Active Overhearing: Development in Preschoolers' Skill at 'Listening in' to Naturalistic Overheard Speech

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Abstract

Overhearing can be seen as active learning, and overheard speech provides an increasingly viable source of linguistic input across development. This study extends previous results showing learning from overhearing simplified, pedagogic speech to a more ecologically valid context. Children learn multiple words and facts corresponding to novel toys either through an overheard phone call or through direct instruction. Remarkably, 4.5–6-year-olds learned four new words equally well in both conditions. Their performance on a set of six facts was even better, especially when taught directly. Analysis of the videos revealed that older children with high test accuracy both looked toward the experimenter often, and tracked objects as she discussed them. 3–4.5-year-olds only learned facts from overhearing, and exhibited greater varability in attention. These results suggest learning from overhearing is driven by attention to the indirect input, and may be a skill that undergoes substantial development during the preschool years.

Keywords: active learning; lexical development; overhearing

Introduction

While studies of children's word-learning primarily examine dyadic interactions where adult and child are engaged in joint attention, this represents but one of the myriad contexts in which children across the world learn their first words (Correa-Chávez & Rogoff, 2009; Ochs, 1982; Schieffelin, 1990; Ward, 1971). Not only does the degree to which children's early word-learning occurs in dyadic labeling contexts vary substantially across cultures (and even households), but the link between joint attention and vocabulary development arguably wanes in the second year of life (Akhtar & Gernsbacher, 2007). An existing body of work has demonstrated children's ability to learn individual items from simplified speech. The current study extends this work by providing a more ecologically valid test in an effort to understand the potential utility of learning from overhearing in the wild. We explore the idea that the disassociation between joint attention and vocabulary development even in cultures where a child typically receives substantial child-directed speech might mark the beginning of her playing a more active role in her own lexical development. Specifically, we examine preschooler's acquisition of new words by overhearing non-child-directed speech through the lens of active, or self-directed, learning.

Learning new words and information through overhearing can be seen as a case of active learning for several reasons. For one, children's information-gathering in this context is self-directed (Gureckis & Markant, 2012), and their learning seems to be linked to the degree to which they attend to the indirect speech (Martínez-Sussman, Akhtar, Diesendruck, & Markson, 2011). If a feature of self-directed learning, as suggested by Bruner (1961), is also that an individual improves at the very skill of it through practice, then cross-cultural variation in child-directed speech customs, which uniformly result in linguistic proficiency on the part of the child, might represent evidence of children having 'learned to learn.' More specific evidence for this idea comes from Shneidman et al. (2009), who found children who spent more time alone with multiple adults performed better in an overhearing task. Finally, recognizing an 'information gap' (Loewenstein, 1994) like the unknown names of novel objects, as well as how to fill it (i.e., by overhearing) requires the metacognitive awareness that may well be considered a characteristic of an active learner.

Experimental studies of overhearing have demonstrated that children can learn new words from indirect speech as early as 18 months (Floor & Akhtar, 2006; Gampe, Liebal, & Tomasello, 2012). In these studies, learning of a word for a novel object by children exposed to the object-word mapping via overhearing is compared to that of children who were taught the mapping via direct address (Akhtar, Jipson, & Callanan, 2001; Akhtar, 2005; Floor & Akhtar, 2006; Gampe et al., 2012; Martínez-Sussman et al., 2011; ?, ?). These studies have found learning from a third-party adult conversation even in the presence of a distracting toy (Akhtar, 2005). While these studies have successfully demonstrated that toddlers can learn new words without joint attention, they leave room for improvement in terms of the naturalistic nature of the overhearing opportunity. In many cases, the child witnesses a new word being taught pedagogically to another adult, and the word often appears in child-directed speech and/or simplistic linguistic frames: either explicit labeling contexts (e.g., "This is a *blicket*."), or embedded in a directive (e.g., "Can you put the *toma* in here?"). The current study follows Gampe et al. (2012), which avoids such linguistic frames because they are rarely used between adults and therefore likely fail to simulate the daily opportunities children have to learn new vocabulary from overhearing. Both explicit labeling and directives might make it unnecessarily simple for the child to attend to the novel word. We similarly used adult-directed, rather than child-directed speech. While children undoubtedly have ample opportunity to overhear adults talking to other children, we saw overhearing adult-directed speech as a more stringent test of children's capacity.

The current study also improves upon previous investigations of overhearing by increasing the number of learning targets, with the assumption that the inter-adult speech children have access to will contain not one, but many words which are unfamiliar. As in Martínez-Sussman et al. (2011), both words and facts are included to compare learning of new vocabulary to learning of information more generally. We selected a phone call, used in related studies of social cues to word learning (Baldwin et al., 1996; Bannard & Tomasello, 2012), as our overhearing context. Discussions with parents during piloting indicated that this was a familiar situation, and in fact, several parents' cell phones rang during the course of the study. By using a phone conversation, the overheard input could be highly controlled and non-pedagogical while still being representative of naturalistic, adult-directed speech. It is worth noting that while undoubtedly present in many homes, this is a source of linguistic input that has previously been discounted, along with speech to pets, in examinations of effective input for vocabulary development, as it does not involve a present human interlocutor (Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013).

In line with the increased complexity of the learning situation, we tested older children than the youngest involved in previous studies. Participants in Experiment 1 were 4.5–6 years old, and those in Experiment 2 were 3–4.5. Both studies seek to address (1) whether children can learn new words and facts from naturalistic overheard speech, and (2) how self-directed and didactic language-learning compare during this period of development.

Experiment 1

Participants

Participants were 48 children between 4.5 and 6 years of age (26 female; M = 5.22 years, SD = 0.51 years). An additional three children participated but were excluded for failing familiar trials (1), refusing to complete the study (1), or having already witnessed a sibling participate (1). Participants were tested in a quiet space at UC Berkeley, a preschool, or a children's museum. Parents and siblings were often present, and sessions were typically video recorded by at least one camera, contingent on parental consent.

Stimuli & Procedure

Stimuli were six toys, four novel, and two familiar (a plush dog and a toy cup of milk), shown in Figure . Participants were randomly assigned to one of two conditions: Overhearing or Didactic, and were trained on one of two mappings between novel labels and objects. Target words and facts corresponding to one of the mappings appear in Table 1.

Figure 1: Stimuli used in Experiment 1.

Table 1: Words and facts used in Experiment 1.

Word	Fact
fep	from Disneyland
pimwit	my sister loves
toma	uncle gave me
zav	found in the garden
dog	bring to school
cup	had for two years

Overhearing Participants in the Overhearing condition sat across a low table from a confederate. The experimenter entered the room separately, placing a box with the six toys on the table, and introducing them with "These are my toys!" The confederate then removed each toy from the box individually, commenting that they were unfamiliar to her ("I've never seen these toys before, these are [Experimenter]'s toys!"). The experimenter sat on a chair against the wall to the child's left, "working" on her laptop. After all the toys were out, the confederate encouraged the child to continue playing, and went to fill out paperwork against an adjacent wall. One minute later, the experimenter's phone rang, and she delivered a script casually describing each of the toys in the context of a naturalistic conversation with a friend. Following a brief greeting and exchange of pleasantries, she discussed each of the novel objects in segments approximately 15 seconds long, during which she referred to physical properties of the objects (e.g., color, shape), and mentioned each word five times and each fact once. She avoided making eye contact with the child. At the end of the phone call, she briefly mentioned the words and their associated facts again, before telling the friend she had to hang up to play a game and joining the child at the table for the test phase.

Didactic Children in the Didactic condition heard the same script, but directly addressed to them. The experimenter spoke enthusiastically, made eye contact, and directed their attention to each object as it was labeled. Properties that appeared in the script (e.g., "has stickers that you can take on and off") were pedagogically demonstrated for the child. As in the Overhearing condition, the learning phase was followed immediately by the test phase.

Test Phase The test phase was identical in both conditions, and consisted of three blocks of six trials each. These 18 test trials were presented in one of two pseudorandom orders, one the reverse of the other. The first two blocks tested word-learning, while the third tested learning of facts. On each trial, the child was asked to place the toy associated with a particular word or fact into a container, which varied by block (i.e., "Can you put the *zav / one I found in the garden* in the bowl/box/hat?"). Responses were recorded and coded for correctness. Children who failed trials requesting familiar objects by name were excluded. At the end of the test phase, the experimenter asked the child to identify her favorite toy, and noted her response.

Videocoding Videos of sessions in the Overhearing condition were coded in Datavyu to analyze children's behavior during the experimenter's phone call. The experimenter's speech was coded into segments distinguishing the social portions of the call from the learning-related content of the script, which was further divided into periods comprising discussion of each individual toy. Periods in which the child turned her head to the experimenter, along with the specific object or objects with which the child was playing were coded without audio or reference to the speech coding. Given that Martínez-Sussman et al. (2011) found a positive relationship between the child's gaze to the experimenter and learning, we predicted that children who looked more toward the experimenter as she spoke would show greater accuracy at test. Our study involved many objects, however, so visual attention to the experimenter might actually jeopardize identifying the appropriate object to which to map an overheard novel word or fact. We therefore coded their touch behavior and later related it to the segments of the experimenter's speech as a proxy from which to infer children's accurate tracking of the objects as the experimenter discussed them. We also predicted that children who demonstrated better tracking of the objects would perform better at test.

Results & Discussion

Test Performance Children learned both novel words and facts above chance (0.25 and 0.17, respectively) in both conditions (Overhearing, words: 43% accuracy, $t(191) = 5.22$; facts: 67% accuracy, $t(143) = 12.68$. Didactic, words: 41% accuracy, $t(191) = 4.53$; facts: 88% accuracy, $t(143) = 25.61$; all $p's < 0.001$). While children in the Didactic condition performed significantly better than those in the Overhearing condition on facts ($t(256.32) = -4.33$; $p < 0.001$), there was no difference in performance between the two conditions in word-learning ($p = 0.6$). Finally, performance on word-learning was significantly worse than that on fact-learning in both conditions (Overhearing: $t(315.86) = 4.30$; $p < 0.001$; Didactic: $t(330.37) = 10.28$; $p < 0.001$). Performance means by learning target and condition appear in Figure 2.

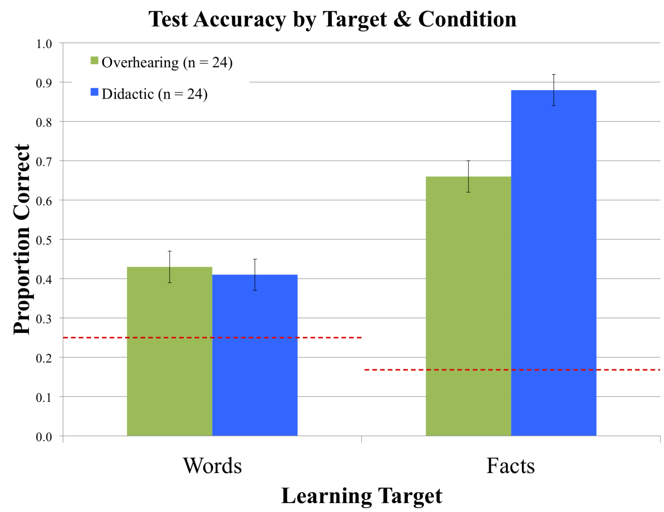

Figure 2: Experiment 1 mean accuracy at test by learning target and condition. Chance for each target type is indicated with a dashed line, and error bars indicate SEM.

We further fit a mixed effects logit model predicting test accuracy (incorrect = 0, correct = 1) from an interaction between condition (Didactic or Overhearing) and learning target (word or fact), with random intercepts for subject to the data, excluding the trials testing comprehension of the familiar object labels used as controls. Fact-learning was better than word-learning in both conditions ($B = 2.43$, $SE = 0.01$, $z = 8.01$, $p < 0.001$), and condition only made an impact on accuracy on facts, such that being in the Overhearing condition decreased one's odds of accuracy on fact performance ($B = -1.42$, $SE = 0.38$, $z = -3.73$, $p < 0.001$), but not on word performance ($B = 0.11$, $SE = 0.26$, $z = 0.44$, $p = 0.66$). This model resulted in a significantly better fit than the null model with no predictors and random intercept ($\chi^2(3) = 36.62$, $p < 0.001$, AIC for model with interaction: 816.7, AIC for null model: 1100.5), as well as a model which included both learning target and condition, but not their interaction ($\chi^2(1) = 14.67$, $p < 0.001$, AIC for model without interaction: 829.4). Models including these predictors and preferred item, requested item, age, gender, order (1 or 2), learning order (taught in the first or second half of learning phase) mapping (1 or 2) also did not result in significantly better fits, suggesting these factors were not significant influences on children's performance.

To test the potential impact of the inclusion of facts relating to familiar versus novel objects, we fit an additional model with condition and familiarity-of-object to just the fact-learning data. A model which also included an interaction between condition and familiarity resulted in a significantly better fit ($\chi^2(1) = 4.25$, $p < 0.05$, AIC without interaction: 295.65, AIC with interaction: 293.40).

The familiarity of the object affected children's accuracy on fact-learning only in the overhearing condition, where a fact's correspondence to a novel, rather than familiar, object decreased their odds of demonstrating learning of the mapping at test ($B = -1.40$, $SE = 0.68$, $z = -2.06$, $p < 0.05$).

Video Measures To obtain a single measure of each child's attention to the content of the phone call, we first calculated the proportion of each segment of the call during which the experimenter was discussing one of the novel objects, and the child was touching that same object. From this, we subtracted the mean proportion the child was playing with that novel object during the five segments of the call in which the experimenter was *not* discussing that object. If the child exclusively attended to that object when it was the one the experimenter was describing, the score would remain unchanged. If, on the other hand, the child merely liked that object, and played with it regardless of what the experimenter spoke about, or played with non-matching objects generally more often, the score would be negative or zero. A score of 1 would indicate the child only ever touched that object while the experimenter spoke about it, and any positive score below 1 would imply she did this more often than not. Seventeen out of the 19 participants for whom we received video consent received positive scores on this measure, and one of the 19 did not touch the objects at all (range: $-0.04 - 0.63$, $M = 0.31$, $SD = 0.18$).

In addition, there was substantial variation in the proportion of the call's duration children spent orienting their gaze toward the experimenter ($0 - 0.47$, $M = 0.14$, $SD = 0.14$). Here, the mixed effects logit model with the best fit to the data for novel word and fact accuracy in video recorded children in the Overhearing condition included an interaction between the child's gaze and touch measures, such that their odds of accuracy increased the higher the two scores were ($B = 15.728$, $SE = 7.0$, $z = 2.25$, $p < 0.5$). While the gaze measure alone had no significant impact ($B = -1.49$, $SE = 1.71$, $z = -0.87$, $p = 0.38$), the touch measure otherwise slightly decreased subjects' odds of accuracy on test as it increased ($B = -4.09$, $SE = 1.58$, $z = -2.58$, $p < 0.01$). The interaction between the two validate the measure in that their relation makes sense given the demands of the task. While it might be detrimental to look only at the experimenter, or interact exclusively with the toys as they are discussed, a learner who distributes her attention between the experimenter discussing the objects, and the objects themselves, is most likely to learn the mappings.

Experiment 2

Having demonstrated that 4.5–5-year-olds can learn multiple new words from a single overhearing exposure as well as they can through didactic instruction, we pursued the development of this skill in younger children. Will we see more of a tradeoff in learning between conditions in younger ages? Several children in the Overhearing condition of Experiment 1 made triumphant declarations at test of having "spied" to discover the answers, suggesting they were unaware the phone call was for their benefit, but recognized it was relevant to their situation. Will younger children have the same realization and overhear to learn more about the objects?

Participants

54 children ages 3–4.5 years participated (25 female; M = 3.89 years, SD = 0.40 years). An additional six children participated, but were excluded due to failing the familiar trials (4), not finishing the task (1), or experimenter error (1).

Stimuli & Procedure

The method for Experiment 2 is identical to the previous experiment, except that the number of novel words was reduced by one to make it more appropriate for a younger age range. The children therefore learn—either through overhearing or didactic instruction—three novel words and five novel facts, and receive 15 test trials rather than 18.

Results & Discussion

Test Performance Like their older counterparts, both Overhearing and Didactic participants performed above chance (0.20) on fact-learning (Overhearing: 49% accuracy, $t(108) = 5.95$. Didactic: 71% accuracy, $t(114) = 12.11$; both $p's < 0.001$). Where the younger children differ, however, is in their word-learning through overhearing. While children in the Didactic condition performed above chance (0.33) on word-learning (51% accuracy, $t(137) = 4.24$; $p < 0.001$), those in the Overhearing condition did not (36% accuracy, $p = 0.59$). Performance on both word- and fact-learning was better in the Didactic condition (words: $t(261.36) = -2.60$, $p < 0.01$; facts: $t(216.91) = -3.54$, $p < 0.001$). Mean accuracy on words and facts for the two conditions is plotted in Figure 3.

As in the previous experiment, models with Condition (Didactic or Overhearing), learning target (words or facts) and random intercepts for subject were fit to the data for facts and novel words. Both were significant predictors, and indicated that being in the Overhearing condition decreased one's odds of accuracy at test ($B = -1.02$, $SE = 0.29$, $z = -3.5$, $p < 0.001$), as did the target being a novel word, rather than fact ($B = -0.89$, $SE = 0.19$, $z = -4.78$, $p < 0.001$). The model which included an interaction between Condition and learning target did not result in a significantly better fit ($\chi^2(1) = 0.97, p = 0.33$, AIC without interaction: 755.93, AIC with interaction: 756.97), suggesting that the impact of condition did not differ substantially by learning target, as it had in the previous experiment. Adding mapping, order, learning order, age, gender, preferred item, or requested item as predictors did not result in models with significantly better fits, suggesting they were not particularly influential in children's performance. The selective effect of familiarity in the overhearing condition was replicated for this age group. A model with random intercepts for subjects, familiarity, condition, and an interaction between the two as predictors of test performance was fit to the fact-learning data. The

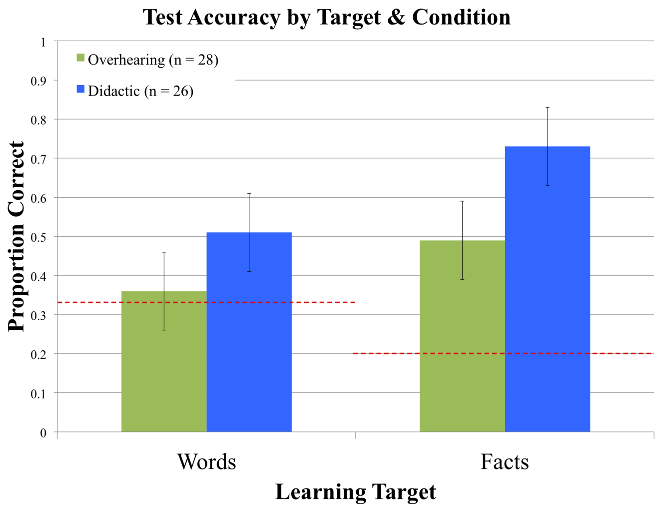

Figure 3: Experiment 2 mean accuracy at test by learning target and condition. Dotted lines show chance, and error bars indicate SEM.

interaction between familiarity and condition was a significant predictor of test accuracy ($B = -1.75$, $SE = 0.58$, $z = -3.04$, $p < 0.01$), though neither was independently (familiarity: $B = 0.63$, $SE = 0.40$, $z = 1.55$, $p = 0.12$; condition: $B = -0.17$, $SE = 0.48$, $z = -0.36$, $p = 0.72$). The model with the interaction (AIC: 337.88) resulted in a better fit than the same model without it ($\chi^2(1) = 9.53$, $p < 0.01$, AIC: 345.41), and a model with only condition ($\chi^2(2) = 10.56$, $p < 0.01$, AIC: 344.44) or familiarity ($\chi^2(2) = 21.63$, $p < 0.001$, AIC: 355.50) as predictors.

Video Measures The 23 children in the Overhearing condition whose parents consented to videorecording show similar range in both behavioral proxies for attention. Children looked toward the experimenter for up to half the duration of the phone call ($0.01 - 0.49$, $M = 0.15$, $SD = 0.18$), and received varied scores on the touch measure ($-0.28 - 0.43$, $M = 0.11$, $SD = 0.20$). Unlike the older age group, five children received negative scores, one never touched any of the objects, and 16 children scored positive values. Already, the greater number of children with negative values on this measure suggests that the younger age group may not have been tracking the overheard mappings as consistently as their older counterparts.

Consistent with this, entering children's gaze proportions and touch measures into a mixed effects logit model with correct response as the binary outcome variable and random intercepts for subject revealed that neither measure, nor an interaction between them, was significant. Thus, not only were the younger children seemingly tracking the objects less, the attentional coordination they *were* doing was less effective for learning, as it was not related to their later performance at test.

General Discussion

The previous two studies have shown that preschoolers can learn a substantial amount of linguistic information via naturalistic overheard speech. Their ability to do so, however, is developing during this period, and their differential performance by age and learning target leave open several questions. First, what accounts for the persistent advantage of fact-learning over word-learning? Other findings of this same asymmetry have attributed it to the difficulty of learning a new phonological form. While that might explain why children performed better on fact accuracy overall, it does not explain why the older children in the Didactic condition performed far better on facts, but equivalently on words. If what we are seeing is a ceiling effect on learning four new words, then why are both groups at that ceiling, if learning from overhearing is sufficiently difficult to make performance on facts significantly worse? Are words and facts qualitatively different in other ways, perhaps in children's level of motivation to learn them?

Given that both words and facts were presented together, we cannot draw strong conclusions about differences in their ease of learning via different methods. Indeed, the familiarity of the objects was found to improve fact-learning in the Overhearing condition, showing that the two are not entirely dissociable. While there was enough information in the overheard script to map the words and facts independently to the objects (confirmed by the difference in performance between the two), learning of one might influence the other. Learning which objects the facts using familiar nouns referred to, for example, could be done without looking to the physical objects to make the correct association. This might explain why object familiarity conferred a fact-learning advantage particularly in the Overhearing condition. To understand the ways in which learning both types of information about the set of objects may have affected performance, we are currently replicating this study with exclusively novel labels as learning targets. If the difficulty with learning novel words in the Didactic condition stemmed from acquiring novel phonological forms, we might expect children's performance to be equivalent to their performance here. If, however, the memory demands of learning both words and facts corresponding to multiple objects imposed severe memory demands, we might expect children to perform better in the words-only study. Alternatively, learning the new words associated with facts which were themselves easier to remember may have been helpful, predicting children should perform worse in the follow-up.

In the Overhearing condition of this experiment, looks toward the experimenter were equivalent in the two age groups. This may have reflected not only attention to the experimenter's speech, which does not in fact require visual access, but instead attempts to establish joint focus with the speaker, or to determine her referential intent. In this context, in contrast to previous studies, the experimenter's reference to the objects at hand was carried in the content of her speech alone, and not in her gaze to the relevant objects. In a similar context, where objects were labeled without joint attention, but with visible focus on the objects by a single speaker, infants were able to learn new word mappings (Baldwin et al., 1996; Bannard & Tomasello, 2012). When that cue to referential intent was absent by placing the speaker behind a screen, however, infants did not demonstrate learning of the mappings in an explicit pointing task, but did so in a looking task (Bannard & Tomasello, 2012). It may be, therefore, that younger children in our study had greater difficulty establishing specifically word-to-object mappings without the experimenter looking toward the objects, but would have been able to show some association in a subtler test.

We conclude from the video measures that successful acquisition of object-label mappings from overheard speech is due to appropriately coordinating one's attention between the referents and the speaker. This is not an empty claim—much of language-learning, and even the sort of learning that can occur from overhearing (e.g., phonology: Au et al., 2002), happens implicitly. Children in this study needed to recognize that the phone call that was taking place was relevant to their situation and attend to it in order to learn about the toys they were playing with, even in the absence of social cues to reference from the experimenter. The older group reliably did. The age-related difference we see in learning from overhearing in this study may reflect general development in the mastery of self-directed learning and attention management.

Working in an active learning framework provides several additional follow-ups. For example, one proposed advantage of self-directed learning has been retention. If we use the same procedure, then, and call participants back after several days, we might predict less of a memory loss in children from the Overhearing condition. Another possibility stems from the relation between test accuracy and the videocoding measures. If learning in this context is driven by explicitly distributed attention, are there ways to increase metacognitive awareness of the learning opportunity available in overhearing? Children might attend more if their parents were the speakers, for example. Given how much ambient speech they are exposed to, it might be prudent to preferentially attend to a familiar speaker. Alternatively, the 'information gap,' but not the means to close it, might be made either more apparent or more urgent, perhaps through an explicit goal introduced at the beginning of the study, or a topic about which the child is already interested.

As expected, joint attention and direct address seem to be decreasingly important for word-learning, while we do not see evidence for the same trend with more general fact-learning. We are continuing to undertake new studies, including those outlined here, to better understand the contextual factors that enable children to be active learners from environmental input, linguistic and otherwise.

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