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# Number maintenance in subject-verb agreement: evidence from Basque

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In this paper, we investigate whether number is actively maintained as part of matrix subject-verb dependency establishment, and whether it is active enough to be used to resolve temporary number ambiguity of an interpolated noun. In a visual world paradigm, we tested whether number-ambiguous Basque nouns within embedded relative clauses can be disambiguated by the number of the matrix subject-verb dependency actively maintained over them. We manipulated the number of the matrix subject (singular/plural), and measured the proportion of looks toward singular/plural images in the moment when the number-ambiguous noun is heard (and still not disambiguated). The analysis showed that the proportion of looks followed the matrix subject number, as the plural bias increases significantly in the plural matrix subject condition, implying active maintenance of the number feature. These findings add to the literature on the content of the maintained representation in subject-verb dependency establishment, showing that number information is actively maintained, and they don't align with cue-based sentence comprehension models that presume matrix verb maintenance in an inactive, out-of-focus state. We also demonstrate that the parser uses available morphosyntactic information of items kept active in working memory in order to resolve temporary ambiguity.

## KEYWORDS

ambiguity resolution, Basque, feature maintenance, morphosyntax, subject-verb agreement

Syntactic prediction has been defined as the expectation of a certain relation by means of maintaining it or anticipating its conclusion (Ilkin and Sturt, 2011; Staub and Clifton, 2006). Importantly, it has been suggested that, in order to talk about prediction, it is important to find evidence that an element (or part of it) is active prior to its encounter (Ilkin and Sturt, 2011; Kuperberg and Jaeger, 2016), rather than only looking at how maintenance facilitates an element's processing once it is encountered. But how is this *preactivation* manifested in subject-verb agreement?

Several studies suggest that a subject-verb dependency is maintained in real-time sentence processing, incurring processing cost over the elements encountered before the verb (Chen et al., 2005; Ristic et al., 2022). However, the content of the maintained representation remains an open question. It is possible that either the subject representation is actively maintained (in order to establish agreement once the verb is reached), or the verb representation is preactivated at the subject position and maintained active until the verb is encountered.

Some prominent sentence processing models assume the maintenance of the matrix verb representation (DLT/SPLT model, Gibson, 1998, 2000), while others suggest that word category, number, and other features of both matrix subject and verb are maintained (cue-based models; Lewis and Vasishth, 2005; Lewis et al., 2006). However, neither of these two streams of models would predict that the maintained information would have

a measurable effect on the elements over which it is maintained, since they are either predicted to be costless (in DLT/SPLT), or stored in a more passive state, i.e., outside of the focus of attention (cue-based models). On the other hand, filler-gap dependencies have been shown to feature active maintenance of filler-related features, such as animacy (Ness and Meltzer-Asscher, 2019) and semantic information (Chow and Zhou, 2019).

In the current study, we assume, in line with the previous work on prediction and on filler-gap dependencies, that *preactivation* implies that information is available and active in advance, i.e., while other elements are being processed. We thus investigate whether the number feature forms part of the *actively* maintained representation during online subject-verb dependency establishment in Basque, and whether it affects other interpolating elements. While we do not aim to determine whether the maintained number feature belongs to a matrix verb or matrix subject representation, we do assume that the matrix subject triggers the maintenance.

Preceding studies were conducted predominantly in English (or other Germanic languages), thus looking at languages with different morphosyntactic systems can provide useful test grounds to study how features are processed during online establishment of a subject-verb dependency. Basque offers a unique and new setting to study number maintenance, which is through number disambiguation, since nouns that are marked with *-ak* are ambiguous between singular ergative and plural absolutive cases. Numerous studies have shown that the parser uses different contextual cues in order to resolve structural ambiguity, including preceding words' semantic, lexical, or tense features (Trueswell and Tanenhaus, 1991; MacDonald, 1994). Therefore, we investigate whether number information, maintained as part of subject-verb dependency computation, has a disambiguating effect on the interpolating number-ambiguous noun, due to its active status. Note that his exact mechanism has not been proposed previously, but is derived here from the previous research presented above.

To be able to position the *-ak* noun in such a way that it intervenes between the matrix subject and the verb, we created sentences in which the ambiguous word was placed within an embedded relative postnominal clause (Table 1, bold). Since the previous extensive cross-linguistic research revealed a particular processing profile for embedded relative clauses, as well as differences between subject vs. object relative clauses, a review of relevant evidence from Basque is warranted e. Carreiras et al. (2010) have previously studied Basque prenominal relative clauses. They used temporarily ambiguous nouns marked with *-ak*, disambiguated between object relative/subject relative only at the verb, and found longer reading times for subject relative clauses on the subsequent disambiguating verb. A somewhat similar configuration to ours (postnominal relative clauses) was investigated in an unpublished self-paced reading study by Yetano et al. (2010), who reported lower reading times and thus preference for subject relative clauses. Their sentences also included ambiguous *-ak* nouns within relative clauses, however, the matrix subject was also an ambiguous *-ak* noun (*Ikaseak, zeinak erakasleak aipatu bait-ditu, lagunak ditu/dira orain*, "The student(s), who mentioned the teachers/who the teacher mentioned, are/has friends now). While these studies show that differences in

overall preference between subject and object relative clauses might depend on the relative clause type (pre vs. postnominal), they do not measure feature maintenance over ambiguous *-ak* nouns. Namely, in both studies, effects were measured at the disambiguating regions, while the ambiguous regions showed no differences as no preceding elements were manipulated. The subject/object relative preference observed at the disambiguating verb could thus be related to the dependency integration, rather than maintenance mechanisms.

In the current study, the matrix noun, which precedes the ambiguous *-ak* noun within a postnominal relative clause, is always unambiguously singular or plural. We thus assume that, if the number feature of the subject-verb dependency matrix is maintained, it could influence the interpretation of the ambiguously marked noun. We assume that, if the feature is active and available when processing an ambiguous noun, it could influence the interpretation toward singular when the matrix number is singular and toward plural when the matrix number is plural. Using the visual world paradigm (Tanenhaus et al., 1995), we expect more looks to the plural image in the plural matrix S-V condition, indicating plural interpretation of the ambiguous noun, and, conversely, more looks to the singular image in the singular matrix S-V condition, indicating singular interpretation of the ambiguous noun. Importantly, if number is maintained over the relative clause during the establishment of a matrix subject-verb dependency, we assume it could bias the reading of the number-ambiguous noun within the experimental, but not within the control items, where ambiguous nouns does not interrupt matrix subject-verb dependency.

## Participants

Twenty eight native Basque-Spanish bilinguals (12 male) aged 18-40 (SD = 5.92) participated in this experiment. Their dominant language was Basque and they acquired it from birth<sup>1</sup>.

## Stimuli and study design

The experimental stimuli consisted of 60 experimental items. As sentences with postnominal relative clauses are less frequent in Basque, we performed a naturalness judgment test on our stimuli. Twelve native Basque speakers who didn't take part in the experiment rated the sentences on a scale from 1 (=very unnatural, unusual) to 7 (=very natural, usual). The rating revealed a medium naturalness, with the average value of 3.85 (SD = 1.64)

<sup>1</sup> They all received the highest score in the Basque language interview and marked at least 62 out of 65 on the BEST language test (de Bruin et al., 2017), with one participant scoring 59 (SD = 1.49). Twenty-five participants had an official language certificate that proves their high proficiency in standard Basque. Twenty-two participants obtained the EGA certificate, which corresponds to level C1 of the Common European Framework of Reference for Languages; two participants had other types of official certificates that correspond to C1 level, while one participant obtained a C2 level certificate.

TABLE 1 Example of an item used in the experiment.

Item	Matrix number	Disambiguation	Example
Experimental	Sg	erg.sg/ abs.pl	Nere ahizpa <sub>[Sg]</sub> , dirudienez <b>mutilak</b> asko maite <u>duena</u> <sub>[S-Sg,O-Sg]</sub> /dituena <sub>[S-Sg,O-Pl]</sub> , desagertu egin zen. my sister apparently <b>the boy/boys</b> a lot love whom-does/who-does disappear did “My sister, whom <b>the boy</b> apparently loves a lot/who apparently loves <b>the boys</b> a lot, disappeared.”
	Pl	erg.sg/ abs.pl	Nere ahizpek <sub>[Pl]</sub> , dirudienez <b>mutilak</b> asko maite <u>dituenak</u> <sub>[S-Pl,O-Sg]</sub> /dituztenak <sub>[S-Pl,O-Pl]</sub> , kotxe bat erosi zuten. my sisters apparently <b>the boy/boys</b> a lot love whom-does/who-do car one buy did “My sisters, whom <b>a boy</b> apparently loves a lot/who apparently love <b>the boys</b> a lot, bought a car.”
Control	Sg	erg.sg/ abs.pl	Nere ahizpa pozik zegoen azterketagatik <sub>[Sg]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zuen/zituen</u> . my sister happy was the exam-about so <b>the boy/boys</b> drink one take invite did-he-her/did-she-them “My sister was happy about the exam, so the boy invited her for a drink/so she invited the boys for a drink.”
	Pl	erg.sg/ abs.pl	Nere ahizpa pozik zegoen azterketengatik <sub>[Pl]</sub> , beraz <b>mutilak</b> trago bat hartzera gonbidatu <u>zuen/zituen</u> . my sister happy was the exams-about so <b>the boy/boys</b> drink one take invite did-he-her/did-she-them “My sister was happy about the exams, so the boy invited her for a drink/so she invited the boys for a drink.”

The squared brackets subscripts on the nouns mark the number of the noun (Sg = singular, Pl = plural), while the squared brackets subscripts on the auxiliaries mark the agreement with the subject (S) and object (O).

for the experimental items, and 4.16 ( $SD = 1.68$ ) for the control items. We fitted linear mixed effects models, with Matrix Number (Singular, Plural) and Disambiguation (ergative singular, absolutive plural) conditions as fixed effects and random by-subject and by-item intercepts, separately for the experimental and the control items. Effect coding was used for all the independent variables. The analysis on the experimental items showed a main effect of Matrix Number, such that the sentences with singular matrix number were rated as more natural [Estimate: 0.36,  $SE = 0.10$ ,  $t = 3.70$ ]. The analysis on the control items showed no significant effects (all  $t < 1.14$ ).

The critical, ambiguous noun was located within an embedded relative clause, which was interpolated between a matrix subject and a matrix verb. In Basque, the sequence *-ak* in Basque denotes either singular ergative case subjects of transitive constructions (in which case it combines a singular determiner morpheme *-a* and an ergative marker *-k*), plural absolutive case subjects of intransitive constructions, or plural absolutive case objects of transitive constructions (in which case it combines a plural determiner morpheme *-ak* and a zero morpheme). The number of the matrix subject/verb was unambiguously singular (*-a*) or unambiguously plural (*-ek*). Relative clauses were disambiguated only at the auxiliary, either toward ergative (50%) singular or absolutive plural (50%), but the disambiguating region was not analyzed in the current paper<sup>2</sup> (Table 1). While we investigate

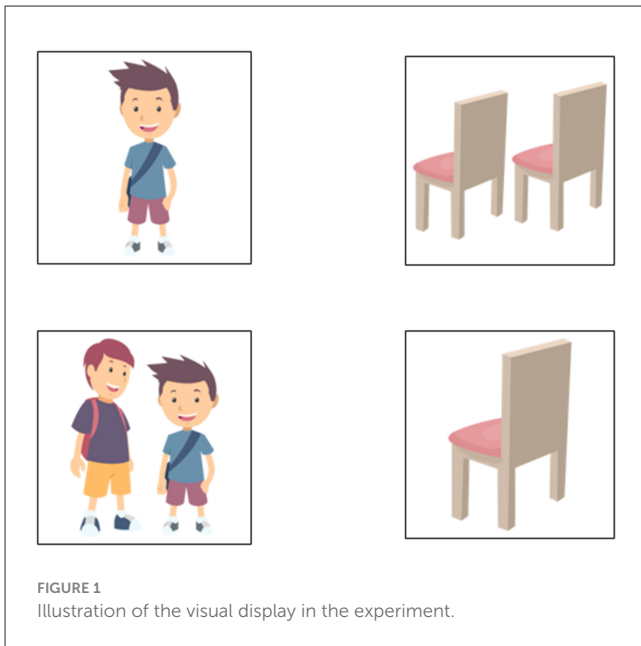
post nominal relative clauses, we note that the prenominal relative clauses are more frequent in Basque (Laka, 1996), and that previous unpublished research on post nominal relatives shows less cost (and thus preference) for subject relatives (Yetano et al., 2010). However, this advantage shows only at the disambiguating region, so we don't expect it to affect the critical noun.

Sixty additional control items were created where the critical ambiguous noun did not interrupt a matrix subject-verb dependency but was preceded by a clause containing a singular or plural-marked adjunct (Table 1). In these sentences, the manipulated non-subject noun is an inanimate, making it even less subject-like. Although, ideally, these control sentences should be created from the same lexical items as the experimental ones, it was not possible in Basque to restructure them so that the clause containing the ambiguous noun doesn't interrupt a subject-verb dependency. Therefore, the control sentences were a separate set of lexical items and were analyzed separately.

The experimental and control items were Latin Squared into 4 lists. 80 fillers were added to each list, whose structure, length, and lexical content were varied. Both in experimental and control items, the critical ambiguous noun was animate, and nouns that are not usually used in either singular or plural form were avoided (e.g., *wives*). The sentences were recorded in standard Basque by a male native speaker.

Four images appeared on the screen with each item: two versions (singular and plural) of the critical, and two versions (singular and plural) of the distractor noun, as shown in Figure 1. For the fillers, one of the inanimate nouns from the sentence was depicted. For the 20 nouns shared by control and experimental items, the same images were used. The number of occurrences of each image across the experiment was balanced, as well as the position of singular/plural and critical/distractor images. The pictures were obtained from a free online source ([www.freepik.com](http://www.freepik.com)) and modified. They were 15 x 15 cm big and limited by a border.

<sup>2</sup> The current experiment was designed to test looking behavior *before* the disambiguating region, which should reflect maintenance mechanisms, while the disambiguating region, i.e., the embedded verb, would be informative about integration mechanisms, and so it is beyond the scope of the current paper. Additionally, since in Basque agreement with both subjects and objects is expressed with additional morphemes, auxiliaries differ in length depending on what they agree with, so this region varies significantly across the conditions (see Table 1), making it hard to perform an informative statistical analysis.



## Procedure

Unlike in the classical visual world paradigm used in sentence processing (e.g., Tanenhaus et al., 1995), we presented the images 500 ms before the critical word onset, aiming to eliminate looking behavior related to the nouns prior to the critical one. Note that this time window length has previously been found to provide an adequate preview of the picture prior to the auditory stimulus onset (e.g., Apfelbaum et al., 2021; Kapnoula et al., 2015). The participants were tested individually and instructed to listen to the sentences carefully through the headphones. They were told to look at the fixation cross, and then wherever they wanted upon the appearance of the images.

The session lasted approximately 45 mins and consisted of two experimental blocks (100 items each), preceded by 5 practice trials. The yes/no comprehension questions appeared after 50% items, equally distributed over experimental, control, and filler items, and were focused on the clause containing the ambiguous noun (e.g., *Does the boy like the girl?* for experimental, and *Did the girl invite her friends for a dinner?* for control items in Table 1). On the remaining items, the participants were asked to listen to the ambiguous noun (isolated from the sentence) once again and click on the image (from the 4-image screen presented with the sentence) that corresponds to it. This task was added in order to make sure that participants paid attention to the visual stimuli and disambiguated well.

Right eye movements were recorded using the SR EyeLink 1,000 eye-tracker with the 500 Hz sampling rate and a chinrest. We performed 9-point calibration before the experiment, between the two blocks, and additionally if fixation stability was lost.

TABLE 2 Outputs of the analyses of the ambiguous noun region for the experimental and control items.

Experimental				
model_max <- lmer(log_ratioP ~ matrixnum + (1+matrixnum  Subject)+(1+matrixnum  Item), data = d8b, REML = F, control = lmerControl(optimizer = "bobyqa"))				
	estimate	Std.error	df	t statistic
(Intercept)	1.85	0.17	76.77	11.00
matrixnum1	-0.77	0.30	66.88	<b>-2.58</b>
Control				
model_max <- lmer(log_ratioP ~ matrixnum + (1+matrixnum  Subject)+(1+matrixnum  Item), data=d8b, REML = F)				
	estimate	std.error	df	t statistic
(Intercept)	1.88	0.16	71.44	11.41
matrixnum1	0.01	0.27	38.34	0.04

Coding for the Matrix Number factor, -0.5=plural, 0.5= singular. Significant effects are in bold.

## Data analysis

Short fixations ( $\leq 80$  ms) were merged with the preceding/following fixation when within 0.5 degrees of visual angle (e.g., Duñabeitia et al., 2009); otherwise, they were removed with an automatic procedure by Data Viewer (SR Research Ltd, 2019). We analyzed only the time window during the auditory presentation of the critical noun (see Ito and Knoeferle, 2023 for a procedure on linear mixed effects models over time windows in VWP data). The length of the critical noun time window ranged from 416 to 980 ms for the experimental, and from 203 to 1,066 ms for the control items. The samples were binned (20 ms) for the analysis. We calculated log-ratio of proportions of looks to the plural vs. singular image, using the formula:  $\log(\text{proportion of looks to plural image/proportion of looks to singular image})$ , with positive values indicating more looks to the plural image (Ito and Knoeferle, 2023; Arai et al., 2007). Note that unlike typical VWP experiments and their corresponding analyses, we don't have a natural target image in the current experiment, so the choice of plural image was rather arbitrary. We used *VWPre* (Porretta et al., 2018) and *lme4* packages (Bates et al., 2015) in R Statistical software (R Core Team, 2017, version 3.4.1) for data preprocessing and analysis, respectively.

The dependent variable was the log-ratio of proportions of looks to plural vs. singular, while the independent variable was the Matrix Number (Singular, Plural). We tested models for the exclusion of random by-item and by-subject slopes (by-item and by-subject random intercepts were included), using the "best-path" algorithm (Barr et al., 2013), starting with the maximal model. When encountering non-convergence problems, a different optimizer was specified. Effect coding was used for all the independent variables. We report the intercept, the estimate, standard error, and the *t* value in Table 2, together with the best fitting model. Experimental and control items were analyzed separately.

## Results

The accuracy was 81.03% on the picture-selection task, and 86.11% on the comprehension questions. Comparable means for the experimental (77.02%) and control items (79.52%) on the comprehension questions suggest that the participant understood the experimental and control sentences equally well.

For the experimental items, we found a significant Matrix Number effect, such that the preference toward a plural image (expressed by the log-ratio) was significantly higher in the plural matrix subject condition, or conversely, significantly lower in the singular matrix subject condition (Table 2, Figure 2). For the control items, we found no significant effect of Matrix Number (Table 2, Figure 2).

## Discussion

In this paper, we investigated whether the number feature of a matrix subject-verb dependency is actively maintained during its establishment. Specifically, we tested whether singular/plural matrix number, which we assumed to be actively maintained and thus available, could modulate the interpretation of a number-ambiguous noun interpolated between the matrix subject and—a mechanism that has not been proposed before. We hypothesized that the noun will be interpreted as singular more often in the singular matrix verb condition, and as plural more often in the plural matrix verb condition, due to maintenance of the singular and plural feature, respectively.

The analysis of the log ratios of proportions of looks to plural vs. singular images showed that the plural preference increased significantly with plural matrix subjects (or decreased significantly with singular matrix subjects). This implies that the ambiguous noun was interpreted as plural more often in the plural matrix subject condition. Importantly, this increase or decrease was absent from the control items, making it possible to attribute this effect to feature maintenance during subject-verb dependency establishment. Certainly, a design where control and experimental items are more similar and analyzed together would remove potential confounds. For example, an additional experiment where the manipulated singular/plural noun in both control and experimental items is inanimate would clear up whether number maintenance is aided by animacy.

Finally, it is important to underline that the matrix subject in the experimental sentences is also a filler for the embedded relative clause. Previous research has evidenced active feature maintenance in filler-gap dependencies, although not with embedded relative clauses (Ness and Meltzer-Asscher, 2019; Chow and Zhou, 2019). Therefore, future research should determine whether: 1. the maintained feature is part of a subject representation, or the verb representation, or both (as noted previously); the maintenance mechanism is triggered because the subject noun is a subject, or because it is a filler, or both. It should be noted, however, that Ristic et al. (2022) found maintenance costs even when a non-relative clause interrupted the matrix subject-verb dependency, indicating that filler status cannot completely explain maintenance effects.

## Morphosyntactic ambiguity in Basque relative clauses

The current study provides a valuable insight into the ambiguity resolution mechanisms. Our results show that number information, which we claim to be available due to active maintenance, can affect temporary ambiguity resolution. This also adds to more general evidence on structural disambiguation in language processing (Trueswell and Tanenhaus, 1991; MacDonald, 1994).

Since number-ambiguous nouns with *-ak* are also case-ambiguous, one might wonder if there is an overall case preference that could affect the results. However, previous research in Basque suggests that absolutive plural interpretation is preferred only when nouns with *-ak* are isolated (Ristic et al., 2020), while sentence-initially, ergative singular interpretation is more frequent (Erdocia et al., 2014; Yetano et al., 2011). When it comes to the temporary structural ambiguity that these nouns also generate, namely between the subject relative and object relative clause, previous studies on Basque relative clauses with ambiguous *-ak* nouns found either object relative preference for prenominal (Carreiras et al., 2010), or subject relative preference for post nominal relative clauses (Yetano et al., 2010). However, these preferences always emerged later, at the disambiguating region, so we believe that structural preferences might be irrelevant at the critical ambiguous region investigated here, i.e., might not be relevant for the maintenance mechanisms. Finally, any potential perceptual bias (e.g., visual salience of plural images) is circumvented by the log ratios, which allowed us to focus on the changes in looks as a function of the matrix subject number, which occur on top of the general bias.

## The mechanisms of maintenance in subject-verb dependency

Since the existing evidence suggests that the establishment of subject-verb dependency incurs processing cost (Chen et al., 2005; Ristic et al., 2022), we can assume that the number feature is only an aspect of the maintained representation that generates that cost. A legitimate question concerns the mechanisms by which this actively maintained information affects the processing of the ambiguous element. In the current study, we propose that the number feature is actively maintained when processing an ambiguous noun, and can affect the disambiguation process. In other words, the parser relies on the active state of the number information to conduct disambiguation.

Another potential outcome of actively maintained representation, which can explain the increased processing cost in the previous studies using different paradigms, is encoding interference. This effect, seen as increased processing cost, occurs between the same or similar features of items while they are encoded or *maintained* in memory (Nairne et al., 1990; Oberauer and Kliegl, 2006), and it has been previously suggested for subject-verb agreement (Jäger et al., 2015). Very few studies have investigated encoding interference by measuring it before the

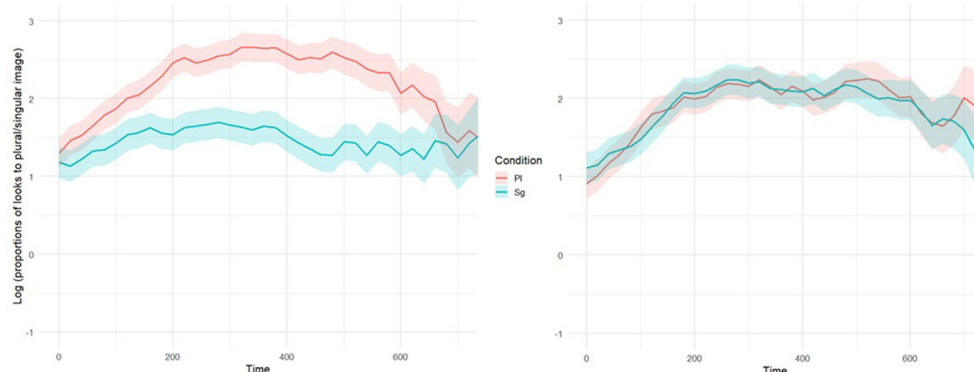


FIGURE 2

Log ratios of proportions of looks toward plural over singular image, during the critical noun time window, for experimental (left) and control (right) items. The length of the critical noun time window was 416–980 ms for the experimental, and 203–1066 ms for the control items. For a clearer presentation, only the first 700 ms are plotted here, as most items fell within that duration. PI = plural matrix number, Sg = singular matrix number.

retrieval at the verb<sup>3</sup>. For example, Villata et al. (2018) found lower accuracy and increased reading times when the subject and an object, occurring before the verb, matched in gender.

Together with our preliminary findings, existing studies suggest that the strategies employed to maintain information relevant for subject-verb dependency might require more resources than postulated by the DLT/SPLT model (Gibson, 1998, 2000), and that the parts of the maintained representation(s) are kept in a more active state than predicted by Lewis and Vasishth (2005) and Lewis et al. (2006). This also goes in line with the studies on long-distance filler-gap dependencies, where filler's features were found to be maintained active across the dependency lengths (Chow and Zhou, 2019; Ness and Meltzer-Asscher, 2019). We suggest that these models should assume a more active maintenance of the features of the elements in working memory, which would account for effects such as disambiguation or encoding interference. Villata et al. (2018) propose a Self-Organized Sentence Processing account of encoding (and retrieval) interference effects, which ascribes encoding interference to the competition of both the subject and the objects representations (*treelets*), the intensity of which depends on how fast the features are passed onto those representations.

## Conclusions

Active maintenance of the features necessary for the establishment of a subject-verb dependency can manifest either as an increased processing cost, due to encoding interference, or it can serve as an additional disambiguating information, as in the

<sup>3</sup> Note that Sturt and Kwon (2024) report absence of maintenance effects, i.e., increased processing cost, when the distractors, intervening between a subject and a verb, match the subject in number (*The widow near the nurses definitely were reluctant ...*). This lack of processing cost was replicated by Fujita (2025), although the cost was reported in this study when multiple elements were maintained in the memory. However, both studies measure processing cost at integration of the embedded subject-verb dependency (on the verb *were*), rather than on the element where the encoding interference would occur (on the distractor *nurses*) and are thus not directly comparable to the current design.

current experiment. We propose that this maintenance is a means of keeping the number feature predicted or *preactivated* prior to encountering the verb, with the final goal of ensuring a more efficient agreement validation at the verb. In line with this, studies focused on other subject-verb dependency-related phenomena have proposed that number is predicted in its computation (Lago et al., 2015).

In sum, our findings suggest that number feature is maintained during long-distance subject-verb dependency establishment in real time, similarly to feature maintenance in filler-gap dependencies. While more data is needed to determine whether these results are specific to the Basque morphosyntactic system, we suggest that this finding reflects a predictive mechanism which, in case of long-distance subject-verb dependency, manifests as active maintenance of relevant features.

## 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: [https://osf.io/8dz7a/?view\\_only=63946859b8cb4d7794bd31dad37b223c](https://osf.io/8dz7a/?view_only=63946859b8cb4d7794bd31dad37b223c).

## Ethics statement

The studies involving humans were approved by the Ethics Review Board of the Basque Center on Cognition, Brain and Language (ethics clearance code: 22082017M1) and complied with the guidelines of the Helsinki Declaration. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

BR: Methodology, Writing – original draft, Formal analysis, Investigation, Data curation, Project administration,

Conceptualization, Writing – review & editing. NM: Conceptualization, Validation, Methodology, Writing – review & editing, Supervision. SM: Writing – review & editing, Validation, Supervision, Formal analysis, Investigation, Conceptualization, Methodology.

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The author(s) declared that this work 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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