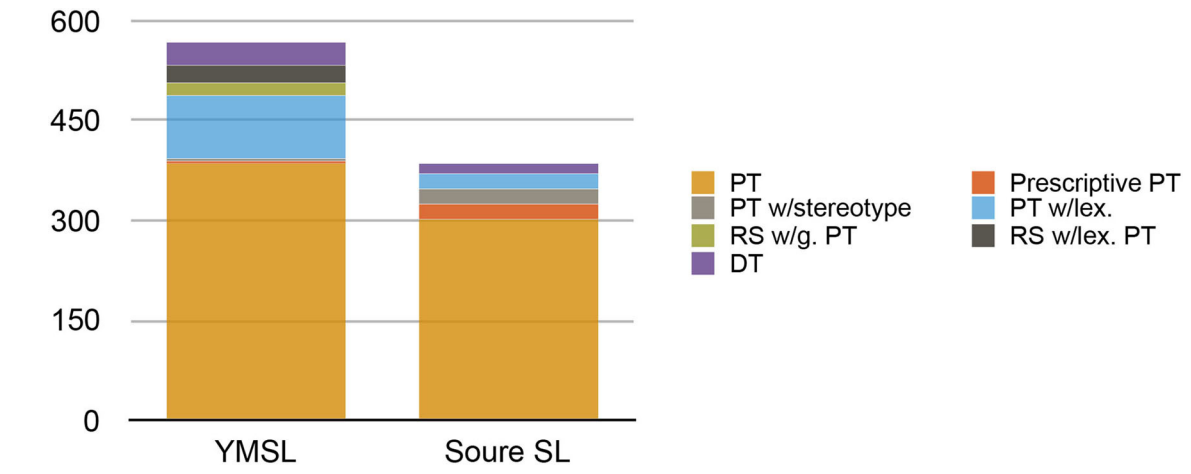


FIGURE 2
Role-taking used in both SLs.

a flower to a woman), whereas Soure signers were asked to transpose a story from various storyboards (e.g., a story about a man falling out of his hammock).

In YMSL, role-taking strongly prevailed in on-camera life narratives, occurring in about 22.75% of all instances, that is 491 units out of the 2,158 produced in this type of discourse. Since data from Soure SL do not include on-camera life narratives, we could not make a comparison on this point.

Frequency of role-taking

As shown in Figure 2, for both SLs, Classic PT was, by far, the most commonly produced. However, we can note differences between the two SLs regarding the other most commonly produced role-taking types. We found the following frequencies:

- In YMSL

Classic PT > PT with lexeme > DT > Reported speech PT w/lexeme

- In Soure SL

Classic PT > PT w/stereotype > PT with lexeme/Prescriptive PT > DT

First, it is worth noting that double transfer (DT), which was a construction previously described as a complex role-taking and probably acquired the latest, was among the three most commonly produced role-taking types in YMSL. In Soure SL, it was one and a half times less observed (3.66% of the produced role-taking for Soure SL vs. 5.78% in YMSL). Second, PT w/lexeme (a role-taking including the production of a lexeme while the signer embodies another character) represented 16.11% of all role-takings produced in the YMSL data while it represented only 5.48% of the role-taking in the Soure SL data. Third, PT w/stereotype was observed more in Soure SL than in YMSL (6.01% in Soure SL vs. 0.7% in YMSL).

Most frequently produced type of role-taking and type of discourse

Concerning the most commonly produced types of role-taking depending on the type of discourse, the following differences were observed.

For elicited data:

- In YMSL

Classic PT > DT > PT w/lexeme

- In Soure SL

Classic PT > Prescriptive PT > DT (PT w/lexeme being the fourth most frequently produced role-taking)

For spontaneous conversation data:

- In YMSL

Classic PT > PT w/lexeme > Reported speech PT w/lexeme

- In Soure SL

Classic PT > PT w/stereotype > PT w/lexeme (Prescriptive PT being then the most produced).

It would thus seem that the type of discourse influenced the proportion of role-taking produced. However, any specific pattern linked to a given type of discourse can be verified in the two SLs. Indeed, for both elicited data and data from spontaneous conversations, the hierarchy of most used role-taking types varied.

Least frequent role-taking

Among the role-taking that were rarely produced or not produced at all (i.e., <3%), we noticed the following:

- in YMSL

  Prescriptive PT and PT w/stereotype

- in Soure SL

  Reported speech PT w/lexeme and Reported speech PT w/gesture

For elicited data, in both YMSL and Soure SL, Reported speech PT w/gesture, Reported speech PT w/lexeme, and PT w/stereotype were the least produced. In addition, Prescriptive PT and PT w/stereotype were produced only in elicited data from YMSL.

Regarding spontaneous data in YMSL, PT w/stereotype, Prescriptive PT, and Reported speech PT w/gesture were the least produced. For Soure SL, it was Reported speech PT w/lexeme and DT.

Diversity of role-taking: Variation between signers of the same SL

In YMSL, for all but two signers, the most produced types were Classic PT and PT w/lexeme. One signer produced just four types of role-taking (the average in the data for this SL being about 63 role-taking per signer). The type of role-taking she produced the most was Reported speech PT w/lexeme. However, it turns out that Reported speech PT w/lexeme shares a feature with PT w/lexeme: it is another type of role-taking where the signer also produces a lexeme while being invested in an embodiment. It was therefore not so inconsistent that this role-taking was the most produced by this signer. The second signer followed the pattern produced by other signers, using the two most produced types of role-taking: Classic PT and Reported speech PT w/lexeme.

In Soure SL, on the other hand, only one signer followed the pattern observed in YMSL and produced a majority of Classic PTs and PTs w/lexeme. However, importantly, in Soure SL, the Classic PT is the role-taking produced by most signers. As mentioned in above, there were fewer PTs w/lexeme in Soure SL compared to YMSL. As for other signers, no particular pattern could be identified. Contrary to the exceptions we observed in YMSL, no Reported speech PT was at the second position of the most produced role-taking in Soure SL.

Differences among the diversity of role-taking types

There were significant differences between signers regarding the diversity of role-taking used. In YMSL, the signer with the highest role-taking diversity used seven different role-taking types while the one with the lowest diversity used only one type, and another one used three. In Soure SL, there was also a gap since the signer with the highest diversity used six different role-taking types. The one with the least diversity uses two while the others used five.

The YMSL signer who produced only three role-taking types was the only one from the second generation of deaf signers. This could have been an explanatory lead as all other participants were first-generation deaf signers, including the person who produced only one role-taking. The observed discrepancy between signers is perhaps due to the quantity of overall role-taking produced. Indeed, the signers in question in YMSL and Soure SL were also those who produced the least amount of role-taking compared to others. It is important to note that the Soure signer who produced the greatest diversity of role-taking (six types) was the one who was the most socially integrated: she interacted very regularly with both deaf and hearing people. For example, she often did occasional jobs at the homes of various hearing families from her neighborhood and also had a unifying role within the deaf community in Soure (see Martinod et al., 2020b). Conversely, the signer who used the least diversity (two role-taking types) was relatively more socially isolated. She often stayed with her hearing family and stepped out very little.

Despite these observations, it is still not easy to determine the potential expressive abilities of the signers in the absence of data to prove it. Perhaps these signers use other types of role-taking in other communication situations, but perhaps not.

Least frequent role-taking types

It should be mentioned that another role-taking category was temporarily added during the analysis of the YMSL data. This was "PT with the use of a real object". It was eventually removed because it was hardly observed in the two SLs. In YMSL, for instance, only two signers produced it but in small quantities, and the other signers never produced it.

On other less frequently used role-taking types, among the YMSL signers, six out of nine never produced PT w/stereotype, four never produced Prescriptive PT, three never produce Reported speech PT w/lexeme, and two produced neither PT w/lexeme nor DT (see Figure 3).

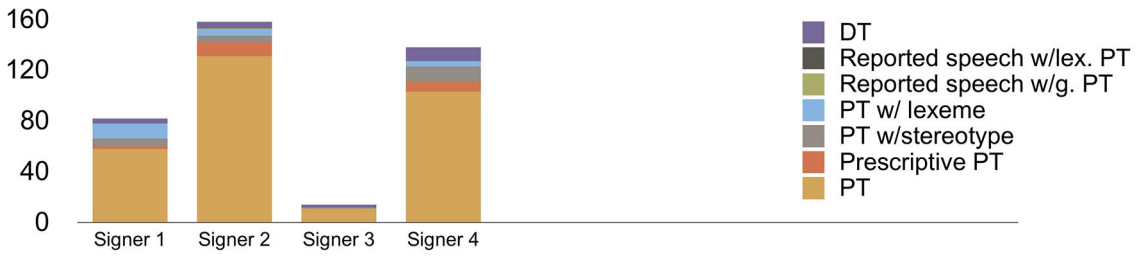


FIGURE 3
Distribution of role-taking types for each Soure SL user.

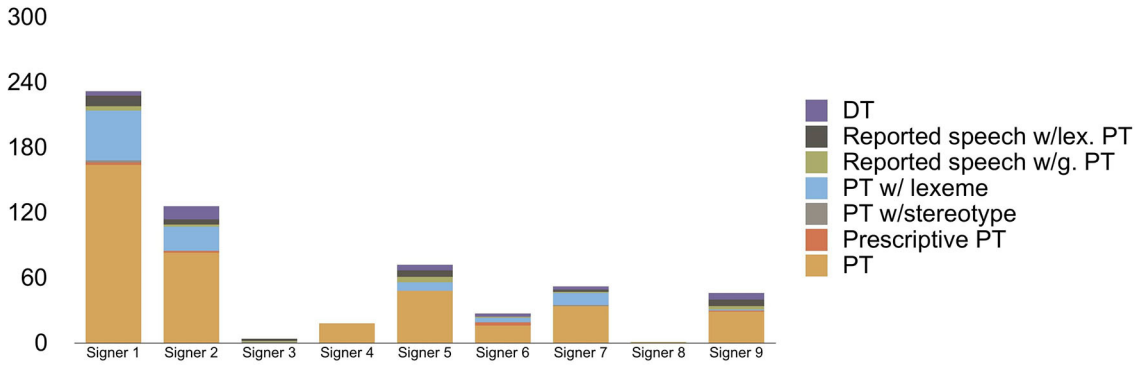


FIGURE 4
Distribution of role-taking types for each YMSL user.

In Soure SL, the only PT that was not produced by any of the four signers was Reported speech PT w/lexeme (see Figure 4).

Diversity of role-taking: Variation between SLs

It appears that there was a greater diversity of role-taking in YMSL as well as in the production of complex role-taking. To begin with, the median of the diversity of role-taking categories of both YMSL and Soure SL signers was five. However, the signer with the greatest diversity of role-taking types is a YMSL signer. He used seven different types while the signer with the highest type diversity in Soure SL used six.

Moreover, as mentioned above, PT w/lexeme is less produced in Soure SL than in YMSL (16.11% in YMSL and 5.48% in Soure SL). This role-taking has the particularity of integrating the lexicon within a role-taking.

Another element to consider is the production of DTs, a role-taking described in the literature as a complex construction that requires a significant body fragmentation and an excellent mastery of the different articulators used concomitantly. DTs represent 5.82% of role-taking produced in YMSL vs. 3.64% in Soure SL.

Eye gaze and role-taking constructions

The gaze examination focused only on the YMSL data, as the image quality of the Soure SL data did not allow a sufficiently fine examination of this feature.

Where do the signers look while producing a role-taking?

In total, 624 role-taking were examined. During the production of this type of construction, the signer's gaze corresponded to the gaze of the embodied entity for 57% of the time. This meant that the gaze was not directed toward the addressee during this amount of time. 20.1% of the time, the gaze was directed toward the addressee while 15.2% was toward the signer's hands. This gaze directed at the signer's hands generally corresponded to the gaze of the embodied entity performing an action. We chose to keep this distinction in the annotation because it seemed important to show that signers tend to look at

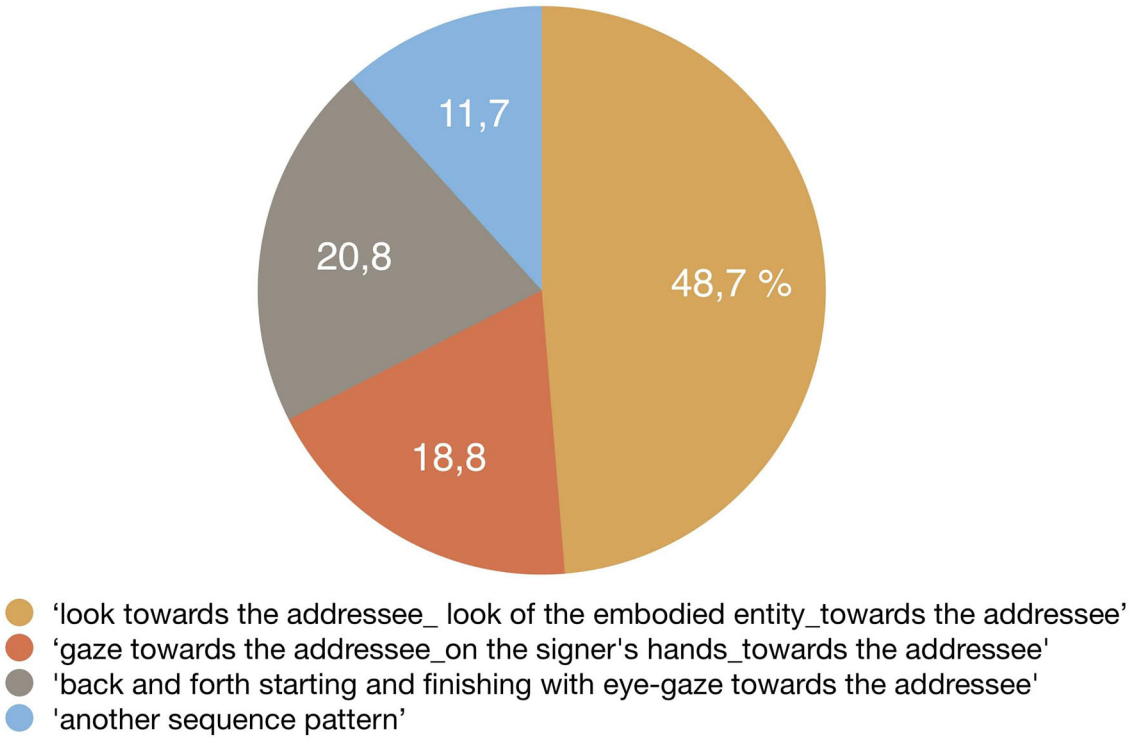


FIGURE 5
Distribution of gaze pattern.

their hands when the embodied character performed an action. The other 2.5% of the time, the gaze anticipated the end of the movement performed by the signer incarnating another character. Finally, 5.2% of the time corresponded to a vague gaze (cf. "gaze to nowhere", Haviland, 2020).

If we examine each signer's gaze, the gaze being the embodied entity's during the production of a role-taking, it remained the most important proportion, except for one signer. It is the same signer who produced only one role-taking in all the data and it happens that his gaze is directed on his hands during the production. In other words, it is the gaze of the embodied entity that is placed on the hands of the signer.

Eye-gaze change of direction before/after role-taking production: A frequent pattern

Gaze direction provides information about the distribution of gaze during the production of role-taking, but it is not sufficient if we are to limit the analysis just to gaze direction in SL. Gaze direction chaining was therefore annotated following the annotation categories specified in Section Annotation. For this second sequence of gaze annotation, only role-taking that was preceded and followed by a lexeme or role-taking produced at the beginning or at the end of a unit utterance was taken into account ($n = 154$). The goal was to identify a pattern without being biased by the role-taking being itself followed or preceded by another role-taking or a Size and Shape Classifier (SASS). The results are presented below (Figure 5).

"Another sequence pattern" implies that the gaze is not detached from the addressee at the beginning and at the end of the role-taking. The sequences annotated "Another sequence pattern" were carefully examined individually. Some elements explain their presence at 11.7% ($n = 18$):

- In elicited data, in particular, the signer frequently looks at the physical stimulus before initiating a role-taking ($n = 12$). In these sequences, the gaze toward the interlocutor at the beginning of the role-taking is not observed but is observed at the end of it.
- Sometimes, the signer is not very involved in the role-taking and his gaze remains directed toward the interlocutor during the whole production ($n = 4$),
- The signer searches in his memories and his gaze is directed upward just before the role-taking ($n = 1$),
- The signer has a vague gaze just before the role-taking ($n = 1$).

This last pattern remains not only minor but it can be explained either by constraints of memorization of the task or by a lesser investment in role-taking. In general, data analysis suggests an almost systematic disengagement of the signer's gaze toward the addressee at the beginning of the role-taking. This gaze would be mostly redirected toward the interlocutor at the end of the role-taking. During the role-taking, the gaze is either the one of the embodied entity (48.7%), directed toward the hands of the signer who performs the actions of the embodied character (18.8%), or goes back and forth between the gaze of the embodied entity and the interlocutor (20.8%).

The back-and-forth pattern framed by a gaze toward the addressee at the beginning and at the end of role-taking has also been observed by Beukeleers and Vermeerbergen (2019a,b) for Flemish SL. In our data, the pattern's main concern was role-taking of long duration. Indeed, the median duration of the role-taking concerned by this pattern was 6 s 06 ms (mean duration: 7 s 58 ms). In comparison, the median duration of all the role-taking in YMSL data was 1 s 24 ms (average duration: 1 s 42 ms). Perhaps this duration would lead the signer to regularly ensure the attention of his interlocutor, using these quick glances directed toward him, while continuing the role-taking. However, not all long role-taking systematically displays this pattern in data.

To conclude, it seems that the data analysis strongly suggests that, on the one hand, YMSL signers look at their interlocutor before and after the production of the role-taking. On the other hand, during the production of this construction, a majority of the signers embodied another entity even in their gaze.

Discussion

The exploratory analysis presented in this study was conducted on data sets of 2 h 50 min 10 s for YMSL and 28 min 14 s for Soure SL. In other words, more data would be necessary to refine our results and sharpen the reflections presented in this study.

In both SLs, role-taking is less present in the spontaneous conversation data. We hypothesize that this lower production might be related to the content of the discourses but not necessarily to the nature of data. Indeed, life stories in YMSL are the type of discourse with the most role-taking, most of them being vivid narratives. For instance, in one of these narratives, the signer explains how a snake attacked a chicken in her garden. Such content is indeed very suitable for the expression of iconicity and, in especially, signers' bodily investment.

In spontaneous data sequence for YMSL, the signer who produces the most role-taking addresses topics such as his experience with illness, and then as a farmer and home builder. This type of topic seems to be suited to iconic representations.

Spontaneous data for Soure SL covered different issues. Martinod's (2019, p. 318–319) analysis showed that the proportions of role-taking were not the same and seemed to depend on the themes addressed by the signers. Role-taking was assumed more when the signers addressed topics such as their shared childhood memories or the effects of age on their health. On the other hand, there was very little role-taking when the signers talked about their place of residence in the city. This latter topic was more suited to the use of constructions using the signer's perspective where the city is represented in the signing space as a scene where the different homes are then placed.

This link between discourse type and preferential use of certain iconic constructions has already been highlighted by several authors (Sallandre, 2003; Ferrara and Johnston, 2014, among others). However, the question of the influence of the semantic content within a particular discourse genre on the production of role-taking remains to be explored. To better understand this influence, we would need to analyze data where the signers would have a "spontaneous" conversation[6] with themes more suitable to iconic representation.

Eye gaze change as a marker of role-taking

Out of the 624 role-taking in our corpus, 154 corresponded to our analysis criteria concerning the change of gaze direction. As a reminder, these criteria were as follows: to be preceded and followed by a lexeme or to be located at the beginning or at the end of a speech utterance. Based on the percentages presented in Section Eye-gaze change of direction before/after role-taking production: a frequent pattern, out of these 154 role-takings, 88.3% show a change in the direction of the signer's gaze. This result suggests, following Cuxac (2000), Sallandre (2003, 2014), and Cormier et al. (2015), that gaze is a marker of role-taking in YMSL.

The next step would be to extend this analysis with an identical methodology for Soure SL and for other non-institutional SLs. A hypothesis to be tested would be that gaze direction command could also be an indicator to assess bifurcation advancement in an SL.

The lack of consensus on terminology: The case of mixed CA/double transfer

Mixed CA is defined as "a role-taking of two characters simultaneously" (Cormier et al., 2015). In the Semiological Approach, DT is seen as a type of role-taking involving the signer's body and the concomitant realization of a

6 With all the ambiguity that this expression carries given that signers know that they are being filmed during the exchange.

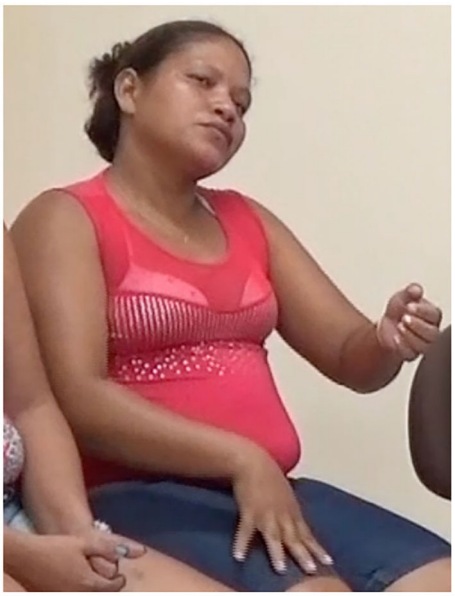


FIGURE 6
An example of a DT in Soure SL, from Martinod (2019).



FIGURE 7
An example of a DT in YMSL.

localization element from another construction involving a signer's perspective. This means that, according to this approach, Figures 6–8 below are all considered DTs even if they are structurally and semantically different.

For instance, Figure 6 shows a Soure SL signer embodying herself in the past while simultaneously representing the pain she felt at that time when spreading long her leg (i.e., Classic PT + the representation of another entity). Figure 7 shows a YMSL user embodying a dead snake while her right arm stands for her actual arm (in the past) holding the animal and her left hand represents the snake's tongue hanging (Classic PT + a part of another Classic PT + a proform[7]). Figure 8 shows another Soure SL user embodying herself while being watched by people from the village (Classic PT + modified lexeme TO LOOK AT/the representation of the part of another entity). Finally, Figure 9 shows an LSF signer embodying a cat while her left hand represents a bowl and her right hand the cat's tongue (Classic PT + the realization of a localization element from another construction involving a signer's perspective + a proform).

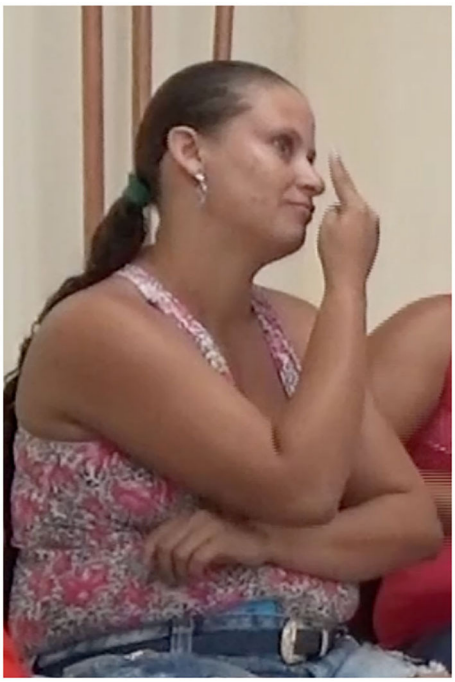


FIGURE 8
An example of a DT in Soure SL, op.cit.

Thus, Figures 7 and 9 represent DTs with a higher semantic 1153 density since each articulator (the signer's body and her two hands and/or arms) has a different meaning. Nonetheless, all also constitute complex constructions involving the representations of (at least) two entities or part of entities.

When annotating our data, both definitions were included under the label 'DT'. However, this broader conception of what constitutes a DT does not seem to be widespread in the literature through the use of the label "Mixed CAs".

This problem, which has already been pointed out in previous studies, seems to remain an issue. It does not facilitate the comparison between SLs. Of course, the use of another

7 Or entity classifier.

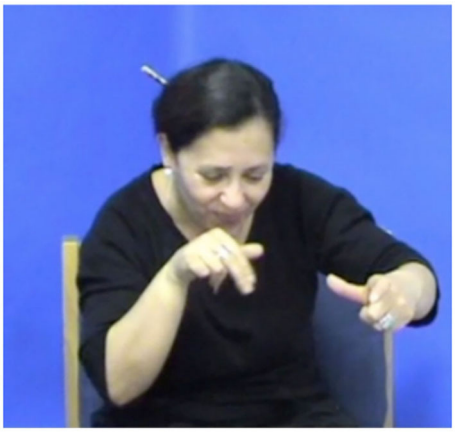


FIGURE 9
An example of a DT in LSF, from Creagest corpora (Sallandre and L'Huillier, 2011).

terminology from the Semiological theoretical approach does not simplify the situation. However, this shows the diversity that can exist and the relevance of some categories for the analysis of these constructions that are not yet sufficiently described in the SLs and whose significance for SL phylogenesis is still to be explored.

Toward the hypothesis of a phylogenetic evolution between SLs and between signers of the same SL

First, for both SLs, the most produced role-taking is the Classic PT. It would therefore be the least complex construction to produce, previously described as an iconic "macro-structure" (Cuxac, 1985, 1996, 2000, 2013). Then, in YMSL, the two least produced types of role-taking are PT w/stereotype and Prescriptive PT. It should be noted that PT w/stereotype and Prescriptive PT are role-taking whose semantic function is very precise: the reference to a culturally marked attitude to represent a physical or mental state of the embodied entity for PT w/stereotype; the prescription for Prescriptive PT. If the semantic content of data does not lend itself to this, it seems less likely that such role-taking will be observed. In Soure SL, PTs w/stereotype related to a particular motherhood stereotype, such as typical attitudes toward taking care of a baby. In addition, a good number of Prescriptive PTs were observed during the spontaneous conversation sequence where several signers mentioned, for example, their depilation techniques. Here again, it would seem that this result in YMSL was mostly related to semantic content. This could also explain why, in both SLs, Reported speech PT w/gesture and Reported speech PT w/lexeme were globally less produced.

As mentioned above, in Soure SL, it is the Semi-TP that is the least produced construction. Semi-TP is a role-taking that includes the production of a lexeme while the signer embodies an entity/a character. This low quantity of Semi-TP in Soure SL could be explained by the fact that the lexicon of this SL presents more lexical variation. Indeed, the social integration of this SL is still in progress. This is also observed in dialogic situationshere signers tend to use few lexemes and rely more on iconic constructions to convey meaning (Martinod, 2019, p. 285). This observation thus seems to be mostly related to the stabilization of the lexicon. Regarding the diversity of role-taking used in YMSL, one signer used all seven role-taking types listed while another used only one. In Soure SL, the signer who used the most used only six and another used two.

Taken together, these results indicated the existence of a small gap in bifurcation advancement both between the two SLs and between signers of the same SL. So far, it is difficult to find an explanation for the difference in bifurcation advancement between YMSL signers. Similarly, for the Soure SL signers too, this difference exists. However, for Soure SL signers, we highlighted the fact that this gap is certainly due to sociolinguistic factors.

In addition, YMSL signers appear to use a greater proportion of DT. This confirms the study of Le Guen et al. (2020a) who pointed out the likely influence of surrounding cultural gestures on the production of this type of complex construction in YMSL. However, the hypothesis of a more advanced bifurcation in YMSL, manifested by the production of more diverse and complex role-taking, could also explain this finding. However, these results should be taken with caution as they may also be related to the amount of data analyzed. These results are less important for Soure SL as only what was produced in front of the camera could be relied upon, and there is still some doubt about the potential abilities of the signers off camera. The ease with which they express themselves naturally is an element to be taken into account, as well as the diversity of the themes expressed.

To conclude, these observations suggest the existence of a slight gap in bifurcation between the two studied SLs. This discrepancy seems to be mainly due to the issue of lexical stabilization, which would be less advanced for Soure SL. Of course, this does not constitute a value judgment, as lexical stabilization is not a goal to be achieved for an SL. We recall in this regard the importance of not considering institutional SLs as a *telos* for other SLs (see Nyst, 2012, p. 566). Even if an SL has a lot of lexical variation, this does not necessarily constitute an obstacle for communication between signers.

Concerning the hypothesis of a phylogenetic evolution between SLs, the constraint of the limited amount of analyzed data calls for caution. Ideally, it would be helpful to compare our data with (i) a non-institutional SL whose degree of social integration would be more advanced than YMSL, and (ii) a homesign, whose social integration would be, as a matter of fact, less advanced than YMSL and Soure SL.

Possible links between phylogenesis and ontogenesis

We focused on the production of three constructions described in the literature as acquired late by a SL learner. First, DTs are described in the literature as complex constructions to produce. They would therefore be acquired the latest by a SL learner. Given that DTs are less produced in Soure SL, a SL that would be at a less advanced stage of bifurcation than YMSL, it seems consistent to draw a parallel between phylogenesis and ontogenesis.

A second construction also described as probably acquired the latest is role shift (i.e., when the signer performs several role-taking constructions in a row where the embodied character/entity changes rapidly, Cormier et al., 2015). This feature was not annotated in our data due to its low presence. Nevertheless, future studies should address this aspect in non-institutional SLs. This might confirm the phylogenetic pattern through which an SL would pass.

Finally, a third example is Subtle CA. This construction is described as acquired late, like role shift. In Table 1, which shows the supposed correspondences between our labels and those found in the literature, Subtle CA is associated with Reported speech w/gesture and Reported speech w/lexeme. It turns out that, for both SLs, these types of role-taking are very rarely produced. These two elements tend to confirm the acquisition pattern proposed by Cormier et al. (2015) but still concern the phylogeny of two SLs.

Data availability statement

Publicly available datasets were analyzed in this study. A part of this data can be found here: https://www.ortolang.fr/market/corpora/corpus-these/v1.

Ethics statement

The studies involving human participants were reviewed and approved by Center for Research and Higher Studies in Social Anthropology (Centro de Investigaciones y Estudios Superiores en Antropologia Social) (CIESAS). The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

EM designed the manuscript and wrote all the sections.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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On the Embodiment of Negation in Italian Sign Language: An Approach Based on Multiple Representation Theories

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Negation can be considered a shared social action that develops since early infancy with very basic acts of refusals or rejection. Inspired by an approach to the embodiment of concepts known as Multiple Representation Theories (MRT, henceforth), the present paper explores negation as an embodied action that relies on both sensorimotor and linguistic/social information. Despite the different variants, MRT accounts share the basic ideas that both linguistic/social and sensorimotor information concur to the processes of concepts formation and representation and that the balance between these components depends on the kind of concept, the context, or the performed task. In the present research we will apply the MRT framework for exploring negation in Italian sign language (LIS). The nature of negation in LIS has been explored in continuity with the co-speech gesture where negative elements are encoded through differentiated prosodic and gestural strategies across languages. Data have been collected in naturalistic settings that may allow a much wider understanding of negation both in speech and in spoken language with a semi-structured interview. Five LIS participants with age range 30–80 were recruited and interviewed with the aim of understanding the continuity between gesture and sign in negation. Results highlight that negation utterances mirror the functions of rejection, non-existence and denial that have been described in language acquisition both in deaf and hearing children. These different steps of acquisition of negation show a different balance between sensorimotor, linguistic and social information in the construction of negative meaning that the MRT is able to enlighten.

Keywords: negation, Italian sign language, embodiment, Multiple Representation Theories, socio-semiotic approach

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THEORETICAL FRAMEWORK FOR THE ANALYSIS OF SIGN LANGUAGES

Our theoretical framework for the description of LIS is inspired by the socio-semiotic and cognitive model developed by Volterra et al. (2019) on Italian Sign Language (LIS) which, following the semiogenetic approach of Cuxac (2000), highlights the embodied and social basis of sign and spoken languages systems.

Humans communicate in a great variety of ways depending on the languages in their repertoire, their communicative needs, the semiotic resources in the context: for example, hearing people can

integrate their speech with pointing and representative gestures that look very similar to signs (see for example, the Italian gesture for coffee which is similar to the LIS sign[1] and deaf people can use mouth actions as complements to the signed utterance (Boyes-Braem and Sutton, 2001; Fontana, 2008; Fontana and Roccaforte, 2015).

In sign languages, the hands, along with the entire body and with facial expressions, become components of a language. The body and the hands are involved in various daily tasks, such as showing, giving and pointing, or in a series of actions such as enumeration, handling, representing objects or characters or actions performed by the characters (Boyes Braem, 1981). Different sign languages choose different representational strategies referring to the same object (see for example the sign for "to eat" in different sign languages; see text footnote 1). Beyond the lexical units (the so-called "frozen" or "standard" lexicon), complex referential expressions with highly iconic and simultaneous features have been identified. These units have been defined as "Highly Iconic Structures" (HIS), and further specified as Transfer of Person, Situation and Form (Cuxac and Antinoro Pizzuto, 2010). Sign languages express meaning in two different ways: (a) a depictive intention, that is "show, illustrate and demonstrate" by using HIS, and (b) a non-depictive intention, consisting of "telling" (without showing) by using the standard lexicon and pointing signs. In other words, sign languages are rooted in a process of iconization of signers' perceptual-practical experience. These two different semiotic intentions are conveyed by the direction of the eye gaze: with standard signs, the eye gaze is directed toward the interlocutor, or toward certain points in space; in the case of the iconic structures, the gaze is directed toward the hands or it represents the gaze of the entities symbolized. Such strategies underlie both the production of signs and of gestures. Crosslinguistic research on the development of language (Marentette et al., 2016) have described four strategies of symbolic representation that have been later classified (Volterra et al., 2019) both in hearing and deaf children and adults which consists namely of: Own-body or enactment where the whole body represents the action or the character (imitating a cow, for example); Hand as hand with the hands assuming a grasping configuration that mirrors the action performed on the object shown (driving a car); Hand as object when the hands become the object (for example a ball); shape and size when the hands trace the shape or indicate the size of the object to be represented (draw a circle to represent a tower).

These strategies have been systematized in sign languages and are mirrored in the three mechanisms of signification recently described for LIS that are pointing, describing and depicting (Volterra et al., 2019) depending on the fact that a physical or social entity is in the context or not. Such embodied mechanisms can be noticed starting from the sub-lexical units which are: at the manual level, handshape, orientation, location movement; at the body level, mouth actions, facial expression, movement of the torso and gaze direction. One important effect of the role of human sensory motor experience in sign languages is iconicity. Types of iconic mapping may range from a form reproducing under a certain respect the referent to a form of iconicity requiring more abstract mapping of features (Perniss and Vigliocco, 2014).

At the same time, these strategies confirm embodied and grounded views according to which acting and interacting with physical and social entities and objects in the environment is the base of our cognitive abilities (Gallese and Lakoff, 2005; Barsalou, 2018; Cuccio and Caruana, 2019). There is a continuity between action, gesture and sign or word that reflects the various aspects of the cognitive structure underlying them. It has been suggested that the activation of motor neurons when we are not actively carrying out any motor act, has a constitutive role in the comprehension of language. Both the mechanism of simulation and the production of gestures while we are speaking can be considered expressions of the embodied nature of meaning (Marghetis and Bergen, 2014) and are tightly interconnected (Cuccio and Fontana, 2017). To date, a huge amount of experimental studies, carried out with several experimental techniques, have supported this embodied approach (Jirak et al., 2010; Cuccio and Gallese, 2018). In this framework, negation might also be grounded in the sensorimotor system and might recruit the neural mechanisms underlying motor response inhibition (e.g., Beltrán et al., 2018). Findings in support of this hypothesis have been provided both in behavioral and electrophysiological studies (for a discussion, Montalti et al., 2021). The latter (e.g., Beltrán et al., 2018) suggested that the processing of negation might modulate the activity of the right inferior frontal gyrus, an area known to play a role in inhibitory control (Aron et al., 2014). Many questions remain open in this debate. First, there is no sufficient evidence to conclude that the mechanism for motor inhibition is recruited during the processing of negation regardless of the sentence contents (i.e., we do not know whether the involvement of motor inhibition resources is specifically linked to the processing of action-related sentences or it also underpin the comprehension of abstract sentences) nor we know whether the motor inhibition mechanism is recruited regardless of the language modality (spoken or signed). We will explore negation in LIS since for their semiotic nature, sign languages can enlighten the continuity between gestures and sign and the role of multimodality and embodiment in expressing negation.

EXPRESSING NEGATION IN ITALIAN SIGN LANGUAGE

Generally, negation is described as a logico-linguistic device that enables us to deny what we speak about (Virno, 2013). However, negation is not only refusing, simulating or dissimulating something: it is above all *acting* a negation in terms of the functioning of the sensorimotor system. There is not only one way but several forms of negation. Various studies have shown that in sign languages negation occurs both at the manual and non-manual level. At the manual level, signed units whose position can differ from one sign language to another are used. At the non-manual level, headshakes and some kind of mouth actions can co-occur either with the lexical unit or with the

[1] https://www.spreadthesign.com/it.it/search/

TABLE 1 | Information about the participant.

Participants	Age	Gender	Profession
A	30–40	Male	LIS teacher
B	30–40	Female	Employee
C	80+	Female	Retired
D	40–50	Male	Employee
E	40–50	Female	Employee

entire utterance. Furthermore, specific lexical units with negative functions, often accompanied by mouth actions, have been described in various sign languages (see Hendriks, 2008; Pfau, 2015; Oomen et al., 2018 for a review). This does not mean that negation functions in similar ways across sign languages. Studies have shown that there are differences on the form and use of the manual and non-manual markers. According to Pfau (2008), non-manual negation markers consist only of side-to-side headshake. It can also consist of non-manual markers that originate from hearing gestures. For example, in the Eastern Mediterranean area (e.g., Greece and Turkey) and in the Middle East (e.g., Jordan), for negation the hearing population use a single backward movement of the head. Such a form of negation has been found also in Sicily, where it is used alongside the negative headshake. In LIS, negation has been described as a formal operator within the Generative Grammar framework (Geraci, 2006). Geraci (2006) describes various manual negative signs such as NO that usually comes at the end of the utterance. In his view, a clause cannot be negated by means of the headshake only, but should be always accompanied by the manual form.

The research conducted by Gianfreda (2010) was devoted to analyzing the linguistic expression of certainty and uncertainty in LIS. The corpus was based on conversations in LIS between deaf people communicating through a video-chat software in an informal context. Gianfreda has described some lexical forms of negation which in his view have gone through a process of grammaticalization such as the various forms of IMPOSSIBLE (pictures taken from Borghi et al., 2014). The sign glossed as IMPOSSIBLE-PA-PA refers to a condition of unfavorable circumstances for an action or an event due to some external event (an authority, for example). This negative sign co-occurs with a specific mouth gesture that is "a-pa."



Figure A. IMPOSSIBLE PA-PA

It seems to be derived from the sign FORBID which shares the parameters of the handshape and downward movement. However, in IMPOSSIBLE-PA-PA, the movement is repeated and more rapid. In the sign glossed as IMPOSSIBLE-fff based on extended fingers that move upward in a circular movement, any possibility for an event to take place are excluded. This sign is accompanied by the mouth gesture which corresponds to "air emission" and has been glossed as "fff."



Figure B. IMPOSSIBLE-fff

This sign seems to derive from the blessing gesture typical of Christian religion and is similar to a gesture of Southern Italy used for referring to a dead or dying person, also in metaphorical terms. It is worth noticing that this last variant has been incorporated into LIS as an autonomous lexical unit, i.e., the sign DEAD, produced without the mouth gesture "fff" which is co-produced in IMPOSSIBILE-fff. The LIS signs IMPOSSIBLE/POSSIBLE respectively convey the notion of absence of certain conditions or characteristics or the existence of actual or potential conditions for an action or event to take place.



Figure C. IMPOSSIBLE/POSSIBLE

The two signs share the same hand configuration (two fists) but are executed with different movements (Wilcox et al., 2010; Gianfreda et al., 2014).

Such research show the various forms of negation in LIS: first, the sign NO/NON-that seems to function as a logical operator for denial; second, body components (facial expressions, head movements, mouth actions) that may act in co-occurrence with the manual signs; third, lexical units (e.g., the various forms of IMPOSSIBLE) that functions for negation and that go to head are strongly embodied in cultural and perceptual experience. The present study intends to explore negation as a form of action through MRT. We will show that negation is bodily grounded and multimodal and that it evolves out of the three steps in the acquisition of negation: (1) rejection/refusal; (2) disappearance/non-existence/unfulfilled expectation; (3) denial (Volterra, 1972; Beaupoil-Hourdel et al., 2016).

We hypothesize that negation involves the whole body together with manual signs and that the interaction between the sensorimotor, social and linguistic components can be fully

understood if the various components of the negation action are analyzed as a global unit.

METHODOLOGY

Data were collected through semi-formal interviews based on pictures to elicit the different negation actions in LIS.

The participants (see **Table 1**) are all part of the signing community and have been exposed to LIS since early childhood.

Participants were invited to describe what they saw in the pictures. They were not asked specific questions on the pictures as we did not want to influence their answers. For this reason, drawing on everyday experience we proposed contrasting pictures that could elicit negation actions in a visual way. As shown below, pictures dealt with general topics such as health, health education, waste collection, healthy vs. unhealthy food, road speed limits and the safety of children.

Data have been glossed on a four-layer line that allow the representation of body components in order to highlight the co-occurrence of the various body and manual components.

sx_____
two handed_____
dx_____
body_____

In this paper, we annotated LIS by using pictures that represented the entire utterances as shown in the examples below.

DATA ANALYSIS

The analysis of data shows that the selected pictures do not always elicit negative units. In some cases participants choose to describe rather than to oppose the two contrasting pictures and use some form of negation. This is probably related to the fact that the participants were simply invited to describe the pictures in order not to influence them. This preliminary result proves to be interesting for further investigation at the level of the eliciting materials. For example, only two out of five participants systematically used negative units: participants A and B.

The negative element of the utterance for **Figure 1** THERE-IS-NOT co-occurs always with a specific facial expression and a mouth action. Depending on the discourse, the mouth action can consist of the mouthing "there is not" fully or partially articulated, or of the mouth gesture based on lips protrusion.

The utterances of two participants (A and B) are based on a similar structure, although the two-handed sign THERE-IS-NOT, is articulated with one rather than two hands by one of the two participants, as shown above.

The verb "sneeze" of the utterance 1 for **Figure 2** is a transfer unit that reproduces the action of sneezing. The negation unit NO occurs at the end of the utterance and co-occurs with raised eyebrows and with the mouthing "no."

Participant B does not use any negation unit in the utterance and simply explains that it is possible to sneeze outside. Another utterance for the **Figure 2** is based on the following structure: SNEEZE—IN AIR—NO.



FIGURE 2 | Sneeze.



FIGURE 1 | COVID-19 greeting.

Other participants describe the pictures without using any element of negation.

Most participants simply described in **Figure 3**. Two participants use a particular facial expression with the signs BIN FULL to convey an avoidance effect.

In **Figure 4**, healthy and unhealthy food are opposed through the movement of the body on the left- and right-hand side respectively. The "junk food" information is followed by the negation unit NO.

An avoidance effect related to unhealthy food is conveyed by a shift in facial expression which is positive with the sign "healthy food" and negative with the sign "junk food" (Chen and Bargh, 1999).

The same utterance structure has been found in all participants. Participant C simply lists the food shown by the picture, using some personal examples in which no element of negation was found.

Utterance 5 for **Figure 5** is signed with a negation unit by only one participant. Other participants have chosen the lexical unit PROHIBITION or explained the reason why it was dangerous to drive fast. This picture seems to have elicited one more type of negation action that is related to a prohibition or to a specific request of not doing something[2].

This utterance has been produced with an action of refusal/rejection that is conveyed by a backward movement of the body and a facial expression of "rejection."

In another case the expression of rejection conveyed by a backward movement of the body co-occur with the entire utterance.

RESULTS

We have identified three different strategies to express negation in LIS that confirm that negation is bodily grounded and multimodal. In our opinion, negation actions in adults' signing seem to mirror the three steps in the development of negation, previously mentioned: (1) rejection/refusal; (2) disappearance/non-existence/unfulfilled expectation; (3) denial (Volterra, 1972; Beaupoil-Hourdel et al., 2016).

Such strategies can be classified in two formal categories following their form: logical-indexical or lexical. The various forms of negation always occur with different body components such as facial expression, mouth actions, torso backward movements. We consider them as forms of action with various degrees of embodiment. The logical category includes actions of denial which act at a linguistic level and refer to part or the whole utterance such as NO. They occur always at the end of the utterance or of the part of the utterance that has to be negated. Denials are negation actions that have a logic-pragmatic function as they act in the utterance with a linguistic aim. We maintain that the use of negation can negate the utterance content and have also metalinguistic and pragmatic functions related to the meaning. Lexical negation actions include negation units which play a stable lexical role within the utterance such as DO-NOT-LIKE, THERE-IS-NOT, NOT-YET. These negation units always occur with body components. As we have seen, either mouth gestures or mouthings can be used following the discourse needs. Both THERE-IS-NOT and NOT-YET can be considered as example of disappearance/non-existence/unfulfilled expectation and they seem to confirm the continuity between gestures and signs both in early infancy and in adult signing (Marentette, 2016; Volterra et al., 2019). In addition to this, prohibition is conveyed by specific lexical signs as in the utterances related to **Figure 5** and can be somehow related to rejection. Nevertheless, they pragmatically imply different perspectives and they have a different cognitive and symbolic load. Indeed, rejection can be found in preverbal communication and also in animal communication whereas prohibition requires abstract mental representation (Cuccio, 2011). Finally, we have found an item of negation action exclusively on the body with the rejection/refusal action that co-occur with the torso backward movement together with the lexical unit "junk food" or "not

[2]We thank reviewer one for this suggestion.



FIGURE 3 | Separate waste collection.



FIGURE 4 | Healthy and unhealthy food. Available at: https://www.freepik.com/free-photo/assortment-healthy-unhealthy-food_5200655.htm.



FIGURE 5 | Road speed limit. Available at: https://www.pitstopadvisor.com/news/tachimetro-auto-effettiva-velocita/ and https://www.passiamo.lt/Il-limite-dl-velocita-deve-ripetersl-dopo-ogni-intersezione-cass-civ-20-maggio-2014/.



FIGURE 6 | The safety of children in the car.

wearing seat belts," as in the utterances related to **Figure 4** and **Figure 6** although Geraci (2006) maintained that any form of non manual negation is always accompanied by a manual sign. These examples further enlighten the concept of avoidance posited by Chen and Bargh (1999).

Results of the present study prove that the use of pictures can be productive as it does not influence the signing structure and elicit the various forms of negation in LIS, but at the same time, it might not be effective when the participant chooses to describe pictures rather than using negation strategies. Even so, the data have shown that negation in LIS is far more complex than it has been described so far and that it is strongly linked on the one hand to the sensori-motor



Utterance 1 | COVID-19 greeting.



Utterance 2 | Sneezing before and after COVID-19.

system and on the other to the logical structure of the utterance.

SENSORIMOTOR AND LINGUISTIC COMPONENTS IN THE EXPRESSION OF NEGATION: THE MULTIPLE REPRESENTATIONS ACCOUNT

As we have seen, in LIS, negation has been described mainly as a formal operator, or from a functional perspective within the utterance, although it involves various body components in continuity with motor action and gesture. Negation can be considered also a shared social action that develops since early infancy with very basic acts of refusals or rejection. The data discussed in the previous sections, although preliminary, confirm this perspective. The representation of negation in LIS and, generally speaking, the representation of negation in signed languages, seem to combine different kinds of information, ranging from bodily, multimodal and social information to purely linguistic information. Indeed, negation in LIS can be expressed through logical-indexical and lexical structures which co-occur with body components such as facial



RECYCLE



FULL

Utterance 3 | Separate waste collection.

expressions, mouth actions and torso backward movements and can play the functions of rejection/refusal, disappearance/non-existence/unfulfilled expectation, denial. The lexical structures can be considered as forms of action with various degrees of embodiment. Our data, thus, confirm the idea that in LIS, as in all other signed languages, language is embodied not only inside (see below for a discussion of the role of the sensorimotor system in signed language comprehension) but also outside through the involvement of non-purely linguistic components in the process of meaning construction.

Hence, the recruitment of bodily components in signed languages' negation is in line with an embodied account of language, which posits that the production/comprehension of language is grounded in our sensory-motor system (Di Cesare et al., 2017; Cuccio and Gallese, 2018; Gallese and Cuccio, 2018) and further extends this account to logical operators such as negation.

A vast amount of experimental data, in the last years, corroborated the hypothesis that systems for action and perception may also play a crucial role in the processing of different types of linguistic information (Fischer and Zwaan, 2008; Barsalou, 2010; Jirak et al., 2010; Mirabella et al., 2012; Glenberg et al., 2013; Cuccio et al., 2014; Pulvermüller et al., 2014; Spadacenta et al., 2014; Cuccio, 2022). This means that the processing of action and perception related linguistic expressions recruits the sensorimotor system. For example, the comprehension of the sentence "Mary grasps the glass" will activate hand-related areas in the premotor cortex. This mechanism is known as Embodied Simulation (Sinigaglia and Gallese, 2011). Sensorimotor information made available by the mechanism of simulation, in this view, will contribute to the construction of linguistic meaning. This embodied account of language refuses the classical, first generation, cognitive science view based on the idea that concepts and meanings are represented using amodal and abstract symbols (e.g., Fodor, 1983).

Recently, evidence for embodied processing in signed language users have also been provided. For example, in an electroencephalographic (EEG) study, Kubicek and Quandt (2019) showed that the sensorimotor system is recruited during signs processing. In this study, the authors assessed whether systems for action and perception are differently modulated by the observation of signs produced with, respectively, one and two hands. Results showed greater alpha and beta event-related desynchronization during the perception of two-hand signs compared to one-hand signs. Alpha and beta event-related desynchronization is likely due to motor simulation and is thus a mark of an embodied processing of signs. Thus, summarizing,



HEALTHY FOOD GOOD



NO HEALTHY

Utterance 4 | Healthy and unhealthy food.

findings from Kubicek and Quandt (2019) study showed that signs comprehension draws on sensorimotor information, too, determining the activation of the motor cortex. The latter was more extensively recruited by the processing of two-hand signs compared to one-hand signs. Sensorimotor information, in this case, too, contributes to the process of meaning construction. Thus, data seem to support the embodied view of language, independently of the language modality.

In this framework, recent findings have shown that also linguistic negation, which is thought of as an abstract and purely logico-linguistic operator, is grounded in the sensorimotor system. Indeed, it has been shown that the processing of negation recruits the mechanisms for motor response inhibition (e.g., Montalti et al., 2021). Behavioral (e.g., Montalti et al., 2021) and EEG (e.g., de Vega et al., 2016; Beltrán et al., 2018) studies supported the hypothesis of the embodiment of negation in motor inhibitory mechanisms. For example, de Vega et al. (2016) carried out an EEG study in which participants were asked to read negative and affirmative action-related sentences while performing a Go/NoGo task. The Go/no GO task is specifically designed to evaluate the recruitment of resources for motor inhibition and consists of a go-task and a noGo-task. Trials of the two tasks are randomly intermixed, the Go-trials are the most frequent type of trials and require the subject to respond (i.e., pressing a key on the keyboard) as fast as possible when a go-signal is presented. The noGo trials are less frequent and require the subject to withhold a response (not pressing any key). Findings from de Vega et al. (2016) study showed that negative sentences modulate theta bands, a marker of motor inhibition, over the frontal cortex. These data suggest that, to explain the processes underlying the construction of meaning in the expression of linguistic negation, very likely, we need to account for how different kinds of information, including sensorimotor knowledge, contribute to this process.

Although studies on the embodiment of negation in signed languages have not yet been conducted, in the light of the data discussed in the previous sections, showing that the expression of negation in LIS involves bodily, multimodal and social information together with purely linguistic information, we might hypothesize that the expression of negation is embodied independently of the language modality and that negation in sign languages might recruit, too, the mechanism for motor response inhibition.

It follows that we need to develop a model of how purely linguistic, social and sensorimotor information all contribute to and are balanced in the process of meaning construction,



Utterance 5 | Road speed limit.

especially in the expression of negation, and we need to develop a model which can account for this process independently of the language modality.

We must admit that this is not an easy endeavor. To date, to develop an account of how sensorimotor information might interface with purely symbolic or social knowledge in the formation of abstract meanings, such as negation, is the most difficult challenge for any embodied approach to language. Lately, the issue of the integration of different kinds of information (i.e., sensorimotor, purely linguistic and social) in the representation of both concrete and abstract meanings/concepts has been addressed in the framework of the so-called *Multiple Representation Theories* (henceforth, MRT; e.g., Borghi et al., 2017). Different MRT variants are currently discussed. They differ in some respects, but all share the basic idea that concrete and abstract meanings/concepts representation relies on both sensorimotor, as well as on linguistic and social knowledge. The degree of involvement of these different sources of information has been differently accounted for and varies in relation to the kind of meaning/concept, the context, or the performed task.

In this paper, we framed our proposal following the Word as Social Tools (WAT) theory which is the account developed by Borghi et al. (2019) within the MRT approach. According to the WAT theory, abstract meanings/concepts are linguistically and socially acquired whereas the acquisition of concrete meanings/concepts rely mostly on perceptual similarity. Social and linguistic information is, thus, by large more important in the acquisition of abstract meanings/concepts. Since abstract and concrete meanings/concepts follow different trajectories of acquisition, they are also differently represented in the brain. Indeed, whereas both recruit the sensorimotor system, the networks underlying linguistic and social cognition are more activated by abstract concepts. More specifically, the WAT theory



SITTING



NO



SEAT BELT



THERE ISN'T

Utterance 6 | Child safety in the car.

predicts that, since concepts/meanings are grounded in the same perceptual and motor systems that support their acquisition, abstract meanings/concepts processing determines the activation of the mouth (for spoken languages) and of the hands (for signed languages). This prediction has been confirmed by empirical data with regard to spoken languages (see Borghi et al., 2019). Data is still missing for signed languages.

Since the modality of acquisition impacts on the different representation of abstract and concrete concepts/meanings in the brain, it might be extremely useful to have a look at psycholinguistic data on the acquisition of negation. Psycholinguistics research has suggested that, independently of the language modality, there are at least three steps in the acquisition of negation: (1) rejection/refusal; (2) disappearance/non-existence/unfulfilled expectation; (3) denial (Volterra and Antinucci, 1979; Dimroth, 2010; Cuccio, 2011, 2012). Rejection is the first category of negation to be acquired and is used to express refusal of something in the present context. Examples of rejection can be found in human pre-linguistic gestures and even in animal behavior. Whereas rejection, according to Pea (1980) does not require abstract mental representation, non-existence and denial do require them. The second category of linguistic negation to arise is non-existence/unfulfilled expectation. At this point, children are able to signal the absence or disappearance of an expected referent in the context of speech or indicate something that violates their expectations, based on previous experience. Lastly, the third category to be acquired is denial which implies negation of a predication. The referent is usually symbolically expressed.

Following the MRT approach, we suggest that the acquisition of linguistic negation, in these three different steps, determines a path from concrete to more abstract meanings. Negation is initially acquired in the context of physical acts of refusal to later become an abstract and symbolic operator. Whereas rejection relies more heavily, although not exclusively, on sensorimotor information, linguistic and social knowledge is

crucial especially for disappearance/non-existence/unfulfilled expectation and, most of all, denial. How these sources of knowledge are balanced depends on many factors, such as the context and the performed task.

CONCLUSION

Summarizing, we know that the processing of negation recruits the motor inhibitory mechanisms and that, more generally, the comprehension of abstract meanings recruits the perceptual and motor systems which support their acquisition. Although we do have empirical findings on the embodied processing of signed languages, data are still missing on the embodiment of negation in this language modality. However, the data discussed in the previous sections suggest that the expression of negation in LIS exploits not only manual but also facial and bodily components whose role is in line with an embodied approach to language. In this light, this concluding section will be devoted to proposing an account of how different sources of information interface in the process of construction of meaning, especially abstract meanings such as negation. To this purpose, we will rely on Evans (2006) distinction between lexical concepts and meaning. In Evans' view, lexical entries cannot be considered *per se* as the bearers of meaning. As Evans (2006) says (2006, 491), "[. . .] While lexical concepts constitute the semantic units conventionally associated with linguistic forms and form an integral part of a language user's individual mental grammar, meaning is a property of situated usage-events, rather than words. That is, meaning is not a function of language *per se*, but arises from language use." Linguistic meaning, thus, is much more than purely symbolic knowledge. It is always dependent on contextual factors and on the inferential processes underlying language production/comprehension (Carapezza and Cuccio, 2018). Lexical entries certainly contribute to the process of meaning construction, since symbolic knowledge is a crucial part of our ability to produce and comprehend language. Especially for abstract meanings, which are socially and linguistically acquired, they play a major role. In addition to this, lexical entries can be considered as cues that prompt us to activate our background, encyclopedic knowledge. Importantly, our encyclopedic knowledge includes different kinds of information: sensorimotor knowledge, social information, emotions and feelings. In this view, sensorimotor knowledge, being an integral part of our encyclopedic knowledge, constitutively contributes to the contextually based process of meaning construction. Evans (2006) account of linguistic meaning provides us with a framework to better understand how sensorimotor, social and purely linguistic information might interface. Within this perspective, we can easily envision that the balance between different sources of information is highly flexible and depends not only on the kind of concepts (e.g., concrete or abstract) but also on the context of use of that context and on the background knowledge of the speakers. In our proposal, this holds true also for the expression of negation.

Our results are preliminary. More research needs to be carried out to have a broader comprehension of the bodily grounding of negation in LIS and, generally speaking, in sign languages. Specifically, empirical studies on the embodied processing of this logical operator, with techniques such as the EEG, must be carried out. Furthermore, to have a better understanding of the differences and similarities between the communication of negation in deaf and hearing individuals, it would be extremely useful to compare how hearing participants would describe the very same stimuli used in the current study. These are the next points on our research agenda.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

SF wrote the sections "Theoretical Framework for the Analysis of Sign Languages," Expressing Negation in Italian Sign Language," and "Results." SF and GDS wrote the sections "Methodology" and "Data Analysis." VC wrote the sections "Sensorimotor and Linguistic Components in the Expression of Negation: The Multiple Representations Account" and "Conclusion." All authors discussed and designed the article together.

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