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Young children's transmission of information following self-discovery and instruction

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Children acquire knowledge through both independent exploration and other's instruction. While previous research suggests that children treat these sources of information differently, little is known about how they convey such knowledge to others. The current study investigated whether children distinguish between self-explored and instructed information when teaching a naïve learner and how this distinction may change as they develop. Two- and 5-year-old children (N = 82; 37 females; predominantly White) were shown novel boxes with distinct functions, which they learned about through either self-exploration or direct instruction. In a subsequent teaching phase, children were asked to demonstrate the boxes' functions to a naive adult. The results showed that 2-year-olds were more likely to demonstrate the instructed function first compared to the self-explored function (Cohen's d = 0.55), whereas five-year-olds showed no such preference. These findings suggest that socially acquired information carries different saliency for toddlers and older children, contributing to the under-investigated field of children's teaching in early childhood.

KEYWORDS

information transmission, preferential transmission, instruction, exploration, teaching

Introduction

From the moment they are born, infants embark on an immense learning journey about how the world works. Although there are many formal and informal routes to knowledge (Rogoff et al., 2016), two important ways in which children effectively acquire knowledge are learning through independent exploration, and through others' explicit instruction. From infancy, they actively drive their own learning experience by selectively attending to visual stimuli and manipulating objects in diverse manners, and with increasing age their exploration becomes more sophisticated (e.g., Chen et al., 2022; Kidd et al., 2012; Sim and Xu, 2017; see Schulz, 2012 for a review). Through independent exploration, children learn ample information about the world such as how novel objects function (e.g., Bonawitz et al., 2011; Schulz and Bonawitz, 2007) and causal mechanisms inherent to their environment (e.g., Sobel and Sommerville, 2010; Yuniarto et al., 2020). When interacting with novel objects, children seem to prioritize the evidence that they themselves generated over the evidence generated by others, and learn better from their own interventions (e.g., Kushnir and Gopnik, 2005; Schulz et al., 2007; Sobel and Sommerville, 2010). For instance, Sobel and Sommerville (2010) presented 4-year-old children with a novel box featuring different underlying causal relations as to how different buttons could activate different colored lights (e.g., the button associated with a red light could also activate the green light but not vice versa). After familiarizing them with the novel box, children were assigned to three conditions: discovery (i.e., children acted on the novel box to discover the novel causal relationship, then watched the experimenter act on the box), confirmation (i.e., children first observed the experimenter and then acted on the box themselves to confirm the efficacy of the actions that were previously performed), and observation condition (i.e., children only observed others act on the novel box), and were later asked several questions about the underlying causal structure of the box. Children who acted on the novel box to discover rather than to confirm or observe the efficacy of the actions performed better with regards to understanding the causal structure of the box.

While children are good at learning through independent exploration, much of their understanding of the world also originates from social interactions such as observing others, watching their demonstrations, or receiving verbal information (Harris, 2012; Paradise and Rogoff, 2009; Tomasello, 1999). In playful interactions with others, children may hear objects being labeled or may be exposed to verbal descriptions of objects (e.g., Hilton and Westermann, 2017; Ma et al., 2022; Suanda et al., 2019), they may observe others showing how to use a tool or a toy (e.g., Bazhydai et al., 2020; Bonawitz et al., 2011), listen to others' explanations about a concept (e.g., Gelman and Markman, 1987; Lane and Shafto, 2017), or be corrected by someone (peer or adult) after they make a mistake (e.g., Wood et al., 1995). While observing others and acting on observed or taught information is important for early learning (Paradise and Rogoff, 2009), as children develop, the knowledge they acquire through social means becomes more abstract and less reliant on direct observation or physical action (Harris, 2012). Through a combination of their own exploration and instructional input from others, children develop a broad and flexible knowledge base.

Children as informants

When information transmission is considered, the possession of knowledge is undoubtedly a defining feature of the teacher. In a typical teaching-like situation, the more knowledgeable ones (often adults such as parents, teachers, or older siblings) share information with the less knowledgeable ones, typically children, pupils, or younger siblings. Although maturity is typically associated with increased knowledge, the knowledge states are transient, and can vary depending on the context. For instance, depending on the context, a generally more knowledgeable individual may lack relevant information whereas a less experienced individual such as a child may know it. This lays the foundation for bidirectional knowledge exchange, including cases where children act as teachers. Despite this potential, children's roles as informative, effective teachers remain disproportionately understudied (Qiu et al., 2024).

Like their abilities to actively acquire information, children also demonstrate an early ability to share knowledge with others (Bazhydai and Harris, 2021; Gweon, 2021). The initial signs of information transmission emerge by 12 months of age through behaviors such as pointing to relevant information (Liszkowski et al., 2006). Children between 3.5 and 5 years increasingly share information with others. These transmission episodes start as mere demonstrations of actions necessary to achieve goals such as playing a game. Later, these demonstrations are woven into instructions that are accompanied by, for example, explaining game rules (e.g., Davis-Unger and Carlson, 2008; Strauss et al., 2002). As children mature, their transmission skills become more sophisticated. They begin to consider who they are sharing information with (e.g., Karadag and Soley, 2023; Kim et al., 2016) and tailor the type of information they transmit depending on the context (e.g., Bridgers et al., 2020; Danovitch et al., 2023; Gweon and Schulz, 2019; Pueschel et al., 2022; Strauss and Ziv, 2012). However, most research on children's information transmission has focused on children older than 4 years (e.g., Gweon, 2021; Strauss and Ziv, 2012; Qiu et al., 2024). Although this focus appears theoretically justified assuming that the cognitive prerequisites for transmitting information such as theory of mind or intentionality are absent in younger children (e.g., Corriveau et al., 2018; Strauss, 2022; Kulke et al., 2018), emerging findings demonstrate that toddlers do engage in meaningful information transmission based on what they have learned from others even without assuming that these capacities are in place (for review, see Bazhydai and Harris, 2021). Therefore, neglecting this age group creates a mismatch between empirical findings and theoretical models.

Some studies conducted on younger children have examined adjacent behaviors, such as instrumental helping (see Buttelmann et al., 2009; Martin and Olson, 2013; Warneken and Tomasello, 2006, 2007) which are conceptually distinct from informing. While both roles require sensitivity to others' states such as needs in the case of helping and knowledge in the case of informing, the latter often involves more abstract reasoning that is not confined to the immediate context. For instance, by nature, instrumental helping relates to the "here-and-now," whereas informing—while still applicable to the "here-and-now"—tends to encompass the transmission of information that can potentially persist beyond the immediate presence, and thus may involve distinct cognitive mechanisms that merit closer investigation in early development. It is evident that, despite the existence of some evidence with older children (Qiu et al., 2024), research on infants' and toddlers' roles as informants remains in its infancy.

What drives children's decisions to transmit information?

While children's decisions as to what information to transmit to others are often influenced by what others know or do not know, considering the vast variability in knowledge levels between individuals, focusing solely on a knowledge gap (e.g., Strauss et al., 2002) is not always useful for effective information transmission. Instead, it might be more beneficial to invest transmission efforts in imparting information that holds a certain unique significance. Such significance might depend on inherent properties of information, such as complexity, generalisability, or social relevance (Ronfard and Harris, 2018) as well as the context in which they learned about it, such as whether they were explicitly taught or learned it through self-exploration (Bazhydai and Karadag, 2022). A question that remains unanswered is, then, whether the way in which toddlers and children learn information influences what they themselves transmit to other people. It is possible that children's own learning history might drive what they select to transmit (Ronfard et al., 2016). Indeed, a specific claim has been made about preferential transmission of information learned through others' instruction (Vredenburgh et al., 2015), arguing for a special status of taught information by virtue of ostensive communication signaling culturally relevant generalisable knowledge (see also

Csibra and Gergely, 2009, 2011, though this theory does not make assumptions about child-led information transmission). Ostensive cues are important for attention selection and might influence how children make inferences about information acquired in different contexts (e.g., learner-driven or teacher-led) (Butler and Markman, 2012; Buchsbaum et al., 2011; Rhodes et al., 2010); however, their engagement with pedagogically acquired information does not stay uniform and children can increasingly combine different cues in their learning environment and treat information acquired through these cues in more nuanced ways.

While it is possible that children might nonetheless prioritize taught information for transmission, the existing evidence is mixed especially for younger children because a handful of findings specifically on this question have been conflicting. Vredenburgh et al. (2015) found that 2-year-old children learn from adults' pedagogical demonstrations (i.e., accompanied by ostensive cues) equally well as from non-pedagogical demonstrations (i.e., intentional but lacking ostensive cues); however, they preferentially transmitted pedagogically acquired actions to a naïve recipient (Vredenburgh et al., 2015). In a later study, however, this finding was not replicated, and 2-year-olds did not show any preference between choosing to transmit actions learned through pedagogical or non-pedagogical demonstrations. Instead, their transmission was influenced by information complexity favoring a simple over a complex action (Bazhydai et al., 2020). Considering these findings, whether toddlers prefer transmitting taught information, or not is not clear. While toddlers may be sensitive to, and their learning might benefit from, ostensive communication, this alone is not enough to prescribe a special status to ostensively communicated information enabling copying or propagating it as culturally relevant (e.g., Bazhydai et al., 2020; Tecwyn et al., 2020). It is important to note that in both studies the main experimental manipulation was whether children were taught ostensively or not. Thus, these two studies do not provide us with insights about children's preferential transmission when taught information is pitted against self-explored information.

Another study, on the other hand, addressed this specific question. Ronfard et al. (2016) investigated whether 4- to 7-year-old children's teaching would be influenced by how they initially learned about target information (i.e., their own learning history). They presented children with novel puzzle boxes holding stickers inside and taught them different methods varying in complexity to retrieve stickers from a box. Additionally, half of the children were provided with a chance to actively explore the boxes before being taught how to retrieve the stickers. The authors found that children transmitted the method faithfully if they only learned it through instruction, and they preferentially transmitted the taught over the self-discovered method only when the taught method was more complex to figure out on their own. Finally, when the difficulty of both methods was similar, they did not show a preference for either method in their transmission decisions. Ronfard et al. (2016) concluded that, at this age, children's information transmission is influenced by how children themselves initially acquired the information in conjunction with the complexity of the acquired information. However, two aspects of the study should be noted: the nature of the tasks was instrumental to retrieving a reward, and the information learned was causally relevant to the instrumental goal. These two aspects might have primed children to consider other factors such as figuring out the quickest and/or more efficient way of retrieving the reward from the box in addition to how they learned about the different methods ("naïve utility calculus," e.g., Aboody et al., 2021; Jara-Ettinger et al., 2016).

While the findings reported above generate important insights regarding older children's behavior, they shed little light on the question whether children, especially toddlers, would transmit taught or self-explored information preferentially when there is no immediate instrumental goal. One could expect a preference for both transmitting information acquired through instruction and self-exploration simply because the information learned through these different means can be differently salient. Salience is often described in relation to attention selection (Koch and Ullman, 1987; Posner, 1980) such that the properties of the external world that are immediately attention-grabbing and difficult to suppress or ignore are considered salient. This is important because salience positively biases information retention and salient information is often processed better than non-salient information (Santangelo, 2015). In any learning situation, then, there are differently weighted cues associated both with the information itself (i.e., how salient the different features of the object are) and the learning context (i.e., how salient the learning from self-generated actions or other's instruction is to the learner). The combined salience of these different cues is weighted against each other by the learner implicitly, and the more salient cues are selected for further learning (see Yurovsky and Frank, 2017 for a similar approach in the word learning domain). This approach can be applied to the information transmission context as well (Bazhydai et al., 2020), such that the weight assigned to different salience-based cues during learning might influence what information children transmit to others leading them to form a preference for one over the other. The salience-based cues might be related to either the properties of information or the learning context associated with this information. By keeping the former almost identical for each learning context, it is possible to test the role of the learning context on children's subsequent transmission of learned information.

Taking children's competence in learning from independent exploration into this salience-based account, one could argue that children might be inclined to preferentially transfer this type of information to others. In other words, this potential preference might stem from the salience of their own self-exploration. For example, when children act on an object independently, their interaction with the object is more likely to be driven by their own interests (e.g., Mani and Ackermann, 2018, in the context of word learning) compared to when they would be explicitly (and passively) taught the same information by others. Supporting the role of self-exploration argument, a recent study conducted with 3- to 5-year-old children found that children tend to overestimate the role of one's own actions on others' learning, even when they observe that learning actually occurs through the instruction of a teacher rather than through self-exploration of the learner (Sobel and Letourneau, 2018). Thus, at the core of this argument is the idea that if learning about an object is self-driven by inherent attention, interest or simply the involvement of the self (through self-generated, unsupervised actions) during the learning process, transmitting what was learned through this salient self-led exploration might be prioritized.

On the other hand, children might prefer to transmit information that they were explicitly taught due to their heightened attention to the context where a social partner, typically using ostensive cues, demonstrated a particular action or shared new facts. Based on the salience-based account, this would increase the child's focus on the learning environment without the need to assume its special status due to communicative and referential intentions of social partners (Heyes, 2016, 2017). While acknowledging the prominence of ostensive communication in children's learning, it can be ultimately construed as one of the cues among other highly salient social and non-social cues.

As children mature, a developmental change in their preferential transmission may occur. This change may be indicative of shifts in how children evaluate and integrate different salience-based cues. For instance, younger children may rely more heavily on perceptual salience (e.g., novelty or attention-grabbing features), while older children might begin to attend more to cues related to epistemic or social relevance as a natural outcome of the developmental advances in cognitive skills such as attention, working memory, and inhibition, which facilitate more selective processing and greater flexibility in evaluating multiple sources of information (Yurovsky and Frank, 2017). Additionally, children's developing understanding of the knowledge exchange process, theory of mind and executive functioning skills and increased exposure to more formal modes of learning, such as schooling, might overall contribute to how the salience of different information is processed, and how different salience cues are integrated, and how they may guide decision-making (see Qiu et al., 2024 for a meta-analysis). Consequently, an investigation into whether children would preferentially transmit taught or self-explored information in light of this framework may provide a new venue for the debate on the factors that influence children's preferential information transmission.

Finally, understanding whether children prioritize information learned through different modes—social instruction vs. self-exploration—may have educational implications. This investigation may provide insight into early cognitive development, offering guidance for designing educational strategies that align with children's evolving preferences for guided and independent learning.

Current study

In this study, we asked whether 2- and 5-year-old children selectively transmit information that they were explicitly taught over information that they self-explored. Since both possibilities are motivated by the salience-based account as both carry the salient weight, we did not form a directional hypothesis.

We further reasoned that children's preference for one type of information over the other might undergo a developmental change. Thus, we investigated this question with two age groups, 2- and 5-year-old children who are different from each other in several aspects (e.g., language skills, executive function, theory of mind, social and normative understanding) and have different learning experiences (e.g., 2-year-olds are only exposed to instruction in informal play contexts, whereas 5-year-olds are exposed to both formal and informal educational settings as well as are able to demonstrate more sophisticated exploration skills).

Method

Participants

Forty-one 2-year-old (*Mage* = 24.75 months, Range = 22.86–26.20, 18 females) and 41 5-year-old (*Mage* = 60.30 months, Range = 54.43–71.36, 19 females), healthy, predominantly White, English-speaking children were recruited to take part in this study. For 2-year olds, data from three participants were excluded, with 38 participants in the final data (See Results for exclusion criteria). No participants were excluded in 5-year-old group. We chose the age groups of 2 and 5 years based on the following rationale: (1) in line with previous research on early information transmission 2-year-old children can readily transmit information that they acquired from others (Bazhydai et al., 2020; Vredenburgh et al., 2015), and (2) 5-year-old children have typically had at least a few months of experience in Reception (i.e., the first year of formal schooling in the UK) or have completed it. The age groups in question differ markedly, particularly because 5-year-olds have more developed socio-cognitive skills and early exposure to formal education. This contrast may help us exploration the potential influences of such developmental differences on children's selective information transmission. We used the same paradigm as for the 2-year-old children but made slight modifications to the design to make it more context-appropriate for 5-year-old children (see Procedure). Ethical approval was received from the Faculty of Science and Technology Research Ethics Committee at Lancaster University. Data collection took place between December 2021 and September 2022. Participants were recruited from the Lancaster University Babylab database and social media accounts, were compensated with £5 for their travel expenses and received a storybook or a T-shirt to take home with them as a thank-you gift.

Materials and stimuli

Four novel wooden boxes were created for this study (i.e., two sound boxes and two light boxes). The two sound boxes were perceptually almost identical. They were both oval-shaped, orange and each had one push button on one side of the box (i.e., Box 1 had a black button on the left side of the box, where Box 2 had a silver button on the right side of the box). Each box played a different novel tune that was composed using simple tones, and each tune lasted around 3 s. The two light boxes were also perceptually almost identical. They were both rectangular with a rounded top, green, and each had one small push button and a light bulb on one side of the box (i.e., Box 1 had a red button and a green bulb on the left side of the box, whereas Box 2 had a silver button and red bulb on the right side of the box). Each box turned on a different colored light though the lights were dependent on the button presses, thus, they were on as long as the push buttons were pressed (see Figure 1 for the Stimuli). While the boxes were perceptually similar and thus potentially challenging to distinguish for the duration of the experiment across different phases, we incorporated multiple

FIGURE 1
The stimuli used in the study.

indirect cues into the design to support children's ability to track the source of information without directly asking them. The spatial positioning of the boxes remained consistent across the learning and transmission phases, with placement being counterbalanced for handedness. The boxes remained visible but out of reach between phases, and their orientation and position were preserved by the experimenters. Additionally, it should be noted that the stimuli were designed to test both 2-year-old toddlers and 5-year-old children. Since the younger age group has limited skills compared to the older age group, we focused on 2-year-old toddlers' communicative and cognitive capacities when designing the study. This led us to design a task that would not rely on language skills and create simpler toys with few functions that would be engaging enough but not too distracting.

Design and procedure

Testing took place at the Lancaster University Babylab. Before coming to the lab, researchers sent the informed consent form through a Qualtrics survey platform link to the parents along with the lab approved testing guidelines during pandemic. Two experimenters aimed to interact in an equally friendly and child-directed manner with the child. After welcoming the participant and the caregivers into the lab, Experimenter 1 (E1) explained the aim of the study and the experimental procedure to the caregivers, went over the key points in the informed consent form and ensured that the informed consent form was filled in by the caregivers. Children were told that they would be playing a "game" with no hints to its aim. Later, E1 provided a chance for the caregivers to ask any questions about the study and invited the dyad into the testing room. There were two blocks per child with two different sets of objects (i.e., sound boxes vs. light boxes). Since the boxes were almost identical, the main manipulation was whether participants learned about the boxes through independent exploration or through the experimenter's instruction.

Before the study, both E1 and E2 played with the child for about a minute using a wooden marble run game to familiarize the child with the experimental set-up.

Learning phase

This phase had two trials. In each trial, one box from each set (i.e., sound boxes vs. light boxes) were presented. Children learned about the boxes in different ways such that if the first box was shown by E1, the second box was independently explored by the child,

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and vice versa. The boxes used in the procedure were hidden in a cupboard under the table away from the child's view. E1 initiated the procedure by telling the child that she had some toys that she wanted to show them by saying "Let's now play with other toys, let me show you one." Then, E1 took out one of the sound boxes. In the first trial (e.g., *instruction-first* order), E1 took out the first box and put it on the table outside the child's reach. Upon making sure that the child was attending to the box and making eye-contact with the child, E1 told the child "Look [child's name]! This is how it works.", then demonstrated the target function of the box once. E1 told the child "Your turn" then pushed the box within the child's reach for the child to try. If the child did not engage with the box after 10 s, E1 prompted the child by saying "Do you want to play with it?", if children played with the box, then stopped but had still time to play, E1 told the child "You can play more if you want." After 20 s had elapsed, E1 took the box away from the child and thanked the child. By putting the first box back into the cupboard, E1 took out the second box. This time the experimenter held the box in her hands, turned it around for a second and told the child "Oh, you can play with it," then put the box within the child's reach without showing how the box worked. After giving the box to the child, E1 took her phone and pretended to engage with her phone as the child played with the toy. If the child did not explore the box within 10 s, E1 looked at the child and said, "Do you want to play with it?". If the child played initially but stopped and still had the time, E1 said "You can play more if you want". After 20 seconds had elapsed, E1 took the box away from the child and thanked them. Then, E1 took both boxes from the cupboard when E2 knocked on the door. E1 told the child, "Did you hear that? I think they need me outside; I will go but I will come back. Can you wait for me here?". E1 put the boxes on her chair and left the room. Immediately, E2 entered the room and initiated the transmission phase.

Transmission phase

E2 approached the child and said "Hi [child's name], are you okay?" Then, E2 looked at the chair, noticed the boxes and said "Wow, what are these? I haven't seen these before!" E2 then took the boxes and put them on the table, and by pushing the boxes toward the child, asked "What do these do? Can you show me?" and looked at the child smiling. If the child did not show anything on the box within 10 s, the experimenter prompted the child by saying "Can you show me what these toys do?". If the child showed anything, E2 followed up with saying phrases like "oh," "wow," "cool," "thank you for showing me." After 20 s had elapsed, E2 thanked the child, took the boxes and left the room. Then, E1 re-entered the room and repeated the *Learning Phase* with a different set of boxes with different effects (e.g., light boxes) in the second order (*exploration-first* order) followed by E2 repeating the *Transmission Phase* with the new set of boxes. However, this time in the *Learning Phase,* E1 said "Do you want to see some other toys? Let me show you another one." In the *Transmission Phase,* E2 said "Wow, what are these new toys? I haven't seen these before either." The orders used in the two trials were counterbalanced across participants (see Figure 2).

The order of presentation (i.e., *instruction-first* vs. *exploration-first)* was counterbalanced both within and between blocks and between children. The order of presentation for the sound vs. light boxes was counterbalanced across children.

Design and procedure were identical for both 2-year-olds and 5-year-olds except the following: First, before starting the study, E1 told the 5-year-old children that she was going to show some toys, but these were "baby toys," thus might be a little easy for them, and she was just curious about how they would play with these toys. As the toys were visually and mechanically simple, this framing provided the necessary age-appropriate context to help minimize children's over-interpretation of task demands and reduce the likelihood that children would act out of complex expectations. Second, the trial times were not fixed; once the child overtly demonstrated that they were done with the toys or $\sim$20 s elapsed, the experimenter took the toys back and proceeded with the study.

Measures and coding

Behavioral coding was done offline from the video recordings. A second coder coded 25% of all videos, and a Kappa statistic of 0.70 and a coefficient (Cronbach's) α statistic of 0.80 were aimed for agreement across coders for dichotomous and continuous variables, respectively. Given the visible differences in experimenter behavior when presenting the instructed vs. explored boxes, coders were not blind to condition but remained blind to the study's hypotheses. The results of the reliability analyses showed a perfect Kappa statistic of 1.00 for categorical variables and a minimum α statistic of 0.90 for continuous variables. All disagreements were resolved through discussion and a third coder's judgment.

Learning phase

We coded whether children activated each function that was either explored independently or taught, at least once. If children failed to activate one of the functions during a trial, that trial was excluded from further analyses. Additionally, we coded how many times children activated each function.

Transmission phase

The primary outcome was the first function a child showed to E2. As an additional measure, we also coded how many times they activated each function within each trial. The choice of these measures and the coding procedure was based on the preceding research in information transmission by Bazhydai et al. (2020) and by Vredenburgh et al. (2015)—i.e., first function and the number of actions.

To capture children's preference for transmitting the instructed or explored function, we used the following coding procedure: (1) Children received a score of +1 if they demonstrated the Instructed function first in both transmission trials. We interpreted this as a preference for transmitting the Instructed function. (2) Children received a score of −1 if they demonstrated the Explored function first in both transmission trials. We interpreted this as a preference for transmitting the Explored function. (3) Children received a score of 0 in two cases: if the children demonstrated different functions first in each transmission trial (e.g., demonstrated the Explored function first in one trial, and the Instructed function in the other trial), or if they demonstrated both functions simultaneously in both transmission trials. We

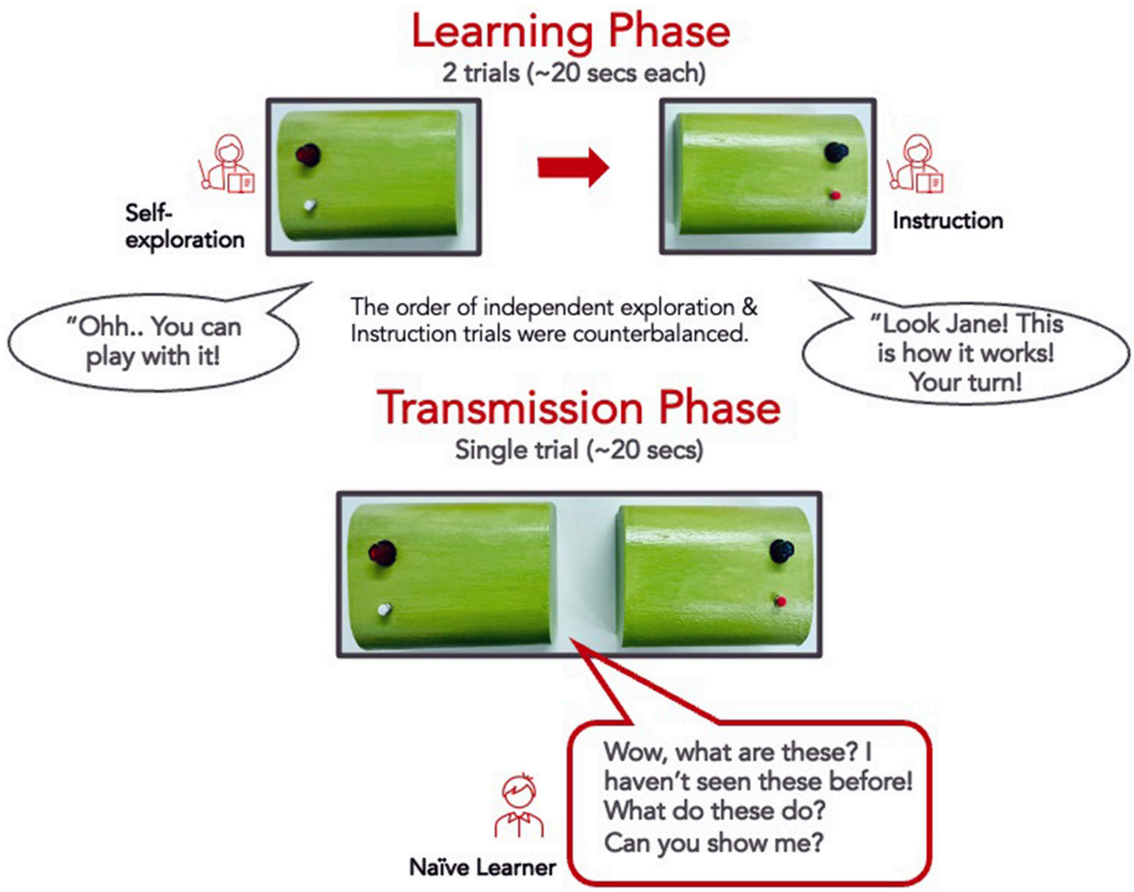

FIGURE 2
Visual depiction of the experimental procedure.

interpreted this as no clear preference for either function. (4) If children demonstrated both functions simultaneously in one transmission trial, and demonstrated only one function first in the other, children received a score for the trial where they made a choice (e.g., +1 for the Instructed; −1 for Explored).

If children contributed data from only one transmission trial, they received a score of +1 if they demonstrated Instructed function first, a score of −1 if they demonstrated the Explored function first, and a score of 0, if they demonstrated both functions simultaneously. The interpretation of these scores the same as above.

Analytical approach

We analyzed the data using a combination of traditional null hypothesis significance testing and, where appropriate, equivalence testing. We assessed engagement with each function in the Learning Phase using independent-samples *t*-tests. We additionally ran two one-sided tests of equivalence (TOST) to check if the number of activations for each function could be considered statistically equivalent across conditions. These results are reported alongside the main findings.

For the Transmission Phase, where children unexpectedly demonstrated both functions simultaneously or across trials, rather than making a clear choice with one of the functions demonstrated preferentially, these responses were coded as "both" but excluded from the main preference analyses to preserve interpretability in light of the research question. However, given the substantial proportion of such cases, we conducted supplementary analyses (reported in the Supplementary material), exploring alternative analytic approaches. Mixed-effects models including participants as random effects were attempted, but these yielded singular fit and overdispersion, indicating they were not appropriate for this dataset. We also conducted simplified models without random effects, which produced results consistent with our primary analyses.

For all analyses, we have tested the necessary assumptions which were met unless otherwise reported.

Results

Exclusions

For both 2- and 5-year-old age groups, we excluded data on a trial basis so that if a participant contributed data from only one trial, they were kept in the dataset. From the 2-year-old group, two participants failed this criterion. Data from one more participant was lost due to camera failure. In total, 22 trials (26.8% of 82 trials) were excluded for the following reasons: not activating both functions at least once during the learning phase (15 trials), not showing anything to E2 in the transmission phase (four trials), and parental interference (1), camera failure (2). From the 5-year-old group, we excluded a total of 10 trials (12.2% of 82 trials) for the following reasons: not activating both functions at least once during learning phase (eight trials), experimenter error or equipment failure (two trials).

Learning phase

As a control check, we conducted a paired-samples t-test to analyse whether children in each group activated the instructed vs. explored functions equally often. For 2-year-olds, there was no significant difference in the total number of times they activated the instructed ($M = 6.42$, $SD = 4.28$) vs. the explored function ($M = 7.68$, $SD = 6.21$), $t(37) = 1.585$, $p = 0.121$, *Cohen's* $d = 0.26$. Similarly, for 5-year-olds, there was no significant difference between activations of the instructed ($M = 17.51$, $SD = 10.16$) and explored functions ($M = 19.17$, $SD = 14.15$), $t(40) = 0.733$, $p = 0.468$. These results confirm that both age groups interacted with the two functions to a similar extent during the task.

While the number of activations for instructed and explored functions did not differ significantly during the learning phase, equivalence tests indicated that it was not possible to confidently conclude that these activations were statistically equivalent, likely due to limitations in sample size and variability in responses. This pattern was consistent across both age groups, indicating that while children engaged with both functions in a similar manner, the observed differences were too variable to meet the criteria for equivalence.

Transmission phase

To assess selectivity in information transmission, we first examined the function children chose to demonstrate first to E2. Twenty-two children contributed data from both trials, whereas 16 children contributed data from only one trial. A one-sample t-test comparing their average first-choice scores against chance (0) revealed a significant tendency to transmit the instructed function, $t(37) = 3.389$, $p = 0.002$, Cohen's $d = 0.55$. Specifically, 20 children showed the instructed function as the first function, five children showed the explored function as the first function; and 13 children either showed both functions simultaneously or showed the instructed function in one trial and the explored function in the other trial as the first function. As our primary interest lay in the study of children's selective preferences and given that the "Both" option does not accurately reflect a clear choice, these cases were excluded from the planned analyses. A binomial test, excluding responses marked as 'Both', confirmed a significant preference for the instructed function, $p = 0.004$. Additionally, we examined the total number of activations for each function, a paired-samples t-test showed no significant difference between activations of the instructed ($M = 5.29$, $SD = 5.80$) and explored ($M = 4.68$, SD $= 5.49$) functions, $t(37) = -1.259$, $p = 0.22$.

In the 5-year-old age group, 31 children contributed data from both trials and 10 from one trial. A one-sample t-test on their first choices did not reveal a significant difference from chance value (0), $t(40) = 1.840$, $p = 0.073$. Fourteen children showed the instructed function first, six children showed the explored function, and 21 children either showed both simultaneously, or each in a different trial. A follow-up binomial test, excluding "Both" cases, indicated no significant preference for either function, $p = 0.115$. As with 2-year-old age group, a paired-samples t-test on the total number of function activations showed no significant difference between the instructed ($M = 9.63$, $SD = 7.61$) and explored ($M = 9.88$, $SD = 8.16$) functions, $t(40) = 0.630$, $p = 0.53$ (see Figures 3, 4).

Control analyses examining the role of box set and order of presentation on these measures for both learning and transmission phases are reported in the Supplementary material.

Cross-group comparisons

We compared children's responses in the transmission phase across both age groups to investigate age differences in transmission preference. First, an independent samples t-test revealed no significant difference between 2- and 5-year-olds' first-function choices, $t(77) = 1.385$, $p = 0.17$. For the secondary measure, we conducted a two-way mixed ANOVA with mode of acquisition (instructed vs. explored) as a within-subjects variable and age group (2 vs. 5 years) as a between-subjects factor. Results showed no main effect of the mode of acquisition on the number of overall activations for each function [$F(1, 77) = 0.347$, $p = 0.56$], indicating that the instructed and explored functions were activated equally. However, there was a significant main effect of age [$F(1, 77) = 9.795$, $p = 0.002$, $\eta p^2 = 0.11$], with 5-year-olds activating each function significantly more than 2-year-olds (see Table 1). There was no significant interaction between age group and the mode of acquisition on children's overall activation of each function in the transmission phase $F(1, 77) = 1.919$, $p = 0.17$).

In the figures below, we present both participant level responses that were used to conduct the statistical analyses (Figure 3) and the trial level responses from each transmission trial without averaging across blocks (for participants who contributed data from both blocks). Note that the latter were additionally analyzed with results presented in the Supplementary material and corroborating those reported above.

Discussion

We investigated whether 2-year-old toddlers and 5-year-old children would display a preference for transmitting information learned from others or through their self-exploration, and whether any potential preference would persist across different age groups. We argued that selectivity for either information type could be explained with the salience-based account (e.g., Bazhydai et al., 2020; Yurovsky and Frank, 2017) where each cue associated with the learning environment is assigned a weight, and a combination of these weighted cues would determine which information is

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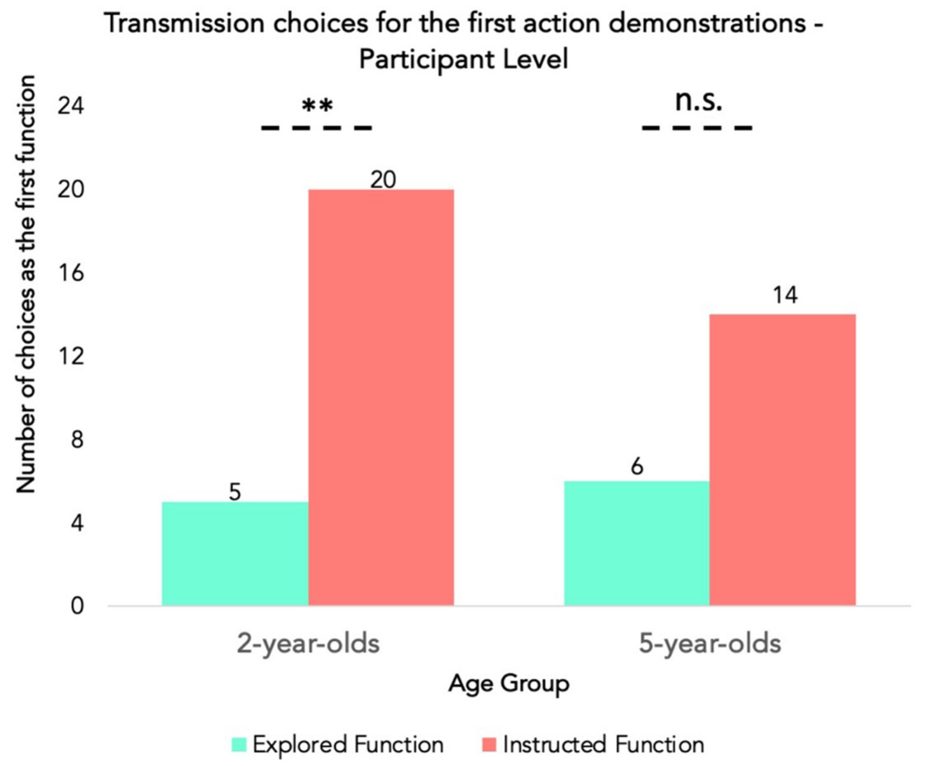

FIGURE 3
Transmission of choices for the first action demonstrations: participant level. This figure shows transmission choices for the first action demonstrations from the participants who made a preferential choice between transmitting Explored or Instructed function in one or both trials.

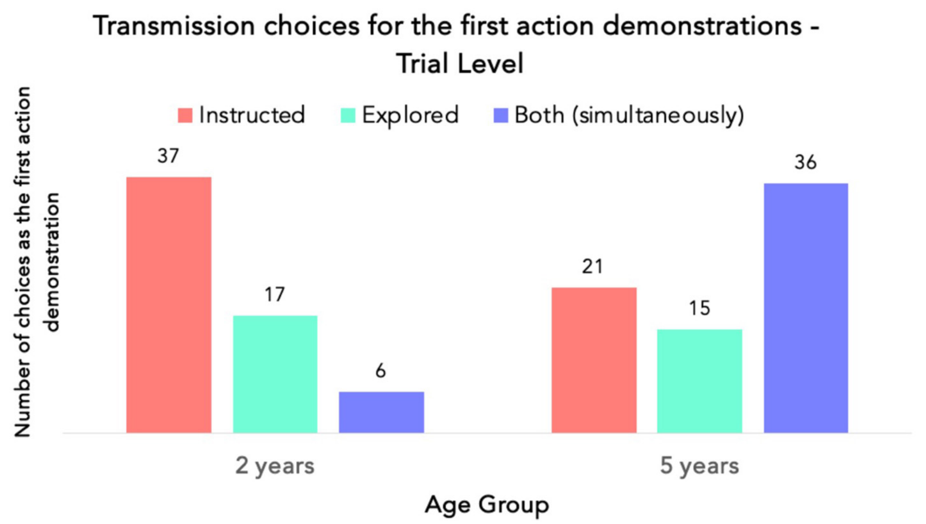

FIGURE 4
Transmission choices for the first action demonstrations: trial level. This figure focuses on each block that was contributed by children across both age groups and shows the transmission choices that children made in each eligible Transmission trial. In total, 2-year-olds contributed 60 trials out of 82; whereas 5-year-olds contributed 72 trials out of 82 trials. Complementary analyses using this trial level data are presented in Supplementary material which corroborated the conclusions reported here. For more detailed information of the descriptive statistics please refer to Supplementary Tables S1–S3.

prioritized when the newly acquired information is selected for further transmission. We found that despite learning equally well through self-exploration and instruction in the learning phase, 2-year-old toddlers preferentially transmitted instructed over self-explored information to a naïve learner in a teaching-like situation. By contrast, 5-year-old children did not show a preference for

TABLE 1 Frequency of activating each function in transmission across age groups.

Type of Function	Age Group	M	SD
Explored function	2-year-olds	4.68	5.49
	5-year-olds	9.88	8.16
Instructed function	2-year-olds	5.29	5.80
	5-year-olds	9.63	7.61

transmitting either type of information. However, when compared directly across age groups, the analyses did not yield statistically significant results, indicating that while there might be some evidence suggesting a developmental shift, it is not supported by direct comparisons between groups. Therefore, we interpret this pattern cautiously and refrain from making strong claims about age-related differences. Additionally, we note that the preference analysis was limited to a subset of children who made a clear first transmission choice, and most of these children opted to demonstrate the instructed function. As such, the findings reflect selective transmission patterns within this subgroup and should be interpreted within that context.

Zooming in on the role of different cues in the learning context (i.e., salience of being taught vs. salience of self-exploration), the results of this study are compatible with the cue-combination framework; however, we did not observe the stability of this preference across the two age groups. It is possible that 2-year-olds weighted cues associated with the learning context more so that learning through a social partner's instruction was more salient than learning through self-led, independent exploration. The different pattern that we observed in 5-year-old children might be due to the changes in the weighting of self-exploration. This is because in parallel with getting more experience with learning through others' explicit guidance and instruction, children with age also become more experienced in self-exploration: engage in more sophisticated forms of exploration and complexity of the information that they learn through self-exploration increases drastically (e.g., Meder et al., 2021; Pelz and Kidd, 2020; see De Simone and Ruggeri, 2022, for a review). Thus, instead of the learning context (i.e., how they initially acquired information), the information that is more complex or difficult might have become more salient and influenced how the acquired information was prioritized for transmission. Given that in this study we kept other cues relevant to the information equally salient such as the complexity, functionality, and appeal of the objects for both instructed and self-explored information, the weight assigned to the social aspect of the learning context alone might not have been sufficient to influence 5-year-olds' preference for transmitting instructed information as observed in 2-year-olds. This interpretation is also compatible with Ronfard et al.'s (2016) findings, where 4- to 6-year-olds' preference for transmitting self-explored or instructed information was modulated by the complexity of the method of extracting the reward, and when the information features were equal (i.e., equally easy), children simply did not show a preference for teaching either method.

It should be noted that although the results for the 2-year-olds might also be compatible with a richer explanation ascribing "special status" to information acquired through others' instructions (Vredenburgh et al., 2015), the finding that 5-year-olds did not show such preference makes this interpretation unlikely. If instructed information indeed had a special status for further transmission, we would expect this advantage to persist, if not become even more pronounced with age (e.g., Hoehl et al., 2019; Marsh et al., 2014; McGuigan et al., 2007; Flynn and Smith, 2012; Flynn et al., 2016). The argument for the early competitive advantage for socially acquired information has also been widely debated in the learning context (e.g., Heyes, 2012a,b) with recent findings showing that both 2- and 5-year-old children learn equally well from social demonstrations as well as individual exploration across different cultures (i.e., UK & China) (Atkinson et al., 2021). We conclude that, while our findings could be interpreted as supporting a special status for instructed information, they are more convincingly explained by the salience-based cue-combination account. Rather than positioning cue salience and social-cognitive reasoning as mutually exclusive, we propose cue salience as a complementary lens that may account for developmental shifts in how children weigh different learning experiences when deciding what to transmit. This perspective aligns with our findings and provides a more integrative understanding of the mechanisms underlying children's transmission choices.

Some methodological considerations of our study warrant further discussion. First, we base our interpretation on the primary outcome measure (i.e., the first function activated in the transmission phase). The "first" responses such as first tap on a touchscreen (e.g., Frank et al., 2016), first visual fixation or look (e.g., Ferry et al., 2010; Gliga et al., 2009; Libertus et al., 2013), first object choice (e.g., Diesendruck and Markson, 2001), first touch (e.g., Libertus et al., 2013), first grip (e.g., Butterworth et al., 1997), first point (e.g., Liszkowski et al., 2006), first reach (e.g., Clearfield et al., 2006), and first action (e.g., Brugger et al., 2007), among others, have been widely used in cognitive tasks with infants and young children. "First" responses are considered to be the most sensitive measures as the responses are yet to be influenced by any input or feedback that participants might receive while completing the task (Diesendruck and Markson, 2001; Evey and Merriman, 1998). Additionally, a recent finding suggests that children's actions on a causal learning task might be influenced by their first responses (Sobel et al., 2022). While the number of times each function was demonstrated could also be considered as an indicator of preference, it reflects more general engagement, which could include exploratory, confirmatory, or repetitive behavior that may not align directly with a selective transmission preference. This helps explain why the two measures do not necessarily yield the same outcome: a child may initially demonstrate one function (indicating a preference) but go on to activate both functions during the rest of the phase, perhaps out of curiosity or thoroughness. Additionally, the traditionally used measures of selectivity in young children such as the first reach or look toward the boxes would have been problematic in the context of our research question because, while they could be indicators of selective attention allocation or an overall preference for engagement, these would not demarcate a preference specifically for transmitting information unless children pressed the buttons to demonstrate what the boxes did. It should be noted that while it is not possible to explain what the "first" responses might signify for children (ease of transmission, importance, etc.), choosing one option over the other first consistently can be a marker of preference. We are therefore confident that our main measure provides crucial information despite not converging with our secondary measure (i.e., the frequency of activating each function).

Second, the simplicity of the objects might have undermined the influence of the self-exploration; while this might be possible for older children, we designed this study primarily with 2-year-olds in mind, reasoning that making the boxes more complex would present a risk to mask toddlers' abilities and preferences to act on the objects. Although we did not quantify it, we have anecdotal evidence to suggest that children's first reaction to a box in both groups differed slightly when they explored the box: some tried to find other functions, some were interested in the physical features of the box (e.g., the color of the box, button and light, the surface of the box, whether the button rotates, etc.), and some were curious about the content of the box and tried to open it. Hence, even with a simple box like we used in this study, self-led actions on the boxes could provide varied and valuable information. In addition, there was substantial variability in children's activation counts for each function, particularly during the transmission phase, as reflected in the large standard deviations. The most likely reason for this is the differing temporal characteristics of the two box sets: while the sound boxes produced a fixed three-second auditory output, the light boxes flashed as long as they were pressed, and if pressed briefly, could be activate more often than sound boxes. This design feature was intentional, we aimed to keep the two box sets as simple as possible, while ensuring the effects were perceptually distinct. Varying the duration of the effect was one practical way to achieve this distinction. Although we thoroughly counterbalanced the assignment of boxes across conditions to avoid introducing bias, these differences may still have affected individual engagement levels. Similarly, it is possible that this was related to the framing of the toys as "baby toys." While this experimental design choice may have influenced children's motivation to explore or transmit certain functions, it was intended to align the task with developmental expectations and reduce demand characteristics. Future studies could standardize the temporal dynamics of effects (e.g., repeated flashes or matched sound durations), while preserving the simplicity, distinctiveness and age appropriateness.

Finally, unexpectedly, we found that 5-year-old children, unlike 2-year-olds, pressed both buttons simultaneously in almost half of the eligible trials, reducing the number of trials that we could include in analysis of selective preferences. More specifically, this pattern of responding led to the exclusion of approximately 34% of 2-year-olds and 51% of 5-year-olds from the participant-level analyses of the first function choices. At the trial level, this corresponded to an estimated 43% of trials for 2-year-olds and 58% for 5-year-olds. While these exclusions were necessary to ensure a consistent criterion for measuring a distinct preference, we acknowledge that this decision reduced the available data, and may have impacted the power of our analyses. To overcome this, future research could employ alternative designs which prevent simultaneous activations such as by using a remote-controlled audio player or potentially making the transmission decision a "forced choice." While such alternative designs might be helpful, they also introduce superficial constraints leading children to make an explicit trade-off and potentially diminishing ecological validity (but also see Qiu et al., 2024 who did not detect differences in outcomes based on such methodological decisions).

While these results should be interpreted with caution, they present a starting point for generating further research questions and opening avenues for discussions about how selectivity in information transmission is conceptualized and how it is influenced by different learning contexts. Additionally, we contribute to the relatively limited literature on the development of teaching behavior in children younger than 4 years, by showing that 2-year-olds eagerly respond to adults' bids for information when prompted, and their transmission may be influenced by how they initially acquired this information. While the increase in the interest for studying children's ability to transmit information is important for developing fruitful theoretical discussions, findings that are limited to older children (e.g., Baer and Friedman, 2018; Danovitch et al., 2023; Gweon and Schulz, 2019; Pueschel et al., 2022) might also lead to relying on richer explanations that assume complex socio-cognitive skills while dismissing leaner approaches (see Qiu et al., 2024). Even though more sophisticated socio-cognitive capacities such as theory of mind, executive functions, and social motivation to be helpful (e.g., Davis-Unger and Carlson, 2008; Strauss and Ziv, 2012) might be essential for effective and more tailored teaching by allowing teachers to consider the learners' epistemic states and maximize the utility of information to be provided (e.g., Aboody et al., 2022; Bridgers et al., 2020), they may not be a prerequisite for the emergence and early development of information transmission (Corriveau et al., 2018).

We argue that the proposed salience-based cue combination account helps understanding the developmental trajectory in preferential information transmission. For instance, considering the performance of 5-year-olds in our study, the salience of the cost (how difficult, complex, or opaque, and lack thereof) might become more pronounced rather than the salience of learning context. As they get older, children might simply be better at appraising different aspects of information enabled by different socio-cognitive skills. Coupled with their increased experiences as learners and teachers, this combination of skills might eventually lead them to reprioritize the cues assigned to the learning context as well as the information itself.

There is still a myriad of questions remaining to be answered with respect to several aspects of children's preferential information transmission, and what type of information is prioritized for further transmission. For instance, it is possible that the salience of learning from exploration decreased because the self-explored object was selected by the experimenter and not by the learner. Here, if the salience of self-explored information came from its relation to own interest and attention, this might have undermined the role of self-exploration. As this was an issue we pre-emptively considered, we intentionally avoided letting children choose the object in this manner because it might have led to a preference just by virtue of having chosen one box over the other (e.g., Silver et al., 2020). Future studies could include a set of three identical objects, where children are given a choice to explore one of the three objects and then could be shown one of the remaining two objects. Children can then be asked which of these objects they would choose to teach (the toy they selected, or the one chosen by the experimenter). While this would not completely account for the potential confound mentioned above (i.e., the preference being affected by the initial choice), it could enhance the role of self-exploration. A carefully controlled set of studies should take our question further by focusing on different social (e.g., receiving direct instruction, observing a knowledgeable adult, ritualistic or normative component of the information and learning process) and non-social (e.g., salience of the different object features, level of complexity) salient cues that might potentially influence children's choices.

While our study was not designed to offer direct practical recommendations, these findings may contribute to a broader understanding of how exploration and instruction shape children's information transmission. Although the current study provides a focused and nuanced insight, future research could explore how balancing different learning approaches might support flexible knowledge transmission which may have implications relevant for educational settings. These considerations may be particularly relevant for younger children and across diverse cultural or developmental contexts where learning modes are emphasized differently.

In summary, our study suggests that toddlers might preferentially share information that they have previously learned through others' instructions compared to their own exploration, whereas such preference is not present in 5-year-old children, all other experimentally controlled factors being equal. This result should be treated as hypothesis generating and be interpreted with caution given the lack of statistical significance in the cross-age comparisons. We suggest that the early preference for transmitting socially acquired information observed in toddlers might be due to its inherent saliency enhanced by several aspects of the learning context such as the use of ostensive cues. As children get older, saliency of the self-led learning might increase leading them to re-prioritize what information to transmit to other people, potentially also considering other aspects, such as efficiency, complexity, or appeal of information to others. Our findings contribute to the growing body of literature within the under-investigated field of children's teaching in early childhood.

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/cm65t/?view_only=d23507fe794f42eb996854c35e2e2adc.

Ethics statement

The studies involving humans were approved by Lancaster University Faculty of Science and Technology Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

DK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. MB: Conceptualization, Investigation, Resources, Supervision, Writing – review & editing. GW: Conceptualization, Funding acquisition, Investigation, Resources, Supervision, Writing – review & editing.

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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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdpys.2025.1553491/full#supplementary-material

References

Aboody, R., Huey, H., and Jara-Ettinger, J. (2022). Preschoolers decide who is knowledgeable, who to inform, and who to trust via a causal understanding of how knowledge relates to action. *Cognition* 228:105212. doi: 10.1016/j.cognition.2022.105212

Aboody, R., Zhou, C., and Jara-Ettinger, J. (2021). In pursuit of knowledge: preschoolers expect agents to weigh information gain and information cost when deciding whether to explore. *Child Dev.* 92, 1919–1931. doi: 10.1111/cdev.13557

Atkinson, M., Renner, E., Thompson, B., Mackintosh, G., Xie, D., Su, Y., et al. (2021). Robust, source-independent biases in children's use of socially and individually acquired information. *J. Exp. Psychol.* 150:778. doi: 10.1037/xge0000959

Baer, C., and Friedman, O. (2018). Fitting the message to the listener: children selectively mention general and specific facts. *Child Dev.* 89, 461–475. doi: 10.1111/cdev.12751

Bazhydai, M., and Harris, P. L. (2021). Infants actively seek and transmit knowledge via communication. *Behav. Brain Sci.* 44:1405. doi: 10.1017/S0140525X20001405

Bazhydai, M., and Karadag, D. (2022). Can bifocal stance theory explain children's selectivity in active information transmission? *Behav. Brain Sci.* 45:1327. doi: 10.1017/S0140525X22001327

Bazhydai, M., Silverstein, P., Parise, E., and Westermann, G. (2020). Two-year-old children preferentially transmit simple actions but not pedagogically demonstrated actions. *Dev. Sci.* 23:e12941. doi: 10.1111/desc.12941

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., and Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition* 120, 322–330. doi: 10.1016/j.cognition.2010.10.001

Bridgers, S., Jara-Ettinger, J., and Gweon, H. (2020). Young children consider the expected utility of others' learning to decide what to teach. *Nat. Hum. Behav.* 4, 144–152. doi: 10.1038/s41562-019-0748-6

Brugger, A., Lariviere, L. A., Mumme, D. L., and Bushnell, E. W. (2007). Doing the right thing: infants' selection of actions to imitate from observed event sequences. *Child Dev.* 78, 806–824. doi: 10.1111/j.1467-8624.2007.01034.x

Buchsbaum, D., Gopnik, A., Griffiths, T. L., and Shafto, P. (2011). Children's imitation of causal action sequences is influenced by statistical and pedagogical evidence. *Cognition* 120, 331–340. doi: 10.1016/j.cognition.2010.12.001

Butler, L. P., and Markman, E. M. (2012). Preschoolers use intentional and pedagogical cues to guide inductive inferences and exploration. *Child Dev.* 83, 1416–1428. doi: 10.1111/j.1467-8624.2012.01775.x

Buttelmann, D., Carpenter, M., and Tomasello, M. (2009). Eighteen-month-old infants show false belief understanding in an active helping paradigm. *Cognition* 112, 337–342. doi: 10.1016/j.cognition.2009.05.006

Butterworth, G., Verweij, E., and Hopkins, B. (1997). The development of prehension in infants: Halverson revisited. *Br. J. Dev. Psychol.* 15, 223–236. doi: 10.1111/j.2044-835X.1997.tb00736.x

Chen, X., Twomey, K. E., and Westermann, G. (2022). Curiosity enhances incidental object encoding in 8-month-old infants. *J. Exp. Child Psychol.* 223:105508. doi: 10.1016/j.jecp.2022.105508

Clearfield, M. W., Diedrich, F. J., Smith, L. B., and Thelen, E. (2006). Young infants reach correctly in A-not-B tasks: on the development of stability and perseveration. *Infant Behav. Dev.* 29, 435–444. doi: 10.1016/j.infbeh.2006.03.001

Corriveau, K. H., Ronfard, S., and Cui, Y. K. (2018). Cognitive mechanisms associated with children's selective teaching. *Rev. Philos. Psychol.* 9, 831–848. doi: 10.1007/s13164-017-0343-6

Csibra, G., and Gergely, G. (2009). Natural pedagogy. *Trends Cogn. Sci.* 13, 148–153. doi: 10.1016/j.tics.2009.01.005

Csibra, G., and Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philos. Transact. R. Soc. B Biol. Sci.* 366, 1149–1157. doi: 10.1098/rstb.2010.0319

Danovitch, J. H., Scofield, J., Williams, A. J., Davila, L., and Bui, C. (2023). Children's selective information transmission in STEM and non-STEM domains. *Cogn. Dev.* 66:101332. doi: 10.1016/j.cogdev.2023.101332

Davis-Unger, A. C., and Carlson, S. M. (2008). Children's teaching skills: the role of theory of mind and executive function. *Mind Brain Educ.* 2, 128–135. doi: 10.1111/j.1751-228X.2008.00043.x

De Simone, C., and Ruggeri, A. (2022). *Searching for Information, From Infancy to Adolescence. Drive for Knowledge: The Science of Human Information-Seeking.* Cambridge: Cambridge University Press. 77–100.

Diesendruck, G., and Markson, L. (2001). Children's avoidance of lexical overlap: a pragmatic account. *Dev. Psychol.* 37:630. doi: 10.1037/0012-1649.37.5.630

Evey, J. A., and Merriman, W. E. (1998). The prevalence and the weakness of an early name mapping preference. *J. Child Lang.* 25, 121–147. doi: 10.1017/S030500099700336X

Ferry, A. L., Hespos, S. J., and Waxman, S. R. (2010). Categorization in 3- and 4-month-old infants: an advantage of words over tones. *Child Dev.* 81, 472–479. doi: 10.1111/j.1467-8624.2009.01408.x

Flynn, E., and Smith, K. (2012). Investigating the mechanisms of cultural acquisition. *Soc. Psychol.* 43:a000119. doi: 10.1027/1864-9335/a000119

Flynn, E., Turner, C., and Giraldeau, L. A. (2016). Selectivity in social and asocial learning: Investigating the prevalence, effect and development of young children's learning preferences. *Philos. Transact. R. Soc. B Biol. Sci.* 371:20150189. doi: 10.1098/rstb.2015.0189

Frank, M. C., Sugarman, E., Horowitz, A. C., Lewis, M. L., and Yurovsky, D. (2016). Using tablets to collect data from young children. *J. Cogn. Dev.* 17, 1–17. doi: 10.1080/15248372.2015.1061528

Gelman, S. A., and Markman, E. M. (1987). Young children's inductions from natural kinds: the role of categories and appearances. *Child Dev.* 58, 1532–1541. doi: 10.2307/1130693

Gliga, T., Elsabbagh, M., Andravizou, A., and Johnson, M. (2009). Faces attract infants' attention in complex displays. *Infancy* 14, 550–562. doi: 10.1080/15250000903144199

Gweon, H. (2021). Inferential social learning: cognitive foundations of human social learning and teaching. *Trends Cogn. Sci.* 25, 896–910. doi: 10.1016/j.tics.2021.07.008

Gweon, H., and Schulz, L. (2019). From exploration to instruction: children learn from exploration and tailor their demonstrations to observers' goals and competence. *Child Dev.* 90, e148–e164. doi: 10.1111/cdev.13059

Harris, P. L. (2012). *Trusting What You're Told: How Children Learn From Others.* Harvard University Press.

Heyes, C. (2012a). What's social about social learning? *J. Comp. Psychol.* 126:193. doi: 10.1037/a0025180

Heyes, C. (2012b). Grist and mills: on the cultural origins of cultural learning. *Philos. Transact. R. Soc. B* 367, 2181–2191. doi: 10.1098/rstb.2012.0120

Heyes, C. (2016). Born pupils? Natural pedagogy and cultural pedagogy. *Perspect. Psychol. Sci.* 11, 280–295. doi: 10.1177/1745691615621276

Heyes, C. (2017). When does social learning become cultural learning? *Dev. Sci.* 20:e12350. doi: 10.1111/desc.12350

Hilton, M., and Westermann, G. (2017). The effect of shyness on children's formation and retention of novel word–object mappings. *J. Child Lang.* 44, 1394–1412. doi: 10.1017/S030500091600057X

Hoehl, S., Keupp, S., Schleihauf, H., McGuigan, N., Buttelmann, D., and Whiten, A. (2019). 'Over-imitation': a review and appraisal of a decade of research. *Dev. Rev.* 51, 90–108. doi: 10.1016/j.dr.2018.12.002

Jara-Ettinger, J., Gweon, H., Schulz, L. E., and Tenenbaum, J. B. (2016). The naïve utility calculus: computational principles underlying common sense psychology. *Trends Cogn. Sci.* 20, 589–604. doi: 10.1016/j.tics.2016.05.011

Karadag, D., and Soley, G. (2023). Children intend to teach conventional but not moral norms selectively to ingroup members. *Dev. Psychol.* 59:567. doi: 10.1037/dev0001455

Kidd, C., Piantadosi, S. T., and Aslin, R. N. (2012). The Goldilocks effect: human infants allocate attention to visual sequences that are neither too simple nor too complex. *PLoS ONE* 7:e36399. doi: 10.1371/journal.pone.0036399

Kim, S., Kalish, C. W., Weisman, K., Johnson, M. V., and Shutts, K. (2016). Young children choose to inform previously knowledgeable others. *J. Cognit. Dev.* 17, 320–340. doi: 10.1080/15248372.2014.952731

Koch, C., and Ullman, S. (1987). *Shifts in Selective Visual Attention: Towards the Underlying Neural Circuitry. Matters of intelligence: Conceptual Structures in Cognitive Neuroscience*. Dordrecht: Springer. 115–141.

Kulke, L., Reiß, M., Krist, H., and Rakoczy, H. (2018). How robust are anticipatory looking measures of Theory of Mind? Replication attempts across the life span. *Cogn. Dev.* 46, 97–111. doi: 10.1016/j.cogdev.2017.09.001

Kushnir, T., and Gopnik, A. (2005). Young children infer causal strength from probabilities and interventions. *Psychol. Sci.* 16, 678–683. doi: 10.1111/j.1467-9280.2005.01595.x

Lane, J. D., and Shafto, P. (2017). Young children's attributions of causal power to novel invisible entities. *J. Exp. Child Psychol.* 162, 268–281. doi: 10.1016/j.jecp.2017.05.015

Libertus, K., Gibson, J., Hidayatallah, N. Z., Hirtle, J., Adcock, R. A., and Needham, A. (2013). Size matters: how age and reaching experiences shape infants' preferences for different sized objects. *Infant Behav. Dev.* 36, 189–198. doi: 10.1016/j.infbeh.2013.01.006

Liszkowski, U., Carpenter, M., Striano, T., and Tomasello, M. (2006). 12-and 18-month-olds point to provide information for others. *J. Cognit. Dev.* 7, 173–187. doi: 10.1207/s15327647jcd0702_2

Ma, L., Twomey, K., and Westermann, G. (2022). The impact of perceived emotions on toddlers' word learning. *Child Dev.* 93, 1584–1600. doi: 10.1111/cdev.13799

Mani, N., and Ackermann, L. (2018). Why do children learn the words they do? *Child Dev. Perspect.* 12, 253–257. doi: 10.1111/cdep.12295

Marsh, L. E., Ropar, D., and Hamilton, A. F. D. C. (2014). The social modulation of imitation fidelity in school-age children. *PLoS ONE* 9:e86127. doi: 10.1371/journal.pone.0086127

Martin, A., and Olson, K. R. (2013). When kids know better: paternalistic helping in 3-year-old children. *Dev. Psychol.* 49:2071. doi: 10.1037/a0031715

McGuigan, N., Whiten, A., Flynn, E., and Horner, V. (2007). Imitation of causally opaque versus causally transparent tool use by 3-and 5-year-old children. *Cogn. Dev.* 22, 353–364. doi: 10.1016/j.cogdev.2007.01.001

Meder, B., Wu, C. M., Schulz, E., and Ruggeri, A. (2021). Development of directed and random exploration in children. *Dev. Sci.* 24:e13095. doi: 10.1111/desc.13095

Paradise, R., and Rogoff, B. (2009). Side by side: learning by observing and pitching in. *Ethos* 37, 102–138. doi: 10.1111/j.1548-1352.2009.01033.x

Pelz, M., and Kidd, C. (2020). The elaboration of exploratory play. *Philos. Transact. R. Soc. B* 375:20190503. doi: 10.1098/rstb.2019.0503

Posner, M. I. (1980). Orienting of attention. *Q. J. Exp. Psychol.* 32, 3–25. doi: 10.1080/00335558008248231

Pueschel, E. B., Shen, Y., Byrd, K., Indik, O., and Moll, H. (2022). Four-year-olds share general knowledge and use generic language when teaching. *J. Genet. Psychol.* 84, 212–228. doi: 10.1080/00221325.2022.2163875

Qiu, F. W., Park, J., Vite, A., Patall, E., and Moll, H. (2024). Children's selective teaching and informing: a meta-analysis. *Dev. Sci.* 28:e13576. doi: 10.1111/desc.13576

Rhodes, M., Gelman, S. A., and Brickman, D. (2010). Children's attention to sample composition in learning, teaching and discovery. *Dev. Sci.* 13, 421–429. doi: 10.1111/j.1467-7687.2009.00896.x

Rogoff, B., Callanan, M., Gutiérrez, K. D., and Erickson, F. (2016). The organization of informal learning. *Rev. Res. Educ.* 40, 356–401. doi: 10.3102/0091732X16680994

Ronfard, S., and Harris, P. L. (2018). Children's decision to transmit information is guided by their evaluation of the nature of that information. *Rev. Philos. Psychol.* 9, 849–861. doi: 10.1007/s13164-017-0344-5

Ronfard, S., Was, A. M., and Harris, P. L. (2016). Children teach methods they could not discover for themselves. *J. Exp. Child Psychol.* 142, 107–117. doi: 10.1016/j.jecp.2015.09.032

Santangelo, V. (2015). Forced to remember: when memory is biased by salient information. *Behav. Brain Res.* 283, 1–10. doi: 10.1016/j.bbr.2015.01.013

Schulz, L. (2012). The origins of inquiry: inductive inference and exploration in early childhood. *Trends Cogn. Sci.* 16, 382–389. doi: 10.1016/j.tics.2012.06.004

Schulz, L. E., and Bonawitz, E. B. (2007). Serious fun: preschoolers engage in more exploratory play when evidence is confounded. *Dev. Psychol.* 43:1045. doi: 10.1037/0012-1649.43.4.1045

Schulz, L. E., Gopnik, A., and Glymour, C. (2007). Preschool children learn about causal structure from conditional interventions. *Dev. Sci.* 10, 322–332. doi: 10.1111/j.1467-7687.2007.00587.x

Silver, A. M., Stahl, A. E., Loiotile, R., Smith-Flores, A. S., and Feigenson, L. (2020). When not choosing leads to not liking: choice-induced preference in infancy. *Psychol. Sci.* 31, 1422–1429. doi: 10.1177/0956797620954491

Sim, Z. L., and Xu, F. (2017). Learning higher-order generalizations through free play: evidence from 2-and 3-year-old children. *Dev. Psychol.* 53:642. doi: 10.1037/dev0000278

Sobel, D. M., Benton, D., Finiasz, Z., Taylor, Y., and Weisberg, D. S. (2022). The influence of children's first action when learning causal structure from exploratory play. *Cogn. Dev.* 63:101194. doi: 10.1016/j.cogdev.2022.101194

Sobel, D. M., and Letourneau, S. M. (2018). Preschoolers' understanding of how others learn through action and instruction. *Child Dev.* 89, 961–970. doi: 10.1111/cdev.12773

Sobel, D. M., and Sommerville, J. A. (2010). The importance of discovery in children's causal learning from interventions. *Front. Psychol.* 1:176. doi: 10.3389/fpsyg.2010.00176

Strauss, S. (2022). "Human teaching's prosocial roots," in *Developing Language and Literacy: Studies in Honor of Dorit Diskin Ravid* (Cham: Springer International Publishing), 295–318.

Strauss, S., and Ziv, M. (2012). Teaching is a natural cognitive ability for humans. *Mind Brain Educ.* 6, 186–196. doi: 10.1111/j.1751-228X.2012.01156.x

Strauss, S., Ziv, M., and Stein, A. (2002). Teaching as a natural cognition and its relations to preschoolers' developing theory of mind. *Cogn. Dev.* 17, 1473–1487. doi: 10.1016/S0885-2014(02)00128-4

Suanda, S. H., Barnhart, M., Smith, L. B., and Yu, C. (2019). The signal in the noise: the visual ecology of parents' object naming. *Infancy* 24, 455–476. doi: 10.1111/infa.12278

Tecwyn, E., Seed, A., and Buchsbaum, D. (2020). "Sensitivity to ostension is not sufficient for pedagogical reasoning by toddlers," in *Proceedings of the 42nd Annual Conference of the Cognitive Science Society.*

Tomasello, M. (1999). The human adaptation for culture. *Annu. Rev. Anthropol.* 28, 509–529. doi: 10.1146/annurev.anthro.28.1.509

Vredenburgh, C., Kushnir, T., and Casasola, M. (2015). Pedagogical cues encourage toddlers' transmission of recently demonstrated functions to unfamiliar adults. *Dev. Sci.* 18, 645–654. doi: 10.1111/desc.12233

Warneken, F., and Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science* 311, 1301–1303. doi: 10.1126/science.1121448

Warneken, F., and Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy* 11, 271–294. doi: 10.1111/j.1532-7078.2007.tb00227.x

Wood, D., Wood, H., Ainsworth, S., and O'Malley, C. (1995). On becoming a tutor: toward an ontogenetic model. *Cogn. Instr.* 13, 565–581. doi: 10.1207/s1532690xci1304_7

Yuniarto, L. S., Gerson, S. A., and Seed, A. M. (2020). Better all by myself: gaining personal experience, not watching others, improves 3-year-olds' performance in a causal trap task. *J. Exp. Child Psychol.* 194:104792. doi: 10.1016/j.jecp.2019.104792

Yurovsky, D., and Frank, M. C. (2017). Beyond naïve cue combination: salience and social cues in early word learning. *Dev. Sci.* 20:e12349. doi: 10.1111/desc.12349