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Contributions of shared book reading to children's learning of new semantic facts through memory integration

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Abstract

Young children rapidly learn facts about the world. One mechanism supporting knowledge acquisition is memory integration: derivation of new knowledge by combining separate, yet related facts accumulated over time. There are both developmental changes and individual differences in young children's learning through memory integration. However, there is little research on how everyday social interactions may promote memory integration and contribute to individual differences. Accordingly, we investigated how the everyday social interactions of caregiver-child shared book reading support 5- to 6-year-olds' memory integration (N = 82 parent-child dyads; 47 female children; M age 6.10; 56.5% White non-Latinx, 15% Black, 6% White Latinx, 5.5% Asian, 17% more than one race). Caregivers read a narrative book that included opportunities to integrate facts. Half the dyads were assigned to an embedded questions condition (questions on facts included throughout the book) and half to a no embedded questions condition (statements only). We measured dyads' extratextual talk while reading for the extent to which they integrated the facts (integration talk). Children's learning was tested with both memory integration and fact recall questions. Dyads in the embedded questions condition had more integration talk. The extent to which the dyads integrated while reading predicted children's integration performance, above and beyond condition effects. This effect was specific to memory integration: integration talk nor condition accounted for fact recall. These results suggest that shared book reading can support young children's integration, especially when books engage dyads through embedded questions and dyads integrate facts while reading.

Keywords

memory integration; semantic learning; shared book reading; embedded questions; extratextual talk; young children

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In early childhood, children rapidly accumulate semantic knowledge about the world through both direct and indirect mechanisms (Bauer, 2021). Knowledge is accumulated directly through encoding and storing information to which one is exposed, and indirectly through drawing inferences that build upon directly learned information. There are a variety of indirect learning mechanisms, including analogical reasoning (Gentner & Maravilla, 2018), transfer (Ganea et al., 2011), and memory integration (Bauer, 2021). In the current research, we focus on memory integration, which is the process of combining separate yet related pieces of information to derive new semantic knowledge. We focus on memory integration because it is an important process for accumulating semantic knowledge over time and is predictive of academic achievement (Esposito & Bauer, 2022; Varga et al., 2019). There are also large developmental and individual differences in one's employment of memory integration to derive new knowledge (Bauer & San Souci, 2010; Varga & Bauer, 2017). However, there remains limited understanding of the everyday social practices that influence young children's derivation of new semantic knowledge through memory integration.

We bridged this gap by investigating the influence of the everyday social practice of caregiver-child shared book reading on children's accumulation of new knowledge through memory integration. Past research on memory integration focused on the component processes involved (e.g., Miller-Goldwater et al., 2021), cognitive factors that predict it (e.g., Esposito & Bauer, 2022), and experimental manipulations that promote it (e.g., Bauer et al., 2015; Bauer & San Souci, 2010). In contrast, research on caregiver-child shared book reading focused on everyday social practices that contribute to learning, such as the influence of caregivers' reading styles and the textual features of books (Dunst et al., 2012; Haden et al., 1996; Miller-Goldwater et al., 2023; Troseth et al., 2020). The major outcome of focus of this research is on language and literacy skills (see Noble et al., 2019, for meta-analysis). There is less research on the influence of caregiver-child shared book reading on the accumulation of world knowledge (see Grøver et al., 2023, for a review and meta-analysis), and no known research on indirect learning, including memory integration. We thus extended prior research to investigate how caregiver-child talk interactions and the textual features of books during caregiver-child shared book reading influenced 5- to 6-year-old children's derivation of new knowledge through memory integration. As discussed by Grover and colleagues, extending exploration of the effects of shared book reading to include a larger variety of learning outcomes is important given how these learning outcomes relate to educational and life achievement.

Memory Integration

To build a knowledge base, one needs to engage in memory integration and combine separate yet related pieces of factual information that have been accumulated over time (see Bauer, 2021, for review). Once the facts have been integrated, one can derive new information that was never directly taught. For example, one may learn that "otters communicate by squealing" and then later learn that "the animal that communicates by squealing lives in groups called rafts." One can then integrate these facts learned across separate episodes to derive the new information that "otters live in groups called rafts." Engaging in memory integration is crucial for building semantic knowledge as we do not acquire all information at once, but instead acquire facts over time and across episodes. As reviewed by Bauer (2021), once information is derived, it becomes indistinguishable from long-term knowledge (Bauer & Jackson, 2015) and can be retrieved over a 1-week delay (Varga & Bauer, 2017).

There are both developmental changes and individual differences in children's memory integration performance. In young children, integration is assessed with short story passages read to them by an experimenter, where there is one fact, referred to as a stem fact, presented per story. Young children can integrate stem facts across story passages to derive new information when asked questions at test that demand integration (e.g., "What is the name of the group that otters live in?" from the example above). Yet, integration becomes more accessible, over time. Four-year-olds tend to rely on forced-choice response options to select the derived fact; whereas 6-year-olds can integrate when probed with open-ended questions (Bauer & Larkina, 2017; Bauer & San Souci, 2010). As children get older, they depend less on demands for integration and begin to integrate when first encoding related stem facts or pieces of information (Schlichting et al., 2014; Shing et al., 2019). In addition to developmental changes, there are pronounced individual differences in memory integration among both children and adults, with performance near zero to one hundred percent, with such variability predicting academic achievement (Esposito & Bauer, 2022; Varga et al., 2019; Varga & Bauer, 2017).

Memory integration can be supported through experimental manipulations. One means is by facilitating one's encoding of stem facts. For example, Bauer and San Souci (2010) facilitated 4-year-old children's encoding of stem facts by reading each fact twice. Additionally, they had children answer questions about the stem facts with corrective feedback. This manipulation resulted in improvements in 4-year-old children's integration in both the open-ended and forced-choice formats. Other means of facilitating 4- and 6-year-old children's integration is by helping them identify relations between two integrable stem facts (Bauer et al., 2012) and by helping them realize the relevance of the stem facts for answering the integration questions (Bauer et al., 2015). In summary, there is both developmental and individual variability in children's memory integration, and research has identified experimental manipulations that support children's engagement in such processes. However, despite the importance of memory integration for promoting semantic knowledge, there is limited understanding of the everyday social practices that may support memory integration and contribute to individual differences.

Shared Book Reading

One everyday social practice through which young children can acquire new knowledge is shared book reading. Shared book reading is the act of reading books with a knowledgeable other. Through shared book reading, young children learn facts on a variety of topics, such as physics, natural selection, nutrition, and biology (Aydin et al., 2021; Hopkins & Lillard, 2021; Kelemen et al., 2014; Miller-Goldwater et al., 2023; Neuman & Kaefer, 2018). They also show evidence of indirect learning through transferring information learned in books to new scenarios (Hopkins & Weisberg, 2021; Strouse & Ganea, 2021), making inferences about character goals and predictions of story events (Filiatrault-Veilleux et al., 2016; Van

Kleeck et al., 2006), and, as reviewed above, integrating separate yet related facts across story passages (Bauer & San Souci, 2010). Books frequently contain opportunities for integrating facts and deriving new knowledge by presenting related facts in different parts of the text. Thus, shared book reading is a source through which young children can learn new factual knowledge through memory integration.

A notable feature of most research on factual learning from books is that it involves having an experimenter or other adult read books to children in controlled contexts that do not involve naturalistic shared book reading interactions. For example, Neuman and Kaefer (2018) report gains in science vocabulary and science content knowledge as a function of a year-long intervention involving teachers engaging in scripted reading of science-related texts. In contrast, in naturalistic and unscripted shared book reading settings in which a caregiver reads books with their child, there is limited research assessing factual learning (discussed in Grover et al., 2023) and no known research assessing indirect factual learning. In this section, to provide insights into how more naturalistic shared book reading interactions may affect children's memory integration, we review research primarily on caregiver-child shared book reading showing how extratextual talk during book reading and the textual features of books influence young children's learning in the contexts of language and literacy skills and direct factual learning.

While reading, caregivers often use extratextual talk, talk beyond the book's text, which promotes children's learning. One type of extratextual talk is elaborative extratextual talk, also referred to by different labels, such as non-immediate talk (Breit-Smith et al., 2017; De Temple et al., 2003; Dunst et al., 2012; Hindman et al., 2008; Miller-Goldwater et al., 2023; van Kleeck et al., 1997). Such talk goes beyond the books' text and provides additional details and examples, draws connections between different textual elements or between the text and the child's life, as well as draws inferences. Caregivers who use more elaborative extratextual talk tend to have children who score higher on measures of language and literacy (e.g., Breit-Smith et al., 2017; Dunst et al., 2012). Additionally, extratextual talk that actively engages the child in the book reading process also supports their learning. For example, when caregivers or experimenters ask questions during book reading, children tend to better comprehend the text and are better able to retell stories (Heisey & Kucan, 2010; Kang et al., 2009; Leung, 2008). Additionally, dialogic reading interventions, which involve home-based interventions that encourage caregivers to ask questions and have caregivers reinforce their child's verbalizations, also support multiple learning outcomes (Pillinger & Vardy, 2022; Whitehurst et al., 1988).

In addition to extratextual talk, the textual features of books affect caregivers' extratextual talk and children's learning, including factual learning. When questions are embedded within books, caregivers tend to engage in more on-topic extratextual talk and ask more questions, even on pages without questions (Troseth et al., 2020). In the context of factual learning, when books include embedded questions and caregivers use more elaborative extratextual talk, children tend to learn more facts from the book (Miller-Goldwater et al., 2023). Taken together, research on caregiver-child shared book reading highlights the important role that extratextual talk and embedded questions play in influencing children's learning from books during caregiver-child shared book reading.

It is reasonable to expect that caregiver-child extratextual talk and embedded questions would support children's memory integration. In terms of extratextual talk, caregiver-child dyads likely engage in processes related to memory integration while reading. For instance, elements of elaborative extratextual talk include drawing connections between different textual elements and making inferences. These aspects of elaborative extratextual talk may involve caregivers helping children integrate and realize the connections between stem facts. We refer to this subtype of elaborative extratextual talk as *integration talk*. To illustrate, a book may teach children that insects have six legs and then later that ladybugs have six legs. Integration talk may involve a caregiver prompting their child to draw the connection that ladybugs are insects (e.g., "If ladybugs have six legs, then ladybugs must be…."). Embedded questions may also support dyads' engagement in memory integration while reading and may support children's memory integration test performance. Embedding questions within books increases on-task extratextual talk (Troseth et al., 2020). Also, having children successfully answer questions about facts after exposure to the facts supports children's memory integration performance (Bauer & San Souci, 2010). Thus, interactions between children and their caregivers during shared book reading and the textual features of books (e.g., embedded questions), may support children's learning of new semantic knowledge through memory integration.

Current Study

We extended past research by investigating the derivation of new semantic knowledge through memory integration in the context of shared book reading. Young children can engage in memory integration (Bauer & San Souci, 2010), yet there is both large developmental and individual variability in children's engagement in such processes (Bauer, 2021). In the present research, we tested whether and how the everyday social practice of caregiver-child book reading may influence learning and contribute to such variability. The question is important given the relations between memory integration and academic achievement (Esposito & Bauer, 2022) and the widely available opportunities for shared-book reading interactions in everyday contexts, compared with the more restricted availability of scripted interventions (e.g., Neuman & Kaefer, 2018). We tested 5- to 6-year-olds because this is an age group where children are still developing skills in memory integration but derive new information when probed with integration questions (Bauer et al., 2012; Bauer & San Souci, 2010).

We had caregivers read to their child a lab-designed narrative book with factual content. Rather than brief text passages that featured a single fact, such as used in prior research (e.g., Bauer & San Souci, 2010), the narrative book included a coherent storyline about a protagonist who learned facts about animals on different school days (i.e., episodes). Each episode included three facts, with each fact relating to a topic (e.g., animal communication, groups of animals). Facts could be integrated across episodes. In addition, there were two between-subject conditions: embedded questions and no embedded questions. The embedded questions condition included pretest and posttest questions asking children to recall aspects of the facts before and after the facts were presented. The no embedded questions condition presented the same information but as statements rather than questions. We measured extratextual talk during book reading for the extent to which caregiver-child dyads engaged with the embedded questions and the extent to which they integrated the stem facts.

We included tests of learning that assessed children's memory integration (i.e., combining stem facts to derive new information) and stem fact recall (i.e., memory of stem facts taught in the book). There were three tests of learning: free recall, probed open-ended, and probed forced-choice. These tests varied from each other in the amount of probing and support for integration and stem fact recall. The free recall test provided the least amount of probing and support as it asked broad questions about what children learned related to the animals and topics in the book. The probed open-ended and forced-choice tests had the same format as past research (e.g., Bauer & San Souci, 2010) and asked specific questions that elicited integration and stem fact recall. The open-ended test had less support than the forced-choice test as the test questions did not provide response options from which to choose. We included this range of tests to assess whether dyads' extratextual talk and embedded questions would have more or less influence on performance when children were provided with different levels of testing support. We were also interested in the free recall test to see whether caregiver-child book reading would help children form an integrated representation of the facts from the book and not require probed integration test questions. Children also participated in a verbal comprehension test, to control for known individual differences in memory integration (Esposito & Bauer, 2022) and reading comprehension (Baumann, 2014; Yildirim et al., 2011).

We had three primary research questions. First, we asked whether condition (embedded questions, no embedded questions) predicted children's memory integration and stem fact recall. We expected that children in the embedded questions condition would have higher integration and stem fact recall than those in the no embedded questions condition. This is because answering the embedded questions should facilitate children's encoding of the stem facts and thus promote their integration performance (Bauer & San Souci, 2010). Second, we asked whether condition predicted dyads' integration talk during shared book reading. We expected that the embedded questions would increase dyads' integration talk. This is because embedded questions would likely increase on-task talk (Troseth et al., 2020) and the questions would facilitate dyads' encoding of the stem facts and the likelihood of integrating while reading. Third, we asked whether dyads' integration talk predicted children's memory integration and stem fact recall above and beyond condition effects. We expected that, above and beyond condition effects, dyads' integration talk would predict children's memory integration performance but not their stem fact recall. We hypothesized that the strongest predictor of memory integration performance would be integration talk. This is because as facts become integrated, they become more accessible (Bauer & Jackson, 2015). We expected this effect would be specific to memory integration and not be an effect related to more general memory (i.e., stem fact recall).

Method

Participants

The sample was 82 children (47 females, 35 males) and their caregivers (80 mothers, 2 fathers). Children ranged in age from 5.48 to 6.97 years ($M = 6.10$, $SD = 0.43$).

Based on caregivers' self-report, children's race and ethnicity (88% reported) was Asian (5.56%), Black (15.28%), White non-Hispanic or Latinx (56.50%), White Hispanic or Latinx (5.50%), and more than one race (16.67%). 97.30% of children had at least one caregiver with a college degree or higher (90% reported). An additional nine dyads were tested but were excluded due to: incomplete session (3), caregiver not following protocol such as by having the child read the book or helping the child answer test questions (3), caregiver reported child learning disability (1), poor internet connection (1, sessions were conducted over Zoom as described in the Procedure section), and session not recorded (1). Participants were recruited through a university database. Caregivers gave informed consent for themselves and their child to participate and children gave verbal assent. Families were compensated with a small prize and a $10 gift certificate. The protocol was reviewed and approved by the university's Institutional Review Board.

Stimuli and Design

Book Stimuli and Design

Types of Facts.: The stimulus was a laboratory-designed narrative picture book that included true, novel facts about animals. There were two fact types: stem and filler. Stem facts could be integrated with another fact to derive new information. For example, the stem fact "Otters squeal to communicate" could be integrated with the stem fact "The animal that squeals to communicate lives in a group called rafts" based on the overlapping element "squeals to communicate." The integrated representation then could be used to derive a novel fact "Otters live in groups called rafts." Each stem fact pair followed an AB/BC structure. The AB stem facts mentioned the animal's name (A element, e.g. "Otters") and a characteristic about it (B element, e.g., "squeal to communicate"). The BC stem facts mentioned the characteristic in the AB fact (B element, e.g., "the animal that squeals to communicate") and a different characteristic (C element, e.g., "lives in a group called rafts"). Integration occurred when combining the A and C elements. Table 1A presents sample stem fact pairs. Filler facts are similar to stem facts but they cannot be integrated with another fact. Their purpose was to provide options for the forced-choice integration test (described in the Test Stimuli section).

The book featured 18 facts: 12 stem facts (six stem fact pairs) and six filler facts. All stem facts had been used in other studies with this age group and had been pilot tested to ensure that children of this age could not answer the integration questions with only one of the two stem facts presented (Bauer & Larkina, 2017; Bauer & San Souci, 2010; Esposito & Bauer, 2017). These studies were conducted in the laboratory and elementary classrooms, with samples that were diverse in terms of race and ethnicity, socioeconomic status (eligible for free/reduced lunch to upper-middle class), and geographic area (rural, metropolitan).

Story Details and Versions.: The book was titled "Rosie's Adventures at School." It presented a story about a protagonist, Rosie, who went to school on six different days (episodes). During each episode, Rosie learned three facts (2 stem facts, and 1 filler) related to a topic (e.g., how animals communicate, groups of animals). The two stem facts presented during the same episode could not be integrated; instead, integration occurred across episodes.

There were two versions of the book. The embedded questions version included pretest and posttest questions to engage the dyads with the facts of each episode before and after the facts were presented. The no embedded questions version presented the same information but as statements. In both versions, there were four pages for each of the six episodes (24 total pages), with the same page structure across each of the six episodes. Below, we provide details of how the four pages were structured and how they differed across versions. Table 2 presents sample pages from two episodes of the embedded questions version of the book.

Page 1 introduced Rosie on her way to school and connected the episode's topic to Rosie's life (e.g., Rosie communicates by talking to her friends).

Page 2 presented Rosie's teacher, who introduced the day's lesson (i.e. episode's topic) and previewed elements of the facts that were part of the episode. In the embedded questions version, the elements were presented as a pretest question (Table 2 underlined text, e.g., "Do you know which animal communicates by honking, which communicates by scratching, and which communicates by squealing? Take a guess!"). In the no embedded questions version, these elements were mentioned as a statement (e.g., "We will learn about animals who communicate by honking, scratching, and squealing.").

Page 3 presented the facts that were part of the episode. The bolded text in Table 2 represents the two stem facts that were part of the episode, with the bolded italicized text representing a stem fact that can be integrated across the episodes represented in Tables 2A and 2B. The italicized only text represents the filler fact. As seen in the table, each fact was presented along with two sentences that provided supporting details. The supporting details were intended to facilitate children's encoding of the facts.

Page 4 repeated the facts from the episode. The embedded questions version included a posttest question before repeating the facts (underlined text Table 2, e.g., "How do the animals communicate to express their needs? Try to remember!"). The no embedded questions version did not have this question.

In terms of illustrations, each page included clipart images (shown in Table 2). The images aligned with the text, representing the narration and the facts. When an AB fact was presented, the image included a picture of the animal (i.e., A element) and the characteristic (i.e., B element). When a BC fact was presented, the image only included a picture of the characteristic (i.e., C element). Each element (A, B, C) was pictured only one time in the book.

Book Counterbalancing.: There were 10 orders per version of the book (20 total). In each order, the stem facts within a pair were presented with 2 to 4 episodes in between (the average distance was 2.67 episodes). Across orders, the AB and BC stem facts within a pair were presented first and second equally often and we varied the position of episodes (i.e., the episode about communication would appear in each of the six possible positions across orders).

Test stimuli—There were tests of learning and a verbal comprehension test. The tests of learning measured children's integration and stem fact recall with three test formats (free recall, probed open-ended, and probed forced-choice). Integration was measured in all formats. Stem fact recall was measured in free recall and probed open-ended recall formats. We did not test stem fact recall in the probed forced-choice format to reduce the sessions' length and the number of filler facts in the book. Table 1B provides sample questions from the tests of learning.

The free recall test asked general questions about the book to assess whether, with minimal prompting, children integrated facts and/or recalled stem facts. There were two types of questions (animal and topic). The animal questions asked about the animals in each book (e.g., "What did Rosie learn about otters?") and the topic questions asked about the topics taught (e.g., "What did Rosie learn about animals that live in groups?"). We measured whether, in response to the free recall questions, children mentioned stem facts that were directly taught in the book (e.g., "otters squeal to communicate") or integrated facts by combining information from two stem facts (e.g., "otters live in groups called rafts", see Table 1A for stem facts).

The probed recall test asked questions that directly prompted stem fact recall (e.g., "how do otters communicate?") and integration ("e.g., "What is the name of the group that otters live in?"). In the open-ended format, children answered questions without options choices. In the probed forced-choice format (integration only), children answered the same integration questions as in the open-ended format but were given three options to choose from: one target (e.g., rafts) and two filler options (e.g., loveliness, blue). The filler options came from two separate filler facts, one that had been presented during the same episode as the target fact and the other having been presented during a different episode. There were twelve free recall (six animal, six topic) and twelve probed recall (six integration, six stem fact) questions.

Children's verbal comprehension was measured with the Comprehension-Knowledge subtest from the Woodcock-Johnson IV Tests of Cognitive Abilities (Schrank & Wendling, 2018), adapted for online administration.

Procedure

The sessions took place online via Zoom. The dyads were assigned to a condition (embedded questions, no embedded questions). The only difference between the conditions was whether dyads received the embedded questions or the no embedded questions version of the book. We balanced conditions based on children's age and gender. At the time of sign-up, we assigned every other participant of a given gender to a different condition. We also evaluated age as assignments were made and adjusted the condition assignments if the condition became unbalanced for age. The final sample included 42 participants in the embedded questions condition (*M* age = 6.11 years, 23 females) and 40 participants in the no embedded questions condition (*M* age = 6.09 years, 24 females).

At the time of scheduling, we asked caregivers to select a time to participate in the session when they could be alone with their child. Before their session, dyads were mailed a package with a physical copy of their assigned book, a small prize for the child, and instructions to not open the book until the experimenter instructed them to do so during the session. We encouraged caregivers to use a laptop or tablet for testing to facilitate recording and the child's viewing of the experimenter and the test stimuli on the screen. Sessions were run by 1 of 5 female experimenters. Consistency between experimenters was maintained by training and regular session viewings by the first author.

The session began by obtaining consent from the caregiver and assent from the child. The sessions lasted ~45 to 60 minutes. There were two main parts: shared book reading and testing.

Shared book reading.—At the start of the shared book reading period, caregivers were not provided with a script on how to read; instead, they were given general instructions. This was to encourage naturalistic shared book reading interactions. Specifically, caregivers were told to read the book as they would normally read a book at home (there is no right or wrong way), but that they should be the primary reader. They were also told that they could flip pages back and forth. After the instructions, the experimenter turned off their video for the duration of this period and told the caregiver that they would be doing other work in the background.

Testing.—After the shared book reading portion, caregivers were instructed that they could stay or leave during this next part. Testing began with an icebreaker task to increase children's comfort in talking to the experimenter. It was a guessing game in which children guessed what animal was behind a box on the screen. Children were then presented with a map and a cartoon bear, who moved positions on the map after each test with a picture of honey at the end of the map. This was used to make the tests into a game of helping the bear get honey. The tests of learning occurred before the verbal comprehension test.

The tests of learning were administered in the following order: free recall (animal questions followed by topic questions), probed open-ended (integration questions followed by stem fact questions), probed forced-choice (integration questions only). For each test of learning, children received the questions in a randomized order. The cover of the book with the cartoon bear on the side was visible on the Zoom screen. The experimenter verbally asked each task's questions one at a time. The experimenter encouraged children to guess if they did not know the answer to a question and told children that they could say "I do not know" if they had no guesses. Additionally, after responding to each question, the experimenter provided encouragement but never corrective feedback.

During the free recall tests, once the child stopped providing information, the experimenter prompted the child two times to provide more information. During the probed open-ended tests, the experimenter prompted the child to provide a new answer only in cases when the child answered the integration questions with a stem fact answer or the stem fact questions with an integration answer (e.g., answering the question "What is the name of the group that otters live in?" with the answer "squealing") or when provided a vague answer (e.g., "big" instead of "heavy"). For probed forced-choice integration testing, children were only asked a given question if they had answered that question incorrectly in the open-ended format.

Verbal Comprehension.: For the verbal comprehension test, the testing procedure was as specified by Woodcock-Johnson IV with the exception that scanned pages of the testing book were presented on the Zoom screen, instead of on physical pages.

Transcription, Coding and Data Reduction

Transcription—We transcribed all speech that occurred during the shared book reading period and during the free recall tests. For shared book reading, the transcribers watched the video recordings and transcribed all extratextual talk (i.e., talk that was beyond the text of the book). Transcribers indicated whether the extratextual talk was provided by the caregiver or the child. For the free recall tests, the transcribers indicated all phrases that the child provided related to each question. Each task was transcribed by one research assistant and checked by another.

Coding—For the coding of shared book reading and the free recall tests, two individuals coded each of the child's responses independently. We compared disagreements between the coders and all discrepancies were resolved through discussions between the first author and the coders. Both transcribers and coders were masked to the children's condition and their performance on all tasks, except for the task they were coding. Agreement between coders for each variable used in analyses ranged from 93%–99%, with Cohen's Kappa's ranging from .86–.98.

Shared Book Reading Coding.: Dyads' extratextual talk during the shared book reading period was coded for providing pretest and posttest responses and for evidence of integration. Examples of dyads' extratextual talk conversations and the coding are provided in Table 3.

For the pretest/posttest response (Table 3, bold only text), in the embedded questions condition, we coded whether the dyads responded to each pretest and/or posttest question. In the no embedded questions condition, we coded whether dyads turned statements into questions and gave pretest and/or posttest responses. This measure was used to ensure that dyads were engaging with questions in the embedded questions condition. We tabulated for each stem fact, whether a pretest and/or posttest response was present, irrespective of accuracy (0,1), and then calculated the proportion of responses per stem fact pair (i.e., number of responses out of two).

There were three integration variables: integration talk, integration talk initiator, and integration talk solver. For integration talk, we coded whether, after reading the 2nd stem fact in a stem fact pair, dyads integrated this 2nd stem fact with the earlier read 1st stem fact (Table 3, bold and italicized test). That is after reading the BC stem fact (e.g., "An animal that communicates by squealing lives in groups called rafts."), did the dyad provide the earlier read A element (e.g., "otters"). Or after reading the AB stem fact (e.g., "Otters communicate by squealing"), did the dyads provide the earlier read C element (e.g., "rafts"). For analyses, we coded each stem fact pair for whether accurate integration occurred (1) or whether it did not occur or inaccurately occurred (0).

The integration talk initiator and solver variables were coded when accurate integration occurred. For the initiator variable, we coded which member of the dyad (caregiver or child) initiated the integration by identifying an opportunity to integrate. For the solver variable, we coded which member of the dyad completed the integration by providing the missing element. The integration talk initiator and solver variables were used in descriptive analyses.

Free Recall Coding.: We coded responses to the free recall questions for whether children provided evidence of integration and/or stem fact recall. Table 4 provides examples of coded responses. In the animal free recall task, children were prompted with the animal's name (e.g., "What did Rosie learn about otters?"), which was always an A element from the AB facts. We coded for stem fact recall when children provided the B element (e.g., "squeals"), and for integration when children provided the unpaired C element (e.g., lives in rafts"). In the topic free recall task, children were prompted with topics that related to the B and C elements of stem facts. For example, for the otter stem fact pair, the topic "communication" related to the B element ("squealing"), and the topic "animals that live in groups" related to the C element ("live in groups called rafts"). We coded for stem fact recall, when children mentioned the A and/or B elements (e.g., "otters/squeal") when a B topic ("communication") was prompted, and when children mentioned the B and/or C elements (e.g., the animal that squeals/lives in rafts") when the C topic ("animals that live in groups") was prompted. We coded for integration when children mentioned the unpaired A element ("otters") when the C topic ("animals that live in groups") was prompted.

In terms of data analysis, we combined scoring from the animal and topic free recall tasks. For integration free recall, we coded for each stem fact pair whether children showed evidence of integration at least once (1) or did not show evidence of integration (0). For stem fact free recall, we coded whether children provided evidence of recalling each of the three elements (A, B, C) at least once when that element was coded as stem fact recall. We created a stem fact free recall proportion score as the number of elements recalled out of the three.

Probed Recall Scoring and Verbal Comprehension—We created three variables from the probed recall tasks: probed open-ended integration, probed total integration, and probed open-ended stem fact recall. For all tests, we scored children's responses during testing as correct (1) or incorrect (0). The first author later reviewed all scoring for consistency. The variables for the open-ended tests were children's scores on each of the six questions per test. The variable for probed total integration was created by adding together children's scores on the open-ended and forced-choice integration tests (forced-choice items were only administered if the item was answered incorrectly in the open-ended format). Finally, we standardized children's verbal comprehension scores based on age using the Woodcock-Johnson IV's scoring and standardization system.

Results

We investigated whether and how shared book reading is a source for facilitating young children's semantic learning through memory integration. We had three primary questions: (a) does condition (embedded questions, no embedded questions) predict children's memory integration (free recall, probed open-ended, and probed total) and stem fact recall (free recall, probed open-ended); (b) does condition predict dyads' integration talk during shared book reading; and (c) does dyads' integration talk predict children's memory integration and stem fact recall above and beyond any effects of condition. The majority of analyses were conducted using mixed-effect models in the lme4 and car packages in R using Type II Wald Chi-Squared test for logistic regression models and Wald III Type F test with Kenward-Rogers degrees of freedom for linear regression (Bates et al., 2015; Fox & Weisberg, 2019). We mean-centered all continuous variables and dummy-coded all factors. One participant had missing data from the free recall test and another from the verbal comprehension test due to not completing those tests. Descriptive and correlational statistics are found in Tables 5 and 6. In the sections below, we first conducted preliminary analyses and then analyses related to our primary research questions.

Preliminary Analyses

First, we assessed whether our conditions were balanced based on age and children's verbal comprehension performance. Independent samples t-test revealed no significant differences based on children's age, $t(80) = 0.22$, $p = .826$, or verbal comprehension performance, $t(80) = 1.05$, $p = .297$. Means and standard deviations are found in Table 5.

Second, we conducted a manipulation check to determine whether dyads in the embedded questions condition provided pre/posttest responses at a greater frequency than dyads in the no embedded questions condition. Whereas the dyads in the embedded questions condition were prompted to respond to the pretest and posttest questions, dyads in the no embedded questions condition also may have provided similar responses by turning statements into questions (e.g., in Table 3, the caregiver in the no embedded questions condition asked a posttest question). To determine whether dyads in the embedded questions condition provided pre/posttest responses at a greater frequency than dyads in the no embedded questions condition, we conducted a linear mixed-effect model testing the effect of condition (embedded questions, no embedded questions) on proportion pre/posttest responses per stem fact pair. We accounted for the participant and trial (i.e., stem fact pair) random intercept. As expected, we found that dyads provided pre/posttest responses more frequently in the embedded questions ($M = .58$, $SD = .31$) than in the no embedded questions condition ($M = .16$, $SD = .16$), $b = .47$, $F(1,78.00) = 81.17$, $p < .001$. Thus, our manipulation led dyads to engage more with the stem facts in the book.

Third, we tested whether children's age and/or verbal comprehension performance related to performance on any of our primary measures (memory integration, stem fact recall, or integration talk measures). As seen in Table 6, age did not significantly correlate with any of the measures. However, verbal comprehension was a significant positive predictor of all measures. Given the strong relations, we controlled children's verbal comprehension in all further analyses to ensure that the effects found were not driven by children's verbal comprehension.

Question 1: Effects of Condition on Tests of Learning Performance

To determine whether condition influenced children's memory integration and/or stem fact recall performance, we conducted mixed-effect models testing the effect of condition on trial-level accuracy. We controlled verbal comprehension and accounted for the random intercept of participant and trial. For all models except for stem fact free recall, we used logistic mixed effect models as accuracy was binary (0,1). We used a linear mixed effect model for stem fact free recall because that measure of accuracy was a continuous measure of the proportion of elements recalled. The results are reported in Table 7 and means and standard deviations in Table 5. As seen in Table 7, condition was a significant predictor of performance for integration free recall, with children in the embedded questions condition having a small but significantly higher odds of correctly integrating during the free recall test ($M = .29$, $SD = .22$) than children in the no embedded questions condition ($M = .19$, $SD = .22$). However, condition did not significantly predict performance on any of the other outcome measures. Verbal comprehension was a significant predictor in all models.

Question 2: Effects of Condition on Integration Talk

Before investigating our research question, we observed caregivers and children's participation in integrating during shared book reading. Descriptively, we observed that on average, caregivers were most likely to initiate that there was an opportunity to integrate (76% of trials with integration talk present) and children were most likely to solve the integration (73% of trials with integration talk present). This showed that caregivers tended to work with their child to engage in integration during reading.

Next to assess whether condition influenced dyads' integration talk, we conducted a logistic mixed effect model testing the effect of condition (embedded questions, no embedded questions) on integration talk accuracy (0,1). We controlled verbal comprehension and accounted for the random intercept of participant and trial. We found a significant effect of condition ($OR = 2.23$, $\chi^2(1) = 6.88$, $p = .009$), such that dyads had a small but significantly higher odds of integrating during book reading when they were in the embedded questions ($M = .42$, $SD = .25$) than in the no embedded questions ($M = .29$, $SD = .29$) condition. There also was a significant effect of verbal comprehension ($OR = 1.03$, $\chi^2(1) = 6.08$, $p = .014$).

Question 3: Effects of Condition and Integration Talk on Test of Learning Performance

To test whether dyads' integrating facts during extratextual talk predicted children's memory integration and stem fact recall performance above and beyond condition, we conducted mixed-effect models testing the effect of integration talk (present, absent) on trial-level accuracy. We controlled the effects of condition (embedded questions, no embedded questions) and verbal comprehension and accounted for the random intercept of participant and trial. As in Question 1, we used logistic mixed-effect models in all analyses except for the analysis of stem fact recall in which we used a linear mixed-effect model. The statistical results are presented in Table 8 and Figures 1 and 2 display the effects. Integration talk significantly predicted children's probability correct on all the memory integration measures above and beyond the effects of condition and children's verbal comprehension. The effect of integration talk had large odds ratios for the free recall and probed open-ended measures and a small odds ratio for the probed total measure. However, integration talk was not a significant predictor of children's stem fact recall on any of the measures. Verbal comprehension remained a significant predictor of performance on all measures, except for integration free recall.

Discussion

In the current research, we assessed whether and how caregiver-child shared book reading and embedded questions within books support young children's semantic learning through memory integration. We hypothesized that condition (embedded questions/no embedded questions) would relate to children's memory integration and stem fact recall performance as well as to dyads' integration talk. Additionally, we predicted that dyads' integration talk would be the strongest predictor of children's memory integration performance, but not of their stem fact recall performance. Our findings mostly provide support for these hypotheses.

In terms of our first question, children in the embedded questions condition had higher memory integration performance during the free recall test than those in the no embedded questions condition. However, counter to our hypothesis, no condition differences were found for any of the other memory integration measures (probed open-ended and probed total), nor were they found for the stem fact recall measures (free recall and probed open-ended). This suggests that the added support for engagement with the stem facts in the embedded questions condition was particularly helpful in facilitating children's memory integration performance when children had the least amount of probing and support for integration.

Regarding our second question, we found that dyads had higher integration talk in the embedded questions than in the no embedded questions condition. Prior research found that embedded questions within books increase on-task extratextual talk (Troseth et al., 2020). Thus, the embedded questions likely supported dyads' integration talk by increasing their engagement with the stem facts, thus making the stem facts more accessible to be used to integrate during book reading.

Lastly in terms of our third question, dyads' integration talk predicted children's memory integration performance above and beyond the effects of condition for all memory integration measures. These effects were specific to memory integration performance as dyads' integration talk did not predict stem fact recall performance. Integrating during book reading likely helped children form an integrated representation of the stem facts, with this integrated representation becoming accessible to use. Support for this explanation comes from our findings that integration talk supported children's memory integration performance across each of the memory integration measures. Additionally, particularly strong support comes from the free recall task. Children had 13.69 higher odds of mentioning an integrated fact during the free recall task (i.e., without being probed for integration) when that fact was integrated during shared book reading. Once the facts were integrated during shared book reading, these integrated facts likely became more accessible to be used by children. This explanation aligns with research showing that once facts are integrated, they become indistinguishable from well-known facts (Bauer & Jackson, 2015).

One remaining question from this research is why condition only significantly predicted children's free recall integration performance and did not significantly predict their performance on any of the probed memory integration measures nor on any of the stem fact recall measures. It is possible that across conditions, our book provided the necessary support for children's encoding of the stem facts to support their probed memory integration as well as their stem fact recall performance. In both conditions, the book's text repeated each fact (stem and filler fact) two times. The text was also cohesive by connecting the facts presented within each topic and providing supportive sentences that elaborated on each fact. Cohesive text can support young children's direct factual learning from books, even without embedded questions (Miller-Goldwater et al., 2023). Considering that there were no significant effects of condition on children's stem fact recall performance, a measure of direct factual learning, our work suggests that children likely encoded the stem facts similarly across conditions. In terms of integration performance, once stem facts are encoded, young children can integrate upon prompts that demand integration (e.g., Bauer & San Souci, 2010). Thus, across conditions, children were likely similarly able to integrate upon demand when asked probed integration questions. In contrast, in the free recall integration task when children were not probed with integration questions, the embedded questions tended to increase dyads' integration talk and likely made the integrated facts more accessible for children in the absence of an integration probe.

Contributions of Current Research

Overall, our findings make several contributions to research on memory integration and indirect factual learning more generally, as well as to research on caregiver-child shared book reading. In terms of contributing to research on memory integration and indirect factual learning, we identified means through which everyday social interactions influence children's indirect learning, specifically memory integration. Prior research on indirect factual learning from books tested children's learning in settings in which an experimenter read books to the participants in the absence of extratextual talk (e.g., Bauer & San Souci, 2010; Strouse & Ganea, 2021). Such research also tended to focus on differences in children's cognitive skills as sources of individual differences (e.g., Currie & Cain, 2015; Esposito & Bauer, 2022). Consistent with past research, we found that children's verbal comprehension related strongly to their memory integration performance. However, this cognitive skill only partially accounted for individual differences in children's performance. We showed that variations in everyday social learning interactions experienced during shared book reading also contribute to individual variations.

Another contribution of this research is that in developing the free recall integration test, we identified a new means of measuring memory integration performance without probing integration. In doing so, we also tested unprobed memory integration in younger children than that of past research. Past research measuring unprobed integration with older children and adults assessed integration indirectly through neuroimaging (Preston et al., 2004; Schlichting et al., 2014) or eye tracking (e.g., Miller-Goldwater et al., 2021). Our test cannot speak to the underlying component processes involved in memory integration like these other tests. However, the present task provides a cost-effective and performance-based measure of memory integration without direct probing for integration.

The current work also makes several contributions to research on shared book reading. It extends past research focused on language and literacy skills as well as on direct factual learning (e.g., Dunst et al., 2012; Miller-Goldwater et al., 2023) to show that both the textual features of books and unscripted caregiver-child shared book reading interactions contribute to children's indirect factual learning. Most past research has not investigated young children's factual learning in the context of caregiver-child shared book reading (discussed in Grover et al., 2023), with no known research investigating indirect learning. The present work thus emphasizes that shared book reading can be a fruitful means of supporting young children's factual learning. This is an especially important finding given that developing a base of factual knowledge is a central task of development and education, and that world knowledge relates to later reading proficiency (e.g., Connor et al., 2016). The present research makes clear that shared book reading is particularly effective when the textual features of books are designed in ways that support children's learning directly as well as indirectly through their effects on promoting caregiver-child talk interactions during book reading. This suggests a readily accessible opportunity for promoting children's accumulation of semantic knowledge. That is, books could be designed with embedded questions and simple instructions to the caregiver to encourage children's attempts to answer the questions and integrate facts. This simple "intervention" could have substantial functional consequences. An additional contribution is that our work identified that when books provide integration opportunities, dyads will work together to integrate the facts to derive new knowledge. We hypothesized that aspects of elaborative extratextual talk may include integration talk (e.g., van Kleeck et al., 1997). However, prior shared book reading research had not directly focused on the integration of semantic facts.

Limitations and Future Directions

Although the current research makes several contributions, it is not without limitations. One limitation is that we used a lab-designed book that had multiple opportunities to integrate facts. We designed this book because we could select facts that were true yet novel to children of this age group. Additionally, we could control the distance between stem facts within a pair and counterbalance the order in which facts were presented. Typically, children's books include integration opportunities; however, they are not necessarily designed with the focus on integration and may not provide many salient integration opportunities. Our work is important in showing that when integration opportunities are present, dyads engage in integrating the facts. However, it will be important for future research to investigate the frequency with which caregiver-child dyads engage in integration talk when reading typical published children's books.

Another limitation is that caregivers in our sample were highly educated and likely of middle to upper socioeconomic status. Prior research found differences in caregivers' extratextual talk styles associated with differences in socioeconomic status and culture (Bus et al., 2000; Heath, 1982; Mol & Neuman, 2014). Future research should test more diverse samples and assess whether there may be differences based on socioeconomic status and/or cultural practices in terms of the effects of embedded questions and engagement in integration talk.

There are a variety of additional future directions to extend this work. One direction is to test the long-term impact of caregiver-child dyads reading books with multiple integration opportunities and to evaluate its impact on children's derivation of new knowledge through memory integration. In the current research, when integration occurred, caregivers tended to initiate that there was an opportunity to integrate the facts and they worked with their child to complete the integration. However, it is unknown whether this type of scaffolding of integration will over time facilitate children in more spontaneously integrating on their own. Past research on shared book reading has shown the long-term impacts of shared book reading on children's language and literacy skills (Barnes & Puccioni, 2017; Demir-Lira et al., 2019). It is thus likely that having caregivers read factual books with their children with multiple integration opportunities would over time promote children's use of memory integration to derive new semantic knowledge.

Another future direction would be to investigate the influence of other social learning contexts on children's engagement in memory integration. One important social learning context to investigate is schools. Prior research has shown that students can integrate information learned in the classroom to derive new knowledge (e.g., Esposito & Bauer, 2022). However, past research has not investigated the influence of teachers in scaffolding integration opportunities. In a related domain, research on memory strategies has shown that teachers vary based on their use of mnemonic language, such as asking students to think about strategies that they could use to solve a task. These differences in teachers' mnemonic language have been shown to relate to differences in their students' use of memory strategies (Coffman et al., 2008). Thus, individual differences in teachers' use of integration talk may relate to differences in students' use of memory integration to derive new knowledge. Another social learning context is museums. Adults have been shown to integrate separate pieces of information learned within virtual museum exhibits to derive new knowledge (Cronin-Golomb & Bauer, 2022). Additionally, caregiver-child dyads have been shown, through their conversations, to transfer information learned in one exhibit to another (Jant et al., 2014). Thus, in addition to schools, it will be important to investigate dyads' experiences in museums to investigate whether and how this everyday social learning environment contributes to individual differences in children's learning of new information through memory integration.

Conclusion

The current research provides insights into how everyday social interactions of shared book reading can influence young children's learning of new semantic facts through memory integration. We found that when books included embedded questions that asked pretest and posttest questions on facts within the book, dyads were more likely to integrate facts across topics. Additionally, the extent to which dyads integrated facts while reading predicted children's integration performance across free recall, probed open-ended, and probed total measures. These findings suggest that shared book reading can be a valuable means of facilitating young children's factual learning through memory integration, particularly when books provide support for integration and when dyads engage in integration talk during book reading.

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Highlights

- Caregivers read to their child a book with opportunities to integrate facts.
- The book either had or did not have embedded questions on the book's facts.
- Questions increased dyads' integration of facts in talk while reading.
- Children's memory integration performance was most predicted by integration talk.
- Shared book reading promotes young children's factual memory integration.

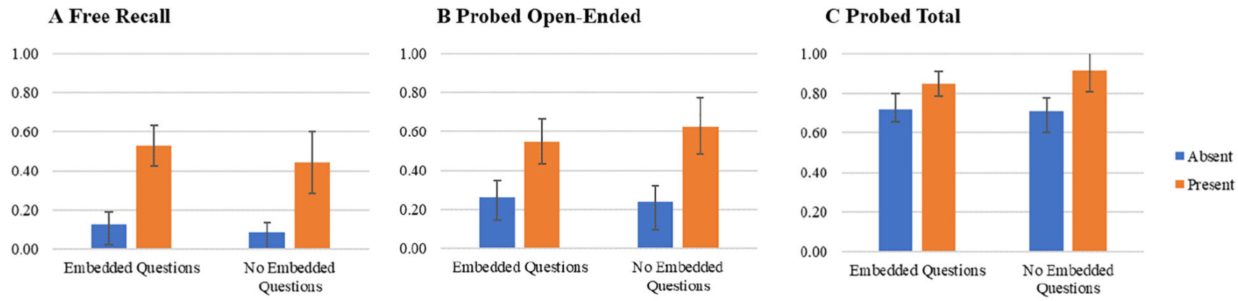


Figure 1.
Condition (embedded questions, no embedded questions) by integration talk (present, absent) on proportion correct memory integration performance for the free recall (A), probed open-ended (B), and probed total (C) measures. The error bars are plotted as 95% confidence intervals.

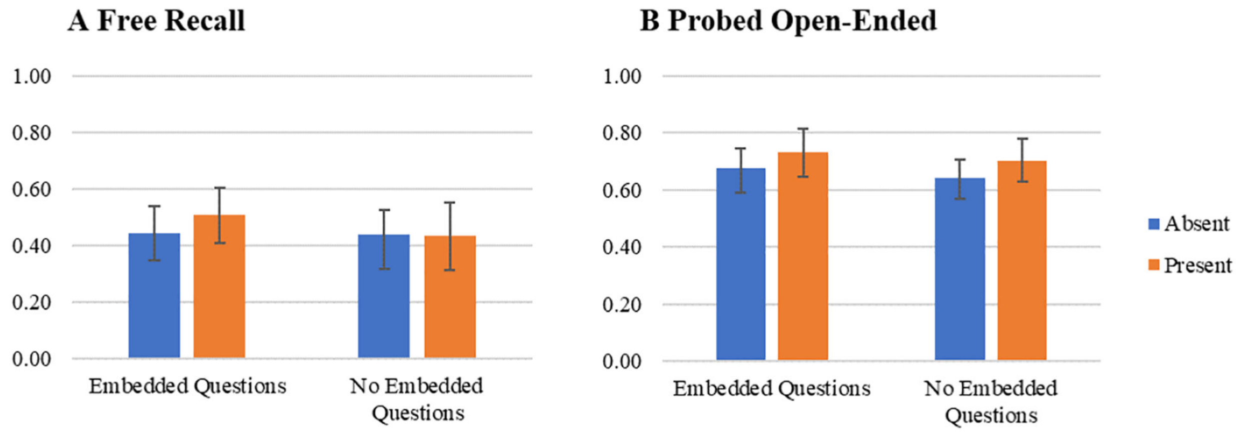


Figure 2.
Condition (embedded questions, no embedded questions) by integration talk (present, absent) on proportion correct stem fact recall for free recall (A) and probed open-ended (B) measures. The error bars are plotted as 95% confidence intervals.

Table 1

A. Sample stem fact pairs

Pair	Type	Topic	Fact
Otter	AB	Communication	Otters communicate by squealing.
	BC	Groups	An animal that communicates by squealing lives in groups called rafts.
Hippo	AB	Names	Hippos have a name that means river horse.
	BC	Communication	The animal whose name means river horse communicates by honking.

B. Sample questions from integration and stem fact recall tests

Pair	Free Recall		Probed Recall		
	Animal	**Topic[a]**	**Open-Ended Integration**	**Open-Ended Stem Fact**	**Forced-choice Integration**
Otter	What did Rosie learn about otters?	What did Rosie learn about animals that live in groups? What did Rosie learn about how animals communicate?	What is the name of the group that otters live in?	How do otters communicate?	What is the name of the group that otters live in? Do they live in groups called loveliness, rafts, or blue?
Hippo	What did Rosie learn about hippos?	What did Rosie learn about how animals communicate? What did Rosie learn about the meaning of animals' names?	How do hippos communicate?	What does the name hippo mean?	How do hippos communicate? Do they communicate by honking, scratching, or squealing?

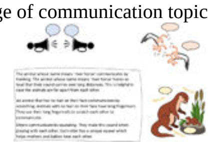
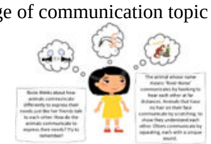
Notes.

[a]Each topic question related to two stem fact pairs. Each topic question was only asked once. Thus, the question in the example, "What did Rosie learn about how animals communicate?" related to both the otter and hippo fact but was only asked one time.

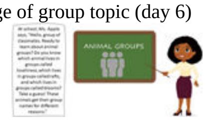
Table 2

Sample pages from the embedded questions condition

A. Sample pages representing the communication topic

Page	Text
1st page of communication topic (day 3) 	On day 3, Rosie walks to school with her friends. They talk the whole way. Rosie says, “It is cool that we are using our mouths to talk today because we are going to learn about how different animals communicate.”
2nd page of communication topic (day 3) 	At school, Ms. Apple says, “No more talking, let’s learn about other ways of communication. Do you know which animal communicates by honking, which communicates by scratching, and which communicates by squealing? Take a guess! Animals communicate in different ways to express their needs.”
3rd page of communication topic (day 3) 	**The animal whose name means ‘river horse’ communicates by honking.** The animal whose name means ‘river horse’ honks so loud that their sound carries over long distances. This is helpful in case the animals are far apart from each other. *An animal that has no hair on their face communicates by scratching.* Animals with no hair on their face have long fingernails. They use their long fingernails to scratch each other to communicate. ***Otters communicate by squealing***. They make this sound when playing with each other. Each otter has a unique squeal which helps mothers and babies hear each other.
4th page of communication topic (day 3) 	Rosie thinks about how animals communicate differently to express their needs just like her friends talk to each other. How do the animals communicate to express their needs? Try to remember! **The animal whose name means ‘River Horse’ communicates by honking to hear each other at far distances**. *Animals that have no hair on their face communicate by scratching to show they understand each other.* ***Otters communicate by squealing, each with a unique sound***.

B. Sample pages representing the group topic

Page	Text
1st page of group topic (day 6) 	On day 6, Rosie walks to school with her friends. She says, “It is great that I have a friend group and each of us has a different family group. I am excited to learn about groups of animals today.”
2nd page of group topic (day 6) 	At school, Ms. Apple says, “Hello, group of classmates. Ready to learn about animal groups? Do you know which animal lives in groups called loveliness, which lives in groups called rafts, and which lives in groups called blooms? Take a guess. These animals get their group names for different reasons.”
3rd page of group topic (day 6) 	*An animal that flies lives in groups called loveliness*. This group got its name because gardeners love seeing these animals that fly in their gardens. Gardeners like it when loveliness come because they help get rid of bugs. ***An animal that communicates by squealing lives in groups called rafts***. This group got its name because these animals that talk by squealing float together. Animals living in groups called rafts sometimes wrap themselves in seaweed, so they stay together. **Sun jellyfish live in groups called blooms.** This group got its name because they have their babies in the spring, just like a flower that blooms. The water moves the sun jellyfish together, and that is how they stay close together in a bloom.
4th page of group topic (day 6)	Rosie thinks about how animals form different groups, just like how her friend group is different from her family group. It is great that each group got its name for a different reason. What are the

	<u>different animals' group names? Try to remember!</u> *An animal that flies lives in groups called loveliness because they make gardeners happy*. ***Animals that communicate by squealing have the group name raft because they float together***. **Sun jellyfish have the group name bloom because they have babies in the spring.**

Note. Stem facts are represented with text that is bold. The stem facts that can be integrated across the two topics in this example are represented in bold and italicized text. Filler facts are represented with text that is italicized only. Pretest and posttest questions are represented by text that is underlined.

Table 3

Examples of Extratextual Talk Coding

	Sample from embedded questions condition		Sample from no embedded questions condition	
	Book's pretest questions: …. which lives in groups called rafts, and which lives in groups called blooms? Child: "**Blue whale** live in blooms I think" Caregiver: "Yes maybe." Book's otter stem fact: An animal that communicates by squealing lives in groups called rafts. Caregiver: ***"What animal lives in groups called rafts? What animal squealed? Remember?*** Child: ***"Otter."*** Caregiver: "Yes." Book's sun jellyfish stem fact: Sun jellyfish live in groups called blooms. Caregiver: "***Hm what did we learn about blooms? Let me see*** (turns pages and reads text from earlier page: ***The animal that lives in groups called blooms is different from other animals because it is the longest.). So, jellyfish are the longest and they live in groups called blooms. "*** Book's posttest question: What are the different animals' group names? Try to remember! Caregiver: "Do you remember what the names were? What were the otters called?" Child: "I don't know." Caregiver: "Remember? They were wrapped together with seaweed." Child: "Jellyfish." Caregiver: "No, the jellyfish was the **bloom**." Caregiver: "It's the animal that communicates by squealing **lives in groups called rafts.** So otters live in rafts. And there's a group that's called the loveliness. And then the jellyfish is called a bloom." Child: "Yes."		Book's pretest statement: We will learn about animals who communicate by honking, scratching, and squealing. Book's hippo stem fact: The animal whose name means 'river horse' communicates by honking. Caregiver: ***"What animal was river horse?"*** Child: "A horse?" Caregiver: "Do horses honk?" Child: "No" Caregiver: ***"Remember hippos are river horse."*** Book's otter stem fact: Otters communicate by squealing. Book's posttest statement: Rosie thinks about how animals communicate differently to express their needs just like her friends talk to each other. Caregiver: "How do otters communicate?" Child: **"Squealing"** Caregiver: "What about the animal whose name means River Horse?" Child: "I do not know." Caregiver: "Ok let's keep reading."	
Measures	**Sample Coding**		**Sample Coding**	
	Otter Fact	**Jellyfish Fact**	**Hippo Fact**	**Otter Fact**
Pretest	0	1	0	0
Posttest	1	1	0	1
Integration Present	1	1	1	0
Integration Initiator	Caregiver	Caregiver	Caregiver	N/A
Integration Solver	Child	Caregiver	Caregiver	N/A

Note. Statements that received pre/posttest responses are represented in bold (only) text. Statements that received an accurate integration talk score are represented in bold and italicized text.

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Table 4

Examples of free recall coding for the otter stem fact pair

Response	Integration	Stem Fact
Animal question (A element prompted): “What did Rosie learn about otters?” Integration = “rafts” (C); Stem fact = “squeal” (B)		
“Otter groups are called rafts because they float.”	1	0
“She learned that the nickname for otter is raft.”	1	0
“That they squeal.”	0	1
“They squeal to their babies to talk.”	0	1
“They are usually in the water.”	0	0
Topic question (B element prompted): “What did Rosie learn about how animals communicate?” Integration = N/A; Stem fact = “otter” (A), “squeal” (B), and “rafts” (C)		
“Otters squeal.”		2
“Some go like squeak squeak.”	NA	1
“They do noises to communicate.”		0
Topic question (C element prompted): “What did Rosie learn about animals that live in groups? Integration = “otters” (A), Stem fact = “squeal” (B) and “rafts” (C)		
“Otters are called rafts.”	1	1
“The animal that squeaks is called rafts.”	0	2
“That some of them are called rafts.”	0	1
“One is raft because the animals float.”	0	1

Note. The A, B, and C letters that are in parentheses represent elements of the stem fact pairs. To receive integration scores, the child needs to associate the A and C elements together. To receive stem fact scores, the child needs to associate the A and B element or B and C element together.

Table 5

Means and standard deviations

Measures		Embedded Questions *M*(*SD*)	No Embedded Questions *M*(*SD*)	Both Conditions *M*(*SD*)
Age (years)		6.10(.43)	6.11(.43)	6.09(.43)
Memory Integration (proportion)	Free Recall	.29(.22)	.19(.22)	.24(.22)
	Probed Open-Ended	.38(.23)	.35(.25)	.37(.24)
	Probed Total	.77(.18)	.77(.21)	.77(.19)
Stem Fact Recall (proportion)	Free Recall	.47(.22)	.44(.18)	.45(.20)
	Probed Open-Ended	.70(.23)	.66(.22)	.68(.22)
Integration Talk (proportion)		.42(.25)	.29(.29)	.36(.27)
Verbal Comprehension (standardized score)		112.05(11.47)	110.73(12.27)	111.38(11.82)

Table 6

Correlations among measures

Measures		Integration			Stem Fact		Verbal Comp.	Integration Talk
		Free Recall	Probed OE	Probed Total	Free Recall	Probed OE		
Age		−.01	.21	.09	.08	.10	−.19	−.11
Integration	Free Recall		.48***	.27*	.43***	.22*	.23*	.49***
	Probed OE			.54***	.24*	.32**	.37***	.55***
	Probed Total				.34**	.18	.37***	.32**
Stem Fact	Free Recall					.35**	.35**	.21
	Probed OE						.39***	.12
Verbal Comprehension								.24*

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Open-ended abbreviated as OE.

Table 7

Statical results for the effects of condition and verbal comprehension on tests of learning performance

Model		Predictor Variable	Odds Ratio/b[a]	$\chi^2(1)/F(1,78)$[a]	*p*-value
Integration	Model 1a: Free Recall	Condition	2.18	6.23	.013
		Verbal Comp.	1.03	5.39	.020
	Model 1b: Probed OE	Condition	1.24	0.73	.393
		Verbal Comp.	1.04	12.97	<.001
	Model 1c: Probed Total	Condition	1.07	0.07	.786
		Verbal Comp.	1.04	12.59	<.001
Stem Fact Recall	Model 1d: Free Recall[a]	Condition	.05	1.32	.254
		Verbal Comp.	.01	11.06	.001
	Model 1e: Probed OE	Condition	1.05	1.19	.276
		Verbal Comp.	1.01	13.78	<.001

Note. All models, except 1d were logistic mixed-effect models, with odds ratio and $\chi^2(1)$.

[a]Model 1d is a linear mixed-effect model with beta and $F(1,77)$. In all models, the participant and trial random intercept were modeled. Open-ended abbreviated as OE.

Table 8

Statical results for the effects of condition, integration talk, and verbal comprehension on tests of learning performance

	Model	Predictor Variable	Odds Ratio/b[a]	$\chi^2(1)$/F[a]	*p*-value
Integration	Model 3a: Free Recall	Condition	1.71	2.11	.146
		Integration Talk	13.69	56.57	<.001
		Verbal Comp.	1.02	1.72	.190
	Model 3b: Probed OE	Condition	0.99	0.00	.964
		Integration Talk	4.43	41.00	<.001
		Verbal Comp.	1.03	9.60	.002
	Model 3c: Probed Total	Condition	0.92	0.10	.748
		Integration Talk	2.71	12.28	.000
		Verbal Comp.	1.04	10.26	.001
Stem Fact Recall	Model 3d: Free Recall[a]	CoiJition[a1]	0.05	1.36	.250
		Integration Talk[a2]	−0.01	0.62	.803
		Verbal Comp.[a3]	0.01	11.09	.001
	Model 3e: Probed OE	Condition	1.05	1.00	.316
		Integration Talk	1.02	0.38	.539
		Verbal Comp.	1.01	13.11	<.001

Note. All models, except 3d were logistic mixed-effect models, with odds ratio and $\chi^2(1)$.

[a]Model 3d is a linear mixed-effect model with beta and *F* values.

The degrees of freedom are a1 (1,78.86), a2(1, 458.28), a3(1, 77.85). In all models, the participant and trial random intercept were modeled. Open-ended abbreviated as OE.