Examining the Effects of Child-driven Question-asking on Early Word Learning

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Introduction

"To know an object is to act on it." – Piaget, 1964

Children are formidable information seekers. From early in life, children tinker with things to test hypotheses and draw conclusions (Gopnik, 2012; Schulz, 2012; Trueswell, 2013; Woodard et al., 2016). This type of active involvement is central to how children construct knowledge. Children's participation in the learning process may not only change the type of information children experience but may also change the way they acquire new information (Piaget, 1964; Montessori, 1912). Here I define "active learning" as learning instances in which the learner elicits responses from others (e.g., pointing to or asking about an object to hear a label for it; Lucca et al., 2019). These active learning behaviors may arise because children generally detect a gap in knowledge, or so that they can more intentionally add that information to their store of knowledge. One form of active learning that is robust in the preschool years is question-asking. Preschoolers are known to be prodigious question askers: they ask about what things are called, how things occur, and why events unfold (Baldwin & Moses, 1996; Chouinard et al., 2007). The primary aim of this study is to determine whether children's question-asking supports retention of novel word meanings.

Children's use of question asking has most typically been discussed in the context of questions used to elicit causal information (Callanan & Oakes, 1992; Chouinard et al., 2007; Frazier et al., 2009). This work has revealed that preschoolers and early elementary schoolers ask why and how things happen to understand novel phenomena (Berlyne & Frommer, 1966; Chouinard et al., 2007; Frazier et al., 2009), and are sensitive to quality of the answers they receive (Frazier et al., 2016). In the current study, I focus on a previously understudied area of question-asking: children's questions about word meanings. In particular, I take seriously the possibility that asking questions might be an optimal strategy for adding new vocabulary items by constraining the hypothesis space and maximizing learning gains (e.g., Ruggeri & Lombrozo, 2015; Trueswell et al., 2012). Of course, it is also possible that asking questions may incur high cognitive costs that could dampen their utility, splitting children's attention between asking a question and attending to the answer requested (e.g., Sweller, 1988). In the current work I investigate these possibilities in the domain of word learning by testing whether children who ask questions about word meanings and then receive a definition are better at 1) using that information immediately to produce the specified action and 2) later retaining that information over time, compared to children who receive the definition without asking a question.

Asking a question may engage the mind of the learner and produce learning and memory benefits. This idea is not new, stemming back to early foundational work by Piaget (1964) and Brown (1982). A more contemporary approach termed the ICAP (Interactive-Constructive-Active-Passive) framework attempts to account for the variable role of the child in the learning environment, by specifically linking the learner's level of cognitive engagement in the task to varied knowledge-change processes and corresponding learning benefits (Chi & Wylie, 2014). This theory predicts that the greatest learning benefits accrue from socially interactive and iterative learning scenarios which prompt the greatest knowledge-change (Chi & Wylie, 2014). Hypothesized cognitive mechanisms underlying this active learning effect include improved ability to coordinate the timing of the encoding event with their attentional resources, and greater elaborative encoding that results from actively obtaining information shaped to meet their specific needs (Markant et al., 2016). In other words, learners who ask questions during a learning episode may benefit for two reasons: they make decisions about which questions to ask, and they receive useful answers at the time they are ready to receive them, both of which may facilitate the process of knowledge change. Specifically, in the process of asking questions, children may reflect on what they already know, which could help them link the new information to their prior knowledge (e.g., Atkinson & Renkl, 2007; Bjork, 2018; Graesser & McMahen, 1993; Schank, 1986). Further, asking may help focus a child's attention more closely on the provided information. Indeed, attention may serve as the mechanistic link between active learning and its associated benefits (Kahana, 2008; Aly & Turk-Browne, 2016a, 2016b; Gottlieb, 2012). Under this perspective, the learning gains hypothesis predicts that when input is received following active questioning, learners will learn and remember the requested meanings better compared to unrequested input.

Indeed, children have shown evidence of active learning benefits in a variety of domains (for a review see Markant & Ruggeri et al., 2016). For example, 5- to 11-year-old children have shown enhanced learning when they actively control the order and pacing of study items (Ruggeri et al., 2019). In both object recognition and object label learning tasks, when children were able to select which objects they wanted to study, and how long to study them before moving to the next item, they performed better compared to their learning when passively observing study decisions of a previous participant. These effects lasted, such that children also showed active learning benefits on a memory test one week later (Ruggeri et al., 2019).

Considering the specific benefits of question-asking on early learning, a popular monograph study tested the benefit of questions compared to guessing on children's ability to correctly identify a hidden referent. In this study of early questions, 4- to 5-year-olds were asked what object was hidden in a box. Some children were told they could ask as many questions as they wanted to determine what was in the box, whereas other children were told they could make as many guesses as they wanted to determine what was in the box. Children who asked questions and received answers selected the correct target more readily, compared to the children who made a series of guesses (Chouinard et al., 2007). This suggests that preschoolers' questions help facilitate their processing of information and give them access to information beyond what they can generate on their own. However, this study did not show a direct benefit of memory for the *content* they asked about or guessed about, as retention was not tested. Notably, there is little information available on preschoolers' ability to retain the information they ask about in their questions.

Despite this lack of information on younger children's memory for questions and answers, one study with older children showed a learning benefit for question asking that may also hold for younger children (Ross & Killey, 1977). In this study, pairs of fourth graders solved a logic puzzle by taking turns questioning an experimenter. Up to 3 days later, children remembered the answers to their own questions better than the answers to their partners' questions (Ross & Killey, 1977). Importantly, children only received information that they asked about; there was no control condition where children received information without the pair requesting it. This made the task relatively active overall, as both children in the pair were contributing to a shared goal where they both asked and received answers to their questions. However, parents and adults frequently offer information to their children that is not necessarily prompted by a child, as in pointing out things to look at in the environment or noting comparisons to other knowledge the child has (Callanan, 1985; 1990; Callanan & Sabbagh, 2004). As such, distinguishing learning outcomes that result from child-prompted information gathering and unprompted information gain is critical to further understanding active learning.

Particularly within the domain of label learning, there is also some evidence of active learning benefits, which further support the idea that question asking may benefit label learning.

Previous work has shown that when adults are able to select which items they want to learn about, they show improved learning of word-object pairs (Kachergis et al., 2013). Importantly, 3- to 5-year-olds show a similar pattern of results. In Partridge et al. (2015) preschoolers in one condition were provided with labels when they tapped one of the items on the screen, until all items had been labeled. In another condition, labels were provided when the child touched a generic button which also generated labels, but the labels were not clearly connected to any individual item. Preschoolers learned more words in the first condition with contingent labeling. As such, preschoolers show an active learning advantage when learning object-label mappings through selecting the ones they want to hear, compared to hearing them randomly (Partridge et al., 2015). Therefore, existing work has shown that active learning benefits label learning, suggesting that these benefits may also exist when children verbally request language input, as through their use of questions.

Alternatively, it is possible that engaging in active learning through verbal requests for input may be quite cognitively costly in terms of learning outcomes. This may be especially problematic for young learners, as they not only have limitations on their experiences, but they also have limitations on their working memory and attentional capacities that are in the process of developing. As one example, successful question asking places high levels of demand on the asker as they must be able to identify a gap in knowledge, know how to ask a question, know who to ask, and know what to expect in an answer to prepare self for learning (Mills & Landrum, 2014; Mills, Legare et al., 2011; Mills & Sands, 2020; Ronfard et al., 2018). As such, active engagement through questions may split attention and place a high cognitive load on the child. With an already limited working memory capacity, children may struggle to keep the relevant information in mind when engaged in asking a question (Gathercole & Baddeley, 1990; Miller, 1956; Sweller, 1988). Further, with attention split, children's ability to remember information may decline, similarly to adults when their attention is divided during encoding and their subsequent memory suffers (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). Importantly, these cognitive challenges would make it difficult to learn word meanings. Thus, under this hypothesis, one would predict that when actively questioning to receive information, learners will show less robust learning and memory for the requested information compared to when they are provided with unprompted information.

Indeed, recent evidence points to these potential cognitive challenges that young children encounter when attempting to reconcile ambiguous information during learning. In one study looking at 3- to 8-years-olds' learning from selections they made in a referential ambiguity task, when children expressed a preference to reduce referential ambiguity by seeking information, they showed inconsistent levels of learning gains (Zettersten et al., 2020). In particular, children showed improved learning for sampled items when ambiguity sampling was low (Exp2), but no improved learning in another experiment for sampled items when ambiguity sampling was higher (Exp3 Zettersten et al., 2020). This finding is echoed in studies of 'discovery learning' in education and math contexts, where guided instruction in math education is shown to boost learning compared to exploration (e.g., Rittle-Johnson, 2006).

There is also evidence in the domain of early label learning that suggests preschoolers' word learning is sometimes better off when they receive information passively. In Ackermann et al. (2020), 2- to 4-year-olds were presented with labels on a tablet app in an active or passive condition. Children in the active condition were allowed to choose which objects they wanted to hear labeled, whereas children in the passive condition were presented with the objects chosen by their active peers. Children in the passive condition (who viewed others' choices about which items to be labeled) showed greater learning gains compared to the active condition (Ackermann et al., 2020; but see also Partridge et al., 2015).

Given the mixed evidence of how consistently and effectively active engagement (e.g., through pointing and selecting items) supports learning, it follows that there are also conflicting predictions about the impact of active *question-asking* on learning. As one possibility, asking questions might be an optimal active learning strategy. Asking may be well-timed not only for learners to acquire relevant new information, but also to acquire it contingently upon their request. Further, because the request is child-initiated, socially motivated, and in context, children may be especially ready for the answer at the time they ask a question (Chouinard et al., 2007). Alternatively, asking questions may be too cognitively costly for preschoolers to benefit in word learning. The high cognitive load necessary to keep relevant information in mind while asking questions may pull attention away from the relevant information to be learned. Instead, asking questions to receive information may result in less robust learning and memory for the requested information compared to when children are provided with unprompted information.

Despite the conflicting predictions (learning gains vs. cognitive costs) about the potential benefits of question-asking on word learning, the bulk of question-asking research has mostly investigated question-asking in the context of children's understanding of causal mechanisms (e.g., "how" and "why questions). Subsequently, questions about *words* have largely been ignored. For instance, questions about words have previously been classified as "other" and omitted from further analyses (e.g., Callanan & Oakes, 1992; Chouinard et al., 2007), classified as "facts" in a catch-all category, or defined as "shallow" compared to explanatory questions (e.g., Chouinard et al., 2007; Kurkul & Corriveau, 2018; Smith, 1933). While this characterization may be fair in terms of questions about labels (e.g., when children ask what something is called, Kemler-Nelson et al., 2004; 2005), questions about more challenging words—such as those with abstract meanings or less stable referents—likely fall somewhere between previous classifications of questions about facts and questions about explanations.

Given the exclusion of questions about words in previous studies, it is not surprising that there is scant evidence about whether children's questions about novel words lead to vocabulary gains. In one recent study, however, preschoolers were found to ask more questions about novel than familiar verbs (Janakiefski et al., 2022). In this study, 3- and 5-year-olds were asked to move a set of familiar toys (e.g., horse, monkey), based on an action instruction that contained a novel verb (e.g., "Transpose the horse and the monkey"). After the instruction was provided, preschoolers had an opportunity to complete the action or to ask a question to gain more information before moving on to the next trial. Both age groups asked more questions when presented with instructions that included a novel verb versus a familiar verb. Five-year-olds were more likely to ask about novel verbs than 3-year-olds, and both groups were unlikely to ask about familiar verbs. This finding indicates that preschoolers attune their questions to maximize vocabulary learning gains. Therefore, one possibility is that preschoolers' word learning may benefit from asking about word meanings.

Current Work

The present study tests whether active learning through question-asking supports or hinders early word learning. Four- to 6-year-old children were tested. This age range was chosen because children in this age range show proficiency with question-asking in other domains (Frazier et al., 2009; Chouinard, 2007) as well as in word learning settings (Janakiefski et al., 2022). Children were asked to move a set of their toys around. Following the Janakiefski et al. (2022) procedure, children were asked to move their toys in instruction statements with either known or unknown verbs. Children were either given the opportunity to ask a question about an unknown word to receive a definition, or they were told the definition right after they were provided with the instruction statement. Children then were asked to select which of a pair of videos showed the target word, for each of the target words from the training. Children also completed a delayed test where they were again asked to select which of a pair of videos showed the target word. Importantly, based on previous work showing high rates of question-asking in this age group in response to unknown words (Janakiefski et al., 2022), we anticipated that children in our study would also show high rates of questions about unknown words when given no other clarifying information.

If questions support learning gains, preschoolers who ask questions about word meanings will outperform preschoolers who do not have an opportunity to ask. Alternatively, if questions have a cognitive cost, preschoolers who do not ask questions about word meanings will outperform preschoolers who do ask questions.

Method

Participants

Participants were 48 4- to 6-year-old children. Participants were recruited from a university pool in the Southeastern United States and state birth records, as well as through word of mouth and social media advertising. Families were compensated with $5 Amazon e-gift cards for their participation.

Design

Participants were assigned to one of two conditions for the Instruction Phase: half the participants were assigned to the No Question condition, and the other half of the participants were assigned to the Question condition.

Participants were also randomly assigned to one of the two word lists such that the word lists were evenly distributed across conditions. The instructions were always presented in the following known-unknown order: ABBABAABABA, where A is known and B is unknown. Each of the word lists were presented in 3 different orders, such that there were a total of 6 different word presentation sets overall, counterbalanced across participants.

Materials

Before the study, parents were asked to gather a set of 6 toys in their home and to provide the researcher with the labels of the toys. The toys were smaller than a mug, and the labels of the toys were known to the child. These toys were referred to and used during the Instruction Phase of the study following the researcher's directions. Parents were instructed to select at least one item that was "soft," as some of the directions provided by the researcher involving 'stretching' or 'squishing' actions. Some examples of the types of toys used in the study included small stuffed toys (e.g., dog, bunny, soft beach ball), small plastic animals (e.g., frog, dinosaur), bath squirt toys (e.g., whale, bird), and small dolls or figurines (e.g., Doc McStuffins, Strawberry Shortcake, Mickey Mouse).

The instruction statements for the word lists were created such that they contained a mix of 6 unknown (e.g., carom, invert) and 6 known words (e.g., bounce, flip). See **Table 1** for the summary of the novel words and their known word matches. Two word lists were therefore created for the procedure, constructed as follows.

First, a set of 12 actions were selected that every child would perform during the experiment, and each action was assigned two labels: a known label and an unknown label. Then the two lists were created by selecting the unknown labels for half the actions, and the known labels for half the actions (and vice versa). For example, List 1 contained the following 6 unknown words: jostle, careen, transpose, occlude, constringe, bifurcate; and the following 6 known words: bounce, flip, join, spin, stretch, stack. Contrarily, List 2 reversed this selection, such that the actions referred to by unknown labels in List 1 were now referred to by their known labels in List 2 (e.g., the "jostle" action from List 1 is now "wiggle" in List 2). This same reversal process was used for the known words (e.g., "bounce" in List 1 is now "carom" in List 2). Specifically, List 2 contained the following 6 unknown labels: carom, invert, merge, oscillate, protract, acervate; and the following 6 known labels: wiggle, tip, switch, hide, squish, split.

Importantly, the use of 2 separate word lists allowed for added control in the Initial Learning and Delayed Learning Tests (which involved selection of the target between two presented videos), such that the target action was always accompanied by an action previously completed in the experiment. As a result, all the actions that the child completed in the Instruction Phase appeared as options in the Initial and Delayed Learning Tests. This allowed each target word to be counterbalanced such that they would appear in a video as a known distractor exemplar in one list and a novel target exemplar in the other list.

The videos for the Initial Learning and Delayed Learning Tests were created as follows. Videos showed hands moving one or two toy objects (e.g., elephant, unicorn, zebra, blocks) on a light wooden table. Videos had a plain green backdrop and only the items in the particular action and the researcher's hands were in view, with no other items in view. Videos were each 7 to 10 seconds long, with pairs matched for length. Videos were also matched for object complexity (e.g., specific object, number of objects). For example, a video with an action involving two objects was always paired with another video with an action that contained two objects.

Table 1

Target word list with novel and known word matches.

Unknown	Known Match
jostle	wiggle
careen	hide
transpose	switch
occlude	tip
constringe	squish
bifurcate	split
carom	bounce
oscillate	flip
merge	join
invert	spin
protract	stretch
acervate	stack

Note. Word List 1 is shown in light gray and Word List 2 is shown in dark grey. Note that words in each List were counterbalanced across participants and re-ordered into a known-unknown pattern.

Procedure

Data collection was completed online. Participants were asked to join a video conferencing call where they interacted with a researcher to complete the experimental tasks. The order of the tasks was as follows: Familiarization, Instruction Phase, Immediate Action Production, Initial Learning Test, Vocabulary Measure, Delayed Learning Test.

Familiarization

The study began with a warm-up familiarization phase to allow the child to become more comfortable talking with the researcher. Participants were first shown a set of animal pictures on the screen and asked to label the animals one at a time and describe particular features of the animals (e.g., the color of the animal, the sound the animal makes). Participants were then asked to show each of their six toys to the researcher and to tell the researcher the label of each toy (e.g., “what’s that toy called?”). This toy naming task was completed to ensure that the child knew the label of the toy and to demonstrate their familiarity with the toy.

Instruction Phase

During the Instruction Phase, participants were given a set of instructions containing both known and unknown verbs (i.e., according to one of word lists) in which they were asked to move their toys around. An example unknown trial is "Jostle the bunny." An example known trial is "Squish the turtle." In the No Question condition, participants were provided with definitions to the unknown verbs right after the instruction involving the target verb (e.g., "Jostle the bunny. Jostle is when you wiggle something."). In the Question condition, participants were provided with definitions to the unknown words in response to their question (e.g., "Jostle the bunny." [pause 5 s] "Jostle is when you wiggle something."). This manipulation was designed such that the researcher waited for 5 seconds to allow time for the child to ask a question.

If a child asked a question (e.g., "What does *transpose* mean?") or stated uncertainty (e.g., "I don't know what *transpose* means") about the target word meaning, the researcher provided an informative definition in response.

Immediate Action Production

Following the instruction statement with the known or unknown target word, the experimenter would allow the child to attempt the action for up to 5 seconds before continuing to the next instruction. This allowed us to evaluate whether children understood and could use the verbal definition information.

Initial Word Learning Test

After the instruction phase, participants were tested on their learning of the target words. On each trial, participants were shown a set of two videos presented side-by-side on screen so that the child could see each at the same time. For all trials, each of the videos were played twice: first, the videos were played one at a time, so the child could see each action; then the two videos were played together at the same time while the experimenter asked the child which video matched the target word (e.g., “Which one shows___?”). Participants first completed 3 warm-up trials, where children saw a familiar items and actions and were asked to select the target familiar word (e.g., “Which one shows walk?”). Then children completed the 6 test trials (e.g., “Which one shows transpose?”). Participants responded by saying “blue” or “red” to indicate the corresponding video. Pointing to select a video was not given credit, as the video did not capture the child’s view of the screen and was therefore ambiguous—instead, in the rare event that a child pointed to a video, the experimenter prompted the child to respond verbally.

The video on the left was always presented on a blue background and the video on the right on a red background. The video presentation side of the words was counterbalanced such that the videos appeared an equal number of times on a blue background and a red background. All 6 test trials were requests for the video depicting the target novel word. The test trials were presented in the same order as they were in the Instruction Phase.

Vocabulary Measure

Following the initial word learning test, participants completed the Quick Interactive Language Screener (QUILS), a normed measure of vocabulary and syntax skill for preschool-aged children (Golinkoff et al., 2017). Participants’ raw vocabulary score (0 to 16) was used as a proxy for their vocabulary skills.

Delayed Word Learning Test

Finally, participants completed the delayed word learning test. The delay was approximately 15-20 minutes, immediately following the completion of the QUILS vocabulary measure. Participants saw the same set of videos from the immediate learning test and in the same order. Participants again selected which video they thought depicted the target word by responding “blue” or “red.”

Coding

The session was videotaped and children’s verbal information-seeking behaviors and scoring on test items were coded offline by research assistants who were naïve to hypotheses. For each trial, participants were given a 1 if they asked an explicit question requesting the definition (e.g., “What does that mean?”) or stated uncertainty about a word’s meaning (e.g., “I don’t know what that means”). Examples of other questions or statements of uncertainty that would elicit a definition from the experimenter and thus earn a score of 1 include: “What does transpose mean?”, “I don’t know what transpose means,” “How do I do that?” Children were given a score of 0 if they did not ask an explicit question or state uncertainty about a word. Scoring was completed separately for known and unknown words, such that children’s scores for verbal information-seeking ranged between 0 and 6 for each of the word types. A second naïve coder evaluated children’s verbal responses for 25% of trials. The first and second coder agreed with excellent interrater reliability (Kappa = 1.00, $p = <.001$), so the first coder’s scores were used for all analyses reported below.

We also coded for whether children correctly completed the actions immediately following the definitions we provided them, as 0 or 1 for each trial. For each trial, participants were given a 1 if they completed the target action (e.g., for “transpose,” the child picked up two toys and traded the places of the toys). Children were given a score of 0 if they did not complete the target action (e.g., for “transpose,” the child only picked up one toy and moved it around but did not use two toys in the action). Scoring was completed separately for known and unknown words, such that children’s scores for the correct action completion ranged between 0 and 6 for each of the word types. A second naïve coder evaluated children's correct actions for 25% of trials. The first and second coder agreed 92.4% of the time (on 110 out of 119 trials) with moderate interrater reliability (Kappa = .65, $p < .001$), so the first coder's scores were used for analyses reported below.

Finally, as a stringent and tightly controlled metric of action coding, masked coding was completed to ensure that our original correct action coding was not biased based on knowing what the child was *supposed* to be doing when providing credit for any given trial. Three naïve coders, who did not complete the above original correct action or reliability coding, completed masked coding of children's actions completed immediately after receiving the instruction. To maintain masking, the coders used previously recorded timestamps for the start and end of each trial and completed coding with the sound off (so as to not hear what the experimenter instructed the child to do). The coding was split evenly among the three coders and assigned such that each coder only completed a maximum of half the trials for any given participant. This way masked coders could not use process of elimination to determine all the actions the child completed. Masked coding was then compared to the correct action coding for consistency (see Table 2 below).

Results

Analysis Plan

To determine the effect of the learning condition (Question vs. No Question) on word learning outcomes, we modeled scores on the initial and delayed word learning tests separately using Generalized Linear Mixed Models (GLMM). We used GLMM with a logit link function since our outcome scores for each test trial was binary (0/1), and the logit link is well-suited to accounting for this data type (Snijders & Bosker, 2012). We used mixed models because our data contained multilevel structure (e.g., each of 6 trials was nested within participant). Data was analyzed using R version 4.1.1 (with the lme4 version 1.1-27.1 and car version 3.0-11 packages, using Laplace Approximation).

We included the fixed effects of experimental condition (Question vs. No Question), observed trial-by-trial information-seeking behavior (0/1 coded behavior), observed vocabulary skill measured by the QUILS, and age (continuous) as predictors of trial-by-trial test accuracy (incorrect = 0, correct = 1) on both the learning and retention tests (modeled separately). We used Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) to determine how well each model fit, with smaller values indicating better fit (Snijders & Bosker, 2012). We also used chi-square deviance measures to test for significance of particular predictors.

These mixed effects logistic regression analyses produce odds ratios, which are a measure of effect size that describe the relative ratio of the odds of a particular outcome (e.g., asking a question), given the presence or absence of a particular circumstance (e.g., age, word type), with odds ratios greater than 10 being considered a large effect (Bates et al., 2015; Bruce & Bruce, 2017; Cohen et al., 2003; James et al., 2013; Singmann & Kellen, 2019). For example, an odds ratio of 10 for the effect of learning condition would mean that the ratio of the probability that a child will learn a word or not given that they are in the Question condition, is compared to the ratio of the probability that a child will learn a word or not given that they are in the No Question condition. The subsequent interpretation of this example is that the likelihood that children in the Question condition will correctly select the target word compared to not select the target word is 10 times greater than the ratio of correct target selection for the No Question condition.

$$\frac{\frac{\Pr(correct\ selection|Question)}{\Pr(\ incorrect\ selection|Question)}}{\frac{\Pr(correct\ selection|No\ Question)}{\Pr(incorrect\ selection|No\ Question)}} = 10$$

Below, we first report descriptive information about children's information-seeking and their word learning test performance before examining whether condition and information-seeking predicted word learning and word retention test scores while including age, target word, and vocabulary skill as predictors.

Descriptive Statistics

Information-seeking During Instruction Phase

The purpose of Experiment 1 was to investigate whether preschoolers' word learning differed based on learning condition (Question vs. No Question). Replicating previous findings (Janakiefski et al., 2022), when given no immediate definition (i.e., Question condition) children asked targeted questions about words, specifically asking more about unknown words (M=4.167 out of 6, SD=1.786) than about known words (M=0.755, SD=1.997). Also replicating previous findings (Janakiefski et al., 2022), when given informative definitions right away (i.e., No Question condition), children asked few questions about both unknown (M=1.458 out of 6, SD=1.532) and known words (M=0.958, SD=2.206). See Figure 1 for the mean number of information-seeking trials by age and word type across conditions as well as the total number of information-seeking attempts for each participant.

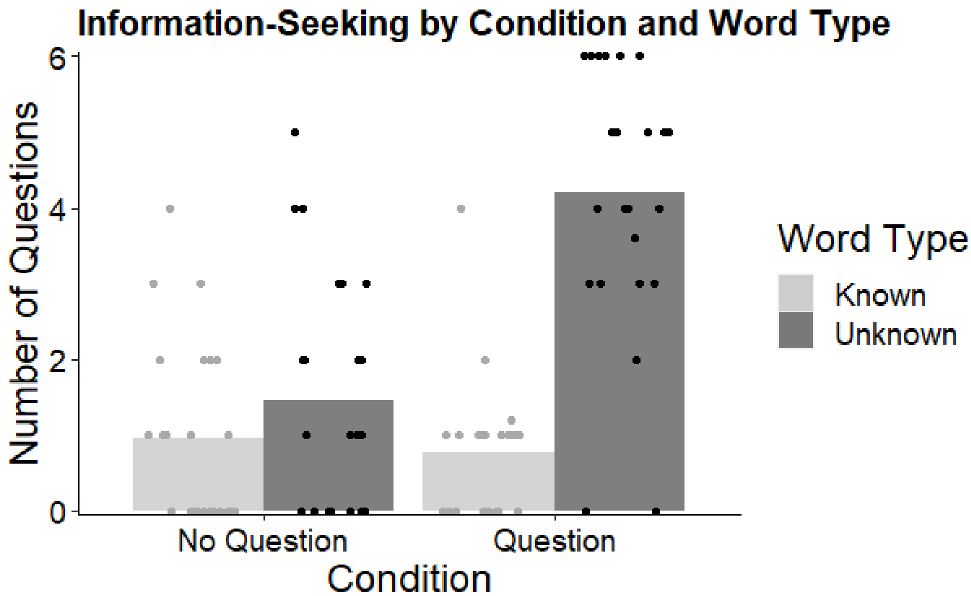

Figure 1. Information-seeking (number of questions) during Instruction Phase by condition and word type. There were 6 unknown words and 6 known words presented in the Instruction Phase.

Immediate Action Production During Instruction Phase

Considering what children did with the verbal information we offered them, results indicated that children made use of the information we provided, correctly completing the actions we requested on 244 out of 288 trials in the No Question condition, and 228 trials out of 287 in the Question condition. See Table 2 below for the breakdown of correct action by word type and condition. This suggests that across conditions children were responding by correctly completing the actions roughly 80% of the time, indicating that the instructions themselves were not too difficult for children to understand.

To ensure that the action coding was not biased by the expectations by the coder or their knowledge of the 'correct action,' we completed an additional masked coding analysis as a more conservative, stringent measure of children's actions following the provided verbal information. With this stringent measure of mased action coding, we again found that children completed the intended action with high accuracy, completing the intended action across conditions on 84.2% of unknown word trials, and 83.8% of known word trials.

Across the two action coding methods, children completed the intended action with high accuracy (see Table 2 for an overview). The key differences in the two coding measures were primarily due to differences in the number of trials considered 'codable.' In the more stringent masked coding method, there were fewer total trials that the masked coders were able to make guesses without sound or any other trial information, resulting in a more conservative number of trials included. Otherwise, the two coding methods both demonstrated that across condition and word types, children used the verbal information we provided them.

Table 2

Accuracy of Immediate Action Production

		Correct Action Coding			**Masked Action Coding**		
Condition	**Word Type**	**Correct Actions**	**Total Trials**	**% Correct**	**Correct Actions**	**Total Trials**	**% Correct**
No Question	Known	124	144	86.1	114	133	85.7
	Unknown	120	144	83.3	116	138	84.1
	Both	244	288	84.7	230	271	84.9
Question	Known	123	143	86.0	114	139	82.0
	Unknown	105	144	72.9	113	134	84.3
	Both	228	287	79.4	227	273	83.2
Grand Total		472	575	82.1	457	544	84.9

Note. Accuracy of actions (based on *correct action* coding and *masked action* coding) completed by participants after hearing each instruction during Instruction Phase by condition and word type. The difference in total trials was based on the number of trials masked coders were able to make guesses on without sound or other trial information, resulting in a more conservative number of trials included.

Initial Word Learning Test

Considering the learning data, children selected the target at relatively similar rates across conditions. Children were no more likely to learn novel words in the Question condition (M=3.208, SD=1.141) than the No Question condition (M=2.875, SD=1.361). Across both conditions, some children showed learning (Question: n=10, No Question: n=9), while others were at chance (Question: n=14, No Question: n=15). See Figure 2 for the mean number of correct target selections on the learning test by condition and word type, as well as the total number of correct selections for each participant represented by the individual data points.

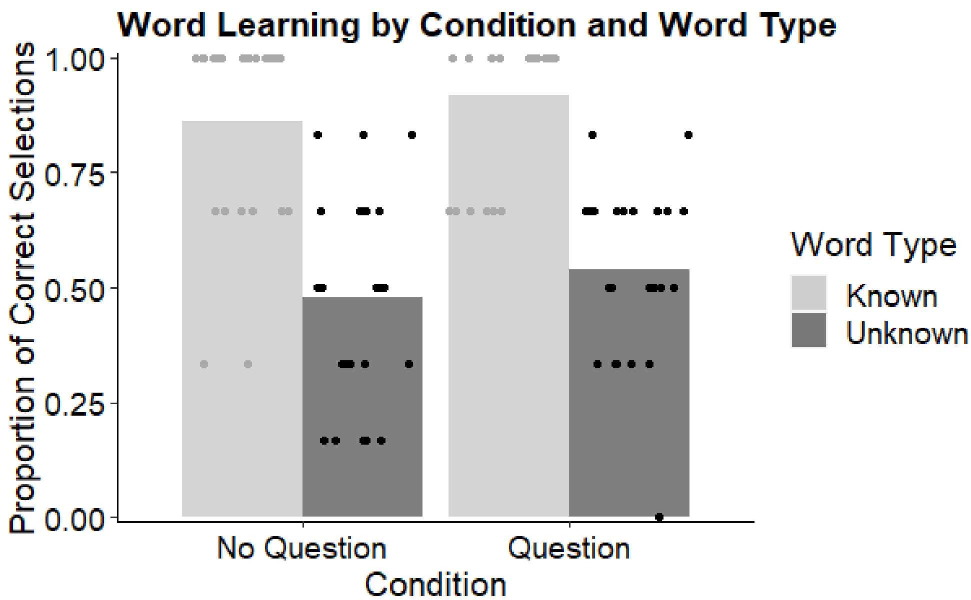

Figure 2. Performance on the Initial Word Learning Test by condition and word type. There were 6 unknown word trials and 3 known word trials on the Initial Word Learning Test.

Delayed Word Learning Test

Considering the memory data, children selected the target again at relatively similar rates across conditions. Children were no more likely to remember novel words in the Question condition (M=3.522, SD=1.273) than the No Question condition (M=3.167, SD=1.273). See Figure 3 for the mean number of correct target selections on the memory test by condition and word type as well as the total number of correct selections for each participant, represented by individual data points.

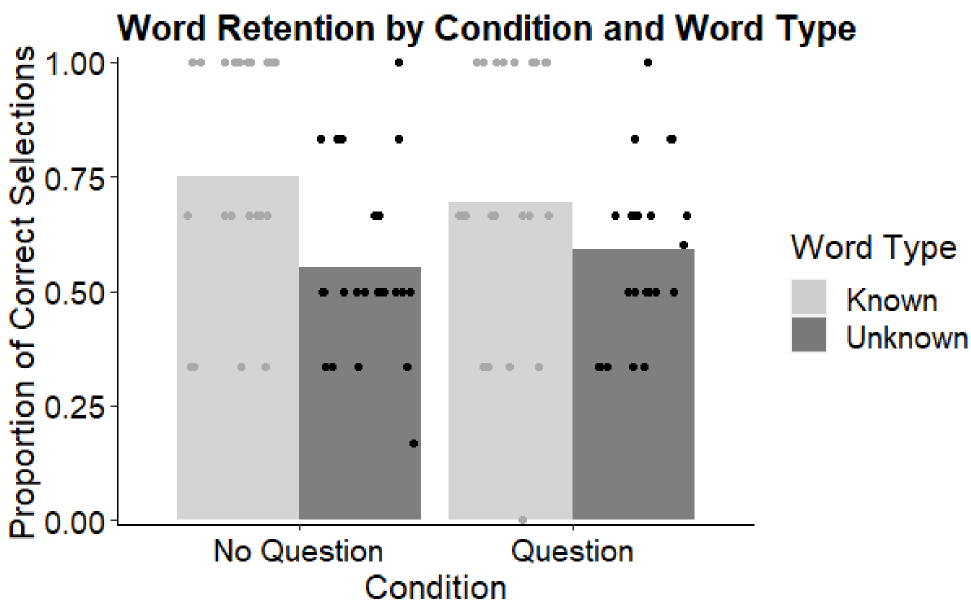

Figure 3. Performance on the Delayed Word Learning (retention) Test by condition and word type. There were 6 unknown word trials and 3 known word trials on the Delayed Word Learning Test.

Model Comparison

To determine the effect of learning condition (Question vs. No Question) on word learning outcomes, we modeled scores on the initial and delayed word learning tests separately.

We fit a mixed effects logit model predicting trial-by-trial test accuracy on the initial learning test (incorrect = 0, correct = 1) from condition (Question or No Question), child's information-seeking behavior for that word (no seeking = 0, seeking = 1), vocabulary skill score on the QUILS (0 to 16), and age (continuous from 4 to 6), with random intercepts for participant. Children were no more likely to respond accurately in the Question condition compared to the No Question condition, (Odds Ratio = 0.949 [0.620, 1.455], Wald $\chi^2(1) = 0.152$, p = .697), suggesting that word learning was not different across conditions. However, this model resulted in a significantly better fit than the null model with no predictors and only random intercepts ($\chi^2(4) = 20.300$, p < .001; Full model with Condition: AIC = 389.5, BIC = 411.2; Null model: AIC = 401.8; BIC = 409.1), though it did not show improved fit compared to the model that included age, information-seeking, and QUILS vocabulary score without condition ($\chi^2(1) = 0.2$, $p > .05$; Nested Model without Condition: AIC = 387.7, BIC = 405.7).

We next fit a mixed effects logit model predicting trial-by-trial test accuracy on the delayed learning test (incorrect = 0, correct = 1) from condition (Question or No Question), child's information-seeking behavior for that word (no seeking = 0, seeking = 1), vocabulary skill score on the QUILS (0 to 16), and age (continuous from 4 to 6), with random intercepts for participant. Children were no more likely to respond accurately in the Question condition compared to the No Question condition, (Odds Ratio = 1.161 [0.657, 2.053], Wald $\chi^2(1) = 0.264$, $p = .607$), suggesting that word retention was not different across conditions. However, this model resulted in a significantly better fit than the null model with no predictors and only random intercepts ($\chi^2(4) = 17.600$, $p < .001$; Full model with Condition: AIC = 370.1, BIC = 391.5; Null model: AIC = 379.7; BIC = 386.9), though it did not show improved fit compared to the model that included age, information-seeking, and QUILS vocabulary score without condition ($\chi^2(1) = 0.3$, $p > .05$; Nested Model without Condition: AIC = 368.4, BIC = 386.2).

Discussion

Given there was no difference in learning across conditions, we considered some possible alternatives that may explain why children varied so strongly in their question-asking tendencies across conditions but did not show learning. One possibility is that the task in the Instruction Phase was too hard, and children did not use the information we provided them at all. However, based on our coding of the actions that children completed, we saw that children in both conditions used the definition information we provided in the moment. This could be loosely compared to a referent selection task immediately following word learning of object labels, commonly used in other work (e.g., Horst & Samuelson, 2008).

Another possibility that may have made the task challenging was that the learning and memory tests may have been too abstract for children to successfully demonstrate evidence that they had learned the word meanings. Choosing between a set of two videos that depict the hands of an actor moving objects that they themselves did not get to interact with (despite the objects being familiar objects, like elephants) may have added too much cognitive load to allow for children to show evidence of learning in either condition (Gathercole & Baddeley, 1990; Sweller, 1988). One future change that could address this possibility is to add a delayed production test. It may be that using a production test would more similarly map onto children's initial experiences with the words, as they similarly produced the actions during exposure to the novel words.

One other possibility that may explain the low mean rates of learning is that the initial word learning test was more delayed than standard tests of word learning (after a 5 min. delay, rather than immediately after exposure), while also including several more items than typically used. The greater number of items for the learning and retention tests was chosen in order to have more data points per child and to give children multiple opportunities to learn. Instead, having several test items may have added cognitive demands that made the task too hard for young children (Gathercole & Baddeley, 1990; Miller, 1956; Sweller, 1988). Considering this possibility, it is important to note, however, that one strength to this design is it expands the limits of word learning beyond "easy" or "hard" words to learn, as there may be word-level or child-level variability that make some words more interesting or easier to acquire. An additional strength of this design is having the delayed learning test, as retention of words is not often evaluated in word learning work (Wojcik, 2013). Previous work has instead more consistently provided an immediate test of learning, which leaves open the question of what children do with word information after they have encoded it. Therefore, one prediction that we return to in the General Discussion, is that while children may utilize word-related information in the moment, they may not keep it in mind in a stable fashion.

General Discussion

The present work tested whether preschoolers' questions about words facilitated or hindered their ability to learn new words compared to more passive learning when children did not ask questions. We found that 4- to 6-year-olds demonstrated robust use of the verbal definitions to complete target actions immediately after receiving the information across study conditions, but showed unreliable learning and retention of those word meanings, regardless of whether children asked a question to receive a verb definition or received an immediate definition of the verb without asking. These findings are consistent with previous results showing that even when young children can complete initial referent selection tasks with novel labels, they may still fail to retain meanings (Horst & Samuelson, 2008).

It is possible that children's difficulty on the learning tests may be explained by cognitive or motivational challenges they had when mapping the novel word onto the meaning. For one example, children may not have felt motivated to learn the word meanings, as there was no explicit reason for them to and the task did not lend itself toward retaining the information for later use. Adapting our task to increase children's motivation to remember the information may also need to incorporate more functional or social reasons for children to use the information later, as social information is a salient cue children use during learning (e.g., Bonawitz et al., 2020; Rittle-Johnson et al., 2008). It may be especially important to further boost social cues in virtual environments, as some of the social context in a virtual interaction is missing, making it more challenging for children to learn (e.g., Troseth et al., 2006). In particular, one way to accomplish this would be to embed the novel verbs in a context where they refer to unique functions of a novel and interesting toy, and to tell children they will need to teach a new "friend" (e.g., another experimenter) how to play with the new toy later. Indeed, this approach of using a novel toy with novel functions may also allow for comparison of the effects of question-asking on learning novel verbs (e.g., the novel functions of the toys) versus novel labels.

A second limitation that may have made the task of mapping novel verbs to action more challenging involves children's memory for the verbal information we offered. Memory for conversation is often low for both adults and children, especially for the other speech partner's contribution to the conversation (McKinley et al., 2017). It may be that children have low memory for the verbal information discussed in the conversation between the experimenter and the child, possibly amplified by the fact that children were not explicitly told or motivated to learn the word meanings. This is an additional future direction that would clarify how children respond to and interact with word information when they are or are not expecting to use that information later. By reducing memory demands overall, such as by reducing the number of target words and test trials, children may be able to show stronger mapping of novel verbs to actions. However, it is also important to note that often children do not always need explicit motivation to learn word meanings, so while these motivational supports may be helpful, they may not be essential for successful word learning.

The difficulty of mapping the novel word and action may have been further compounded by the particular target novel words used in the study. First, the unknown words we used may have been too difficult for the children to pronounce, which subsequently may have made the mapping process more difficult. Being able to pronounce the word may be important for creating or accessing verbal representations. A possible adaptation for an avenue of future work could be to use a more commonly used novel word set (e.g., “blick” or “gorp”) rather than the set of words used here. The novel words in the Unusual Names database, for example, may be useful to use, as they are shorter and children may have an easier time pronouncing them, which may make them more easily represented and held in mind (Horst & Hout, 2016). Second, another possibility that may have made mappings difficult is that the verbs were presented in the ‘command’ form (e.g., “Transpose the cow and the horse”), rather than in the present participle form (e.g., “The boy is gorping the balloon”), which is more commonly used form in previous verb learning studies (e.g., Horvath & Arunachalam, 2019). The strength of using the command form in the present work is that the verbs were presented to children in the context of a task to complete, rather than an event to watch, which may have made the task more interesting or engaging to children. However, as this format has not been used as frequently in previous approaches, it is possible it was more challenging for children to make note of the syntactic cues which are argued to help children identify verb framings (e.g., Arunachalam & Waxman, 2015; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman, 1990).

Finally, the relatively sparse linguistic information and the limited frequency of the information may have further added challenges to children’s ability to establish mappings. In the present work, children heard the target label only twice and heard the definition only once, which may have been too infrequent for children to establish mappings lasting across even a short delay. Further, children may have struggled to use our definitions, as our definitions contained familiar synonyms for the novel words. The use of familiar synonyms in the definitions was chosen following previous work on definitions that parents and adults spontaneously offer (Callanan, 1985; 1990; Callanan & Sabbagh, 2004). However, young children show a tendency to prefer to have only one label for each referent (i.e., mutual exclusivity). Therefore, in order to establish the mapping, children may have needed to override the previous label they had for the action in order to establish and retain the new mapping, which violates the early tendency for one label to map onto only one referent. Importantly, children must eventually overcome this mutual exclusivity approach, and young dual language learners overcome this challenge as well (e.g., Rowe, Silverman, & Mullan, 2013; Benitez, Yurovsky, & Smith, 2016), so it is possible with greater linguistic supports, children may more readily establish mappings in this type of active task. Secondly, our definitions only contained verbal information. There is not much work on how children make use of purely verbal information in both updating and maintaining their word representations (e.g., Saylor et al., 2016). However, previous experiments have shown that when verbal information is presented along with familiar information as an additional support (e.g., with hybrid animals made up of familiar animals, or presenting information in the context of naturalistic vignettes), children show more success differentiating between information and using it to preferentially endorse particular arguments over others (Castelain et al., 2018; Mercier et al., 2014). Together, these findings suggest that preschoolers may more easily retain verbal information when it is offered with more lexical supports, leaving open the question of whether active learning may confer benefits with additional scaffolds (gesture, repetitions of labels, etc.).

Support for the possible benefits of additional lexical scaffolds comes from a previous study investigating children's acquisition of new words during exclusion learning (Horst & Samuelson, 2008). Across 3 experiments, children were highly accurate at selecting the novel object from among distractors (e.g., "Can you show me the modi?") by using exclusion learning principles (i.e., mutual exclusivity) to determine which was the requested referent; however, retention of the object-label mappings never exceeded chance levels (Horst & Samuelson, 2008). Only when an experimenter provided 5 repetitions of the novel word, held up the target object and directly told the child "Look! It's the cheem!" (Exp 2), and only in the first half of the block of words children were tested on, did toddlers learn novel name-object pairs. These findings suggest the combined use of lexical supports may facilitate word learning. Indeed, one strategy that has shown success in supporting early verb learning in young children is to repeat the content noun information before introducing the novel verb (e.g., "Look at the boy! See the boy? The boy is gorping!"), which helps children process the new information more easily (He & Lidz, 2016; 2017). An additional strategy that has shown success in supporting preschoolers' verb learning is the use of gesture information during the verb learning event (e.g., Alibali, Kita, & Young, 2000; de Nooijer et al., 2013; Wakefield et al., 2017; 2018a; 2018b). Indeed, caregivers attend to this potential benefit and make use of gesture when teaching novel words to their infants (Cheung et al., 2021). Current work from our lab is taking these adaptations into account to test whether question asking may provide an additional benefit for learning when receiving these lexical supports in response to their questions (compared to receiving them unprompted).

Asking questions about words could vastly alter how much exposure children get to novel words and meanings. This may subsequently alter the trajectory of the early word learner's later vocabulary and language use (e.g., Mani & Ackermann, 2018). Compared to pointing, looking, and tapping, which might lead the respondent to provide information about an unintended referent, asking questions gets you the specific information you want and in a timely fashion (Baldwin & Moses, 1996). Asking also gives you access to new information, including new topics to talk about and the vocabulary to do so. Indeed, children selectively ask about novel, surprising, incongruous things (Berlyne & Frommer, 1966), which is efficient for avoiding redundant information and boosting potential learning gains. However, as the present study leaves open, it is possible that though the pragmatic ability to successfully ask relevant questions has emerged by the preschool period (e.g., Chouinard et al., 2007), children cannot yet utilize questions to learn and retain words. As such, questions about words warrant further investigation to fully characterize the active involvement of the child in language development.

Models of question-asking often leave off at the point of knowledge reception. These models discuss why animals and humans seek information, and then they typically stop at the point of uncertainty reduction, but rarely go beyond. As such, these models have failed to account for the learning that occurs (or what memory researchers call the encoding process; Wojcik, 2013), and whether that learning is processed, stored, or retrieved any differently from information that is learned from passive reception. Without probing the benefits of active learning on memory, not just on initial learning, observed learning gains and losses may mean little. Previous work has touched on memory for words and meanings (Carey & Bartlett, 1978; Gomez & Gerken, 1999; Markson & Bloom, 1997), but there is much left to be explored in the ways children's memory for words develops across time (Wojcik, 2013). We are not only interested in how well a child can quickly map a word to a label, but in how this mapping exists, lasts, and even changes across time to support a child's subsequent learning. After all, it may not truly be successful "learning" if the information is never able to be recalled.

Parsing the contribution of word-related question-asking to learning outcomes is critical, as it may provide new insight into how children construct such widely variable vocabularies, beyond other factors such as socioeconomic status and parental input. Indeed, it is not clear from the literature what children learn from the information they receive when they ask a question about a word meaning. Future work investigating children's motivation to ask about word meanings, and what children hold in mind once they encounter a new word and ask about, are necessary to determine the active role of the child in shaping their language learning trajectory.

References

Ackermann, L., Lo, C. H., Mani, N., & Mayor, J. (2020). Word learning from a tablet app: Toddlers perform better in a passive context. *PloS one*, *15*(12), e0240519.

Aly, M., & Turk-Browne, N. B. (2016). Attention promotes episodic encoding by stabilizing hippocampal representations. *Proceedings of the National Academy of Sciences*, *113*(4), E420-E429.

Aly, M., & Turk-Browne, N. B. (2016). Attention stabilizes representations in the human hippocampus. *Cerebral Cortex*, *26*(2), 783-796.

Atkinson, R. K., & Renkl, A. (2007). Interactive example-based learning environments: Using interactive elements to encourage effective processing of worked examples. *Educational Psychology Review*, *19*(3), 375-386.

Baldwin, D. A., & Moses, L. J. (1996). The ontogeny of social information gathering. *Child Development*, *67*(5), 1915-1939.

Bates, D., Mächler, M., Bolker, B. M., & Walker, S. C. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Berlyne, D. E., & Frommer, F. D. (1966). Some determinants of the incidence and content of children's questions. *Child Development*, 177-189.

Bjork, R. A. (2018). Short-term storage: The ordered output of a central processor. In *Cognitive Theory* (pp. 151-171). Psychology Press.

Bonawitz, E., Shafto, P., Yu, Y., Gonzalez, A., & Bridgers, S. (2020). Children change their answers in response to neutral follow-up questions by a knowledgeable asker. *Cognitive science*, *44*(1), e12811.

Brown, A. L. (1982). Learning, Remembering, and Understanding. Technical Report No. 244.

Bruce, P., & Bruce, A. (2017). *Practical Statistics for Data Scientists* (2nd ed.). O'Reily Media, Inc.

Callanan, M. A., & Oakes, L. M. (1992). Preschoolers' questions and parents' explanations: Causal thinking in everyday activity. *Cognitive Development*, *7*(2), 213-233.

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Papers and Reports on Child Language Development*, *15*, 17–29.

Castelain, T., Bernard, S., & Mercier, H. (2018). Evidence that two-year-old children are sensitive to information presented in arguments. *Infancy*, *23*(1), 124-135.

Cheung, R. W., Hartley, C., & Monaghan, P. (2021). Caregivers use gesture contingently to support word learning. *Developmental Science*, e13098.

Chi, M. T., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, *49*(4), 219-243.

Chouinard, M. M., Harris, P. L., & Maratsos, M. P. (2007). Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development*, i-129.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. A. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd Edition). Laurence Earlbaum Associates, Inc.

Craik, F. I., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General*, *125*(2), 159.

De Nooijer, J. A., Van Gog, T., Paas, F., & Zwaan, R. A. (2013). Effects of imitating gestures during encoding or during retrieval of novel verbs on children's test performance. *Acta Psychologica*, *144*(1), 173-179.

Frazier, B. N., Gelman, S. A., & Wellman, H. M. (2009). Preschoolers' search for explanatory information within adult–child conversation. *Child Development*, *80*(6), 1592-1611.

Frazier, B. N., Gelman, S. A., & Wellman, H. M. (2016). Young children prefer and remember satisfying explanations. *Journal of Cognition and Development*, *17*(5), 718-736.

Gathercole, S. E., & Baddeley, A. D. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology*, *81*(4), 439-454.

Golinkoff, R. M., De Villiers, J. G., Hirsh-Pasek, K., Iglesias, A., Wilson, M. S., Morini, G., & Brezack, N. (2017). *User's manual for the Quick Interactive Language Screener (QUILS): A measure of vocabulary, syntax, and language acquisition skills in young children*. Paul H. Brookes Publishing Company.

Gomez, R. L., & Gerken, L. (1999). Artificial grammar learning by 1-year-olds leads to specific and abstract knowledge. *Cognition*, *70*(2), 109-135.

Gopnik, A. (2012). Scientific thinking in young children: Theoretical advances, empirical research, and policy implications. *Science*, *337*(6102), 1623-1627.

Gottlieb, J. (2012). Attention, learning, and the value of information. *Neuron*, *76*(2), 281-295.

Graesser, A. C., & McMahen, C. L. (1993). Anomalous information triggers questions when adults solve quantitative problems and comprehend stories. *Journal of Educational Psychology*, *85*(1), 136.

He, A. X., & Lidz, J. L. (2016). What infants learn about a verb depends on its subject. In *90th Annual Meeting of the Linguistic Society of America (LSA), Washington, DC*.

He, A. X., & Lidz, J. L. (2017). Verb learning in 14-and 18-month-old English-learning infants. *Language Learning and Development*, *13*(3), 335-356.

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128-157.

Horvath, S., & Arunachalam, S. (2019). Optimal contexts for verb learning. *Perspectives of the ASHA Special Interest Groups*, *4*(6), 1239-1249.

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Applications in R*. Springer Science + Business Media.

Janakiefski, L., Tippenhauer, N., Liu, Q., Green, M., Loughmiller, S., & Saylor, M. M. (2022). Gaining access to the unknown: Preschoolers privilege unknown information as the target of their questions about verbs. *Journal of Experimental Child Psychology*, *217,* 105358.

Kachergis, G., Yu, C., & Shiffrin, R. M. (2013). Actively learning object names across ambiguous situations. *Topics in Cognitive Science*, *5*(1), 200-213.

Kahana, M. J. (2012). *Foundations of human memory*. OUP USA.

Kemler Nelson, D. G., Louisa Chan, E., & Holt, M. B. (2004). When children ask, “What is it?” what do they want to know about artifacts? *Psychological Science*, *15*(6), 384-389.Kemler-Nelson et al., 2005/6?

Kirschner, P., Sweller, J., & Clark, R. E. (2006). Why unguided learning does not work: An analysis of the failure of discovery learning, problem-based learning, experiential learning and inquiry-based learning. *Educational Psychologist*, *41*(2), 75-86.

Kurkul, K. E., & Corriveau, K. H. (2018). Question, explanation, follow-up: A mechanism for learning from others? *Child Development*, *89*(1), 280-294.

Lucca, K., & Wilbourn, M. P. (2019). The what and the how: Information-seeking pointing gestures facilitate learning labels and functions. *Journal of Experimental Child Psychology*, *178*, 417-436.

Mani, N., & Ackermann, L. (2018). Why do children learn the words they do? *Child Development Perspectives*, *12*(4), 253-257.

Markant, D. B., Ruggeri, A., Gureckis, T. M., & Xu, F. (2016). Enhanced memory as a common effect of active learning. *Mind, Brain, and Education*, *10*(3), 142-152.

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature*, *385*(6619), 813-815.

McKinley, G. L., Brown-Schmidt, S., & Benjamin, A. S. (2017). Memory for conversation and the development of common ground. *Memory & Cognition*, *45*(8), 1281-1294.

Mercier, H., Bernard, S., & Clément, F. (2014). Early sensitivity to arguments: How preschoolers weight circular arguments. *Journal of Experimental Child Psychology*, *125*, 102-109.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81.

Mills, C. M., & Landrum, A. R. (2014). Inquiring minds: Using questions to gather information from others. In *Trust and Skepticism* (pp. 63-76). Psychology Press.

Mills, C. M., & Sands, K. R. (2020). 8 Understanding Developmental and Individual Differences in the Process of Inquiry during the Preschool Years. *The Questioning Child: Insights from Psychology and Education*, *144*.

Mills, C. M., Legare, C. H., Grant, M. G., & Landrum, A. R. (2011). Determining who to question, what to ask, and how much information to ask for: The development of inquiry in young children. *Journal of Experimental Child Psychology*, *110*(4), 539-560.

Montessori, M. (1912). The Montessori Method (1964). *Schocken, New York*.

Partridge, E., McGovern, M. G., Yung, A., & Kidd, C. (2015). Young children's self-directed information gathering on touchscreens. In *Proceedings of the 37th Annual Conference of the Cognitive Science Society,* Austin, TX.

Piaget, J. (1964). Cognitive development in children. *Journal of Research in Science Teaching*, *2*(2), 176-186.

Rittle-Johnson, B. (2006). Promoting transfer: Effects of self-explanation and direct instruction. *Child Development*, *77*(1), 1-15.

Rittle-Johnson, B., Saylor, M., & Swygert, K. E. (2008). Learning from explaining: Does it matter if mom is listening?. *Journal of Experimental Child Psychology*, *100*(3), 215-224.

Ronfard, S., Zambrana, I. M., Hermansen, T. K., & Kelemen, D. (2018). Question-asking in childhood: A review of the literature and a framework for understanding its development. *Developmental Review*, *49*, 101-120.

Ross, H. S., & Killey, J. C. (1977). The effect of questioning on retention. *Child Development*, 312-314.

Ruggeri, A., & Lombrozo, T. (2015). Children adapt their questions to achieve efficient search. *Cognition*, *143*, 203-216.

Ruggeri, A., Markant, D. B., Gureckis, T. M., Bretzke, M., & Xu, F. (2019). Memory enhancements from active control of learning emerge across development. *Cognition*, *186*, 82-94.

Saylor, M. M., Osina, M., Tassin, T., Rose, R., & Ganea, P. (2016). Creature feature: Preschoolers use verbal descriptions to identify referents. *Journal of Experimental Child Psychology*, *152*, 205-220.

Schank, R. C. (1986). Explanation: A first pass. *Experience, Memory, and Reasoning*, 139-165.

Schulz, L. (2012). The origins of inquiry: Inductive inference and exploration in early childhood. *Trends in Cognitive Sciences*, *16*(7), 382-389.

Singmann, H., & Kellen, D. (2019). An introduction to mixed models for experimental psychology. In D. H. Spieler & E. Schumacher (Eds.), *New Methods in Cognitive Psychology* (pp. 4–31). Psychology Press.

Smith, M. E. (1933). The influence of age, sex, and situation on the frequency, form and function of questions asked by preschool children. *Child Development*, *4*(3), 201-213.

Snijders, T. A., & Bosker, R. J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Sage.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257-285.

Troseth, G. L., Saylor, M. M., & Archer, A. H. (2006). Young children's use of video as a source of socially relevant information. *Child Development*, *77*(3), 786-799.

Trueswell, J. C., Medina, T. N., Hafri, A., & Gleitman, L. R. (2013). Propose but verify: Fast mapping meets cross-situational word learning. *Cognitive Psychology*, *66*(1), 126-156.

Wakefield, E. M., Hall, C., James, K. H., & Goldin-Meadow, S. (2017). Representational Gesture as a Tool for Promoting Verb Learning in Young Children. *Boston University Conference on Language Development*, Boston, MA.

Wakefield, E. M., Hall, C., James, K. H., & Goldin-Meadow, S. (2018). Gesture for generalization: gesture facilitates flexible learning of words for actions on objects. *Developmental Science*, *21*(5), e12656.

Wakefield, E., Novack, M. A., Congdon, E. L., Franconeri, S., & Goldin-Meadow, S. (2018). Gesture helps learners learn, but not merely by guiding their visual attention. *Developmental Science*, *21*(6), e12664.

Wojcik, E. H. (2013). Remembering new words: Integrating early memory development into word learning. *Frontiers in Psychology*, *4*, 151.

Woodard, K., Gleitman, L. R., & Trueswell, J. C. (2016). Two-and three-year-olds track a single meaning during word learning: Evidence for propose-but-verify. *Language Learning and Development*, *12*(3), 252-261.

Zettersten, M., & Saffran, J. R. (2020). Sampling to learn words: Adults and children sample words that reduce referential ambiguity. *Developmental Science*, *24*(3), e13064.