Current Directions in Psychological Science
2019, Vol. 28(2) 111–116

DOI: 10.1177/0963721418806673
www.psychologicalscience.org/CDPS
SAGE

Retrieval-Based Learning in Children

Lisa K. Fazio[1] and **Elizabeth J. Marsh**[2]
[1]Department of Psychology and Human Development, Vanderbilt University, and
[2]Department of Psychology & Neuroscience, Duke University

Abstract
Testing oneself with flash cards, using a clicker to respond to a teacher's questions, and teaching another student are all effective ways to learn information. These learning strategies work, in part, because they require the retrieval of information from memory, a process known to enhance later memory. However, little research has directly examined retrieval-based learning in children. We review the emerging literature on the benefits of retrieval-based learning for preschool and elementary school students and draw on other literatures for further insights. We reveal clear evidence for the benefits of retrieval-based learning in children (starting in infancy). However, we know little about the developmental trajectory. Overall, the benefits are largest when the initial retrieval practice is effortful but successful.

Keywords
retrieval practice, testing, children, education, learning

Testing oneself with flash cards, using a clicker to respond to a teacher's questions, and teaching another student are all useful ways to learn information. These learning strategies work, in part, because they require the retrieval of information from memory, a process known to enhance later memory. Retrieval-based learning is more effective than popular strategies such as rereading and highlighting and promotes learning of a variety of types of information (see Roediger & Butler, 2011, for a review). The benefits of retrieval-based learning are now well established for both adolescents and adults in the laboratory and the classroom (e.g., Roediger, Agarwal, McDaniel, & McDermott, 2011; Roediger & Karpicke, 2006), but much less is known about when and how young children benefit.

We define retrieval-based learning as any situation in which one retrieves previously learned information from memory and retention of that information is later measured. The retrieval can be intentional (a teacher asking a child to spell *eight*) or incidental (a child spontaneously spelling *eight*). In addition, the target of retrieval may be a specific event (a magic show), a procedure (how to make a mobile move), a fact (*azul* means blue), or other types of information.

There are multiple reasons to suspect that retrieval-based learning is an effective strategy for young children. In contrast to learning strategies that place a heavier burden on memory or require an understanding of how memory works, retrieval-based learning can be adapted for the child learner. Critically, retrieval-based learning is useful even when memory fails (as long as feedback is provided; Pashler, Cepeda, Wixted, & Roher, 2005) and does not require metacognitive sophistication (even adults often fail to appreciate its benefits; Karpicke & Roediger, 2008).

There is a small but growing literature on retrieval-based learning in children: Retrieval practice boosts recall of word lists in fourth graders (Karpicke, Blunt, & Smith, 2016), helps third graders learn vocabulary terms (Goossens, Camp, Verkoeijen, Tabbers, & Zwaan, 2014), and improves fourth and fifth graders' memory for map locations (Rohrer, Taylor, & Sholar, 2010). Additional evidence comes from studies on children's autobiographical and eyewitness memory in which children are asked to retrieve memories in response to a parent's prompt or an investigator's query. For example, children interviewed about a classroom event later remember the activity better than children who were not initially interviewed (Hudson, 1990; Memon, Wark, Bull, & Koehnken, 1997). These children were in elementary school (Memon et al., 1997) and preschool (Hudson, 1990), but even infants benefit from retrieval practice. The paradigms (e.g., deferred imitation, mobile conjugate reinforcement) are

Corresponding Author:
Lisa K. Fazio, Vanderbilt University, 230 Appleton Place, #552, Jesup 105, Nashville, TN 37203
E-mail: lisa.fazio@vanderbilt.edu

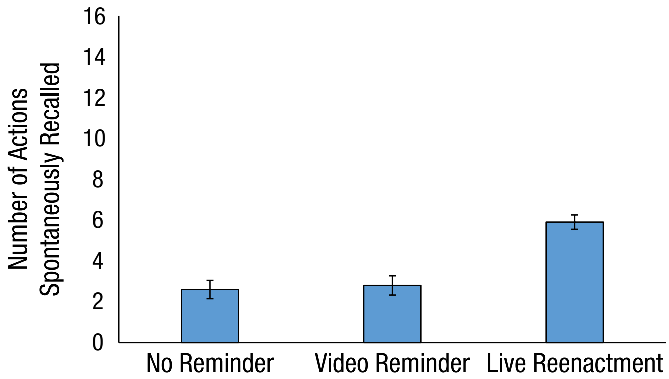

Fig. 1. The mean number of target actions that 18-month-olds spontaneously recalled (retrieved during a free-play session without prompting) during the final test session 12 weeks after learning. Two weeks after learning, children received no reminder, watched a video of the target actions, or were given a chance to recall (reenact) the target actions (with feedback). Error bars show standard errors of the mean. (Data from Sheffield & Hudson, 2006, Experiment 1.)

very different, but the data clearly show that infants benefit from practicing a recently learned action. For example, 2 weeks after learning novel event sequences (e.g., "make a crown" by attaching two plastic jewels and putting the crown on one's head), 18-month-olds either reenacted (retrieved) the sequences or watched a video of them. Retrieval practice led to better memory 12 weeks after learning (Fig. 1; Sheffield & Hudson, 2006). Similarly, 3-month-olds remembered to kick to move a mobile for 14 days if they retrieved the information 3 days after learning but for only 9 days if they simply watched the experimenter move the mobile 3 days after learning (Adler, Wilk, & Rovee-Collier, 2000).

Thus, the same activity, retrieving information from memory, yields memorial benefits for a wide age range of children. The activity can take many forms and be called many names, including reinstatement, reenactment, practice, repeated interviews, retrieval-based learning, and testing, but all share the similarity of requiring retrieval. For example, in the reenactment paradigm, children retrieve previously learned action sequences; in eyewitness studies, children retrieve memories of experienced events in interviews; and in testing paradigms, children retrieve previously learned information to answer questions.

Across literatures, investigations of retrieval practice have unique strengths and weaknesses. The eyewitness-memory literature has the advantage of examining memory over very long delays. However, such studies rarely contain a reexposure (restudy) control, as a reexposure control is not ecologically valid in the context of eyewitness memory. In contrast, education studies often control for reexposure (given that rereading is a common study strategy) but examine relatively short delays and are often limited to one age group. Finally, the research on infants' and toddlers' memories offers insights about how the delay between initial learning and the retrieval opportunity affects memory, but the types of memories studied (nonverbal) and the methods used (e.g., mobile reinforcement) make it difficult to compare the results with those from studies of older children.

In short, there are many examples of children benefiting from retrieval-based learning early in life. Infants as young as 3 months old benefit from an opportunity to retrieve a newly formed association (Adler et al., 2000), preschool children learn the names of toys better if they practice retrieving the names (Fritz, Morris, Nolan, & Singleton, 2007), and elementary school students benefit from retrieving science definitions (Lipko-Speed, Dunlosky, & Rawson, 2014).

Age Differences in the Benefits of Retrieval-Based Learning

Although there are clear examples of children benefiting from retrieval-based learning early in life, we know much less about how these effects may change across development. We know of no longitudinal studies examining the benefits of retrieval practice, and very few studies have directly compared children of different ages. The studies that exist show different patterns, with some finding larger benefits for adults or older children than younger children (Gee & Pipe, 1995; Poole & Lindsay, 2001), others finding larger benefits for younger children (Gates, 1917; Tizzard-Drover & Peterson, 2004), and still others finding no differences (Hudson, 1990; Lipowski, Pyc, Dunlosky, & Rawson, 2014; Principe, Ornstein, Baker-Ward, & Gordon, 2000; Zellner & Bäuml, 2005).

This conflicting pattern of results makes more sense if we consider the mechanisms underlying the benefits of retrieval practice. In the adult literature, much of the work is interpreted within the framework of "desirable difficulties" (Bjork & Bjork, 2011): namely, that some effort or struggle during learning is a good thing as long as the learner is able to overcome the learning challenge. Thus, effortful retrieval should increase memory more than easy retrieval or unsuccessful retrieval. Numerous empirical findings can be accommodated within this framework, including the benefits of varied practice, spacing, and retrieval-based learning (Bjork & Bjork, 2011).

The desirable-difficulties framework clearly highlights the challenges facing the developmental psychologist because the difficulty of retrieval often covaries with age. Thus, any age differences may be driven by differences in ability to retrieve and not in the consequences of successful retrieval. Gates (1917) made this argument when explaining why fourth, sixth, and eighth graders benefited from retrieving nonsense syllables (as opposed to restudying them) but first graders did not—the first graders simply could not retrieve the nonsense syllables during the retrieval practice phase. Thus, retrieval practice was not a desirable difficulty for the first graders—it was simply a difficulty. This retrieval difficulty can be due to young children's immature memory systems (Ghetti & Lee, 2011) or younger children knowing less about a topic (Bjorklund, 1987). But in either case, researchers have to carefully disentangle children's *ability* to retrieve information from the *benefits* they receive from retrieving information.

Another challenge is that some age differences may be better attributed to developmental changes in the control condition rather than to changes in the benefits of retrieval practice. Gates (1917) used this argument to explain why third and fourth graders learning biographies benefited more from retrieval practice than restudying, compared with sixth and eighth graders. Gates hypothesized that both groups benefited equally from retrieval but that the older children learned more from restudying, reducing the difference between the restudy and retrieval conditions for the older children.

At present, the most parsimonious conclusion is that even young infants benefit from retrieval-based learning, but little is known about how the benefits may change across development. Even less is known about how the mechanisms that underlie retrieval-based learning develop over time. Although the desirable-difficulties framework is useful for explaining existing results, it is not a mechanistic account, and it can be difficult to predict a priori which tasks will be desirable difficulties and which will be harmful difficulties. We encourage researchers to use development as a tool to help determine the mechanisms behind retrieval-based learning. For example, semantic elaboration is more likely to occur in older children than younger children (Bjorklund, 1987). Thus, if semantic elaboration is key for retrieval-based learning (Carpenter, 2009), older children should show larger benefits from retrieval practice.

Maximizing the Benefits of Retrieval Practice

In many cases when retrieval-based learning failed to benefit young children, they were unable to retrieve relevant information during retrieval practice (e.g., Karpicke, Blunt, Smith, & Karpicke, 2014; Ornstein et al., 2006; Poole & White, 1991). Thus, one solution is to provide scaffolding or otherwise help young children to perform better during retrieval practice. Asking questions with additional retrieval cues (e.g., "What happened after you saw the giraffe?") will increase retrieval compared with more open questions (e.g., "What happened when you went to the zoo?"). In one example, fourth graders did not benefit from recalling a passage they had read but showed large benefits from answering specific questions (Karpicke et al., 2014).

What is tricky, however, is that too much scaffolding may dilute the benefits of retrieval-based learning. Placing retrieval practice close in time to the to-be-remembered event will increase retrieval success, but it also masses practice and loses the benefits of spacing. Many studies show that young children benefit from spaced learning. For example, children who were interviewed 1 or 6 months after meeting a pirate remembered more about the event 1 year later than children who were interviewed within the first week (Pipe, Sutherland, Webster, Jones, & Rooy, 2004). A similar pattern is found even with infants. Three-month-olds typically remember how to make a mobile move for 5 days after initial training (Galluccio & Rovee-Collier, 2006). As long as practice occurs within this range, infants do better when retrieval practice is delayed longer (e.g., 5 days) than when it is more immediate (3 days; Galluccio & Rovee-Collier, 2006). Similarly, 18-month-olds remember novel event sequences better when they retrieve the sequences 8 weeks after learning compared with 2 weeks (Hudson & Sheffield, 1998).

So how does one ensure that retrieval practice is challenging but not too difficult? One solution is to provide feedback. Children clearly benefit from feedback during retrieval-based learning. For example, compared with retrieving without feedback, retrieving with feedback helped second graders correct errors made on an initial multiple-choice test (Marsh, Fazio, & Goswick, 2012) and promoted fifth graders' learning of definitions of science terms (Lipko-Speed et al., 2014). Given that children as young as 3 years can learn from feedback on other tasks (e.g., Bohlmann & Fenson, 2005), we believe that feedback during retrieval-based learning will be useful for all ages.

In addition, feedback can help students learn from unsuccessful retrieval. In adults, retrieving an incorrect answer and then receiving feedback is more effective than simply studying the correct answer (e.g., Kornell, Hays, & Bjork, 2009). Recent evidence suggests that children also benefit from unsuccessful retrieval. Carneiro, Lapa, and Finn (2018) had children learn weakly associated word pairs (e.g., *dog–paws*). In one condition, the children were asked to guess each associate before it was provided. Children tended to respond with strong associates (e.g., *cat*) and then were corrected (e.g., *paws*). In the other condition, the experimenter guessed incorrectly and was then corrected. As shown in Figure 2, both kindergarteners and second graders performed better on a final test if they had retrieved guesses

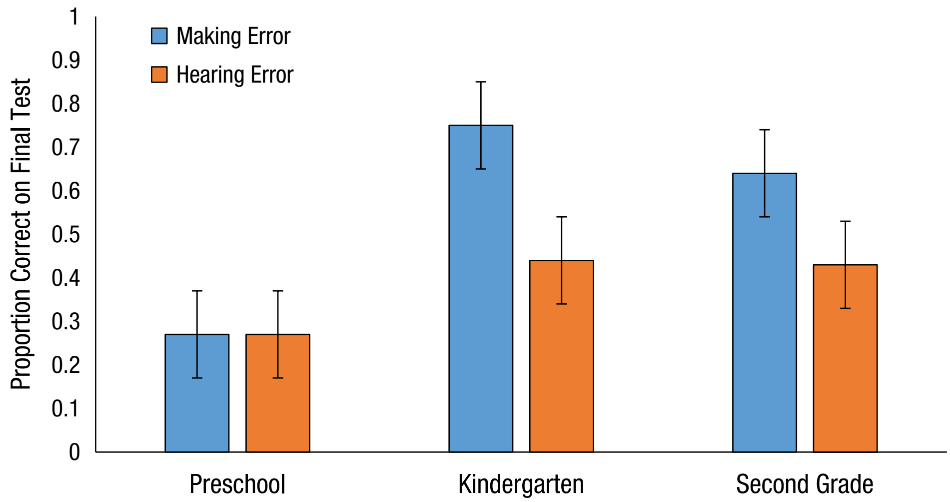

Fig. 2. Children's mean accuracy on a final test after either making an error and receiving feedback or hearing an error and then hearing the correct answer. Both kindergarteners and second graders benefited from the unsuccessful retrieval, but preschoolers did not. Error bars show standard errors of the mean. (Data from Carneiro, Lapa, & Finn, 2018.)

(followed by feedback) during the initial learning as opposed to hearing the experimenter's guess. Preschoolers, however, did not show the same benefits from unsuccessful retrieval (Carneiro et al., 2018).

Importantly, although feedback is useful, especially when initial retrieval success is low, it is not necessary for children to learn from retrieval practice. In situations in which students successfully retrieve most of the information on the initial test, they show benefits from retrieval-based learning without feedback (Jaeger, Eisenkraemer, & Stein, 2015; Karpicke et al., 2016). Although we advise practitioners to incorporate feedback into retrieval-based learning, researchers should be aware that providing feedback prevents one from cleanly examining the benefits of retrieval-based learning. Paradigms that include feedback are measuring not only participants' ability to learn from retrieval but also their ability to learn from feedback.

Open Questions

As mentioned previously, one major open question involves whether the benefits of retrieval-based learning change across development. Future cross-sectional and longitudinal studies are needed that pay attention to the roles of prior knowledge, initial retrieval success, and the provision of feedback. Another key question is how to identify the "sweet spot" in which retrieval is a desirable difficulty. When children are able to retrieve the information without any effort (e.g., on an immediate test), retrieval-based learning is ineffective, but it is also ineffective when children are unable to retrieve the information (Karpicke et al., 2014; Pipe et al., 2004). Finally, most studies have examined typically developing children and have ignored any individual differences between children. Within the eyewitness-memory literature, children with and without intellectual disabilities show similar benefits from repeated interviews (Brown, Lewis, & Lamb, 2015), but no such examination has occurred within the academic context. Similarly, both reading comprehension and overall processing speed are unrelated to the size of the retrieval-based learning benefit in fourth graders learning word lists (Karpicke et al., 2016). We do not, however, know of any studies linking children's working memory scores to retrieval benefits, even though there is some evidence that undergraduates with lower working memory scores benefit more from retrieval-based learning (Agarwal, Finley, Rose, & Roediger, 2017). In short, there is currently no evidence that individual differences play a large role in how much children benefit from retrieval-based learning, but very little research has been conducted on this topic.

Conclusions

Researchers have only recently begun to directly examine the effects of retrieval-based learning in children. However, by combining research on educational strategies, eyewitness memory, and deferred imitation, we found an extensive research base demonstrating clear benefits of retrieval-based learning in children. Children (from infancy to elementary school) regularly retain more information when they are given a chance to retrieve the information from memory.

Recommended Reading

Bjork, E. L., & Bjork, R. A. (2011). (See References). An introduction to the concept of desirable difficulties.

Fivush, R., & Schwarzmueller, A. (1995). Say it once again: Effects of repeated questions on children's event recall. *Journal of Traumatic Stress*, *8*, 555–580. doi:10.1002/jts.2490080404. A review of the effects of repeated interviews on children's event recall.

Hudson, J. A., & Grysman, A. (2013). Extending the life of a memory: Effects of reminders on children's long-term event memory. In P. J. Bauer & R. Fivush (Eds.), *The Wiley handbook on the development of children's memory* (Vol. 1, pp. 255–284). A recent review of the effects of reminders on children's event memory.

Action Editor

Randall W. Engle served as action editor for this article.

ORCID iD

Lisa K. Fazio https://orcid.org/0000-0002-0415-4862

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

References

Adler, S. A., Wilk, A., & Rovee-Collier, C. (2000). Reinstatement versus reactivation effects on active memory in infants. *Journal of Experimental Child Psychology*, *75*, 93–115. doi:10.1006/jecp.1999.2531

Agarwal, P. K., Finley, J. R., Rose, N. S., & Roediger, H. L. (2017). Benefits from retrieval practice are greater for students with lower working memory capacity. *Memory*, *25*, 764–771. doi:10.1080/09658211.2016.1220579

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L. M. Hough, & J. R. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society* (pp. 56–64). New York, NY: Worth Publishers.

Bjorklund, D. F. (1987). How age changes in knowledge base contribute to the development of children's memory: An interpretive review. *Developmental Review*, *7*, 93–130. doi:10.1016/0273-2297(87)90007-4

Bohlmann, N. L., & Fenson, L. (2005). The effects of feedback on perseverative errors in preschool aged children. *Journal of Cognition and Development*, *6*, 119–131. doi:10.1207/s15327647jcd0601_7

Brown, D. A., Lewis, C. N., & Lamb, M. E. (2015). Preserving the past: An early interview improves delayed event memory in children with intellectual disabilities. *Child Development*, *86*, 1031–1047. doi:10.1111/cdev.12364

Carneiro, P., Lapa, A., & Finn, B. (2018). The effect of unsuccessful retrieval on children's subsequent learning. *Journal of Experimental Child Psychology*, *166*, 400–420. doi:10.1016/j.jecp.2017.09.010

Carpenter, S. K. (2009). Cue strength as a moderator of the testing effect: The benefits of elaborative retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 1563–1569.

Fritz, C. O., Morris, P. E., Nolan, D., & Singleton, J. (2007). Expanding retrieval practice: An effective aid to preschool children's learning. *The Quarterly Journal of Experimental Psychology*, *60*, 991–1004.

Galluccio, L., & Rovee-Collier, C. (2006). Nonuniform effects of reinstatement within the time window. *Learning and Motivation*, *37*, 1–17. doi:10.1016/j.lmot.2005.01.002

Gates, A. I. (1917). Recitation as a factor in memorizing. *Archives of Psychology: No. 40*. New York, NY: The Science Press.

Gee, S., & Pipe, M.-E. (1995). Helping children to remember: The influence of object cues on children's accounts of a real event. *Developmental Psychology*, *31*, 746–758.

Ghetti, S., & Lee, J. (2011). Children's episodic memory. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*, 365–373. doi:10.1002/wcs.114

Goossens, N. A. M. C., Camp, G., Verkoeijen, P. P. J. L., Tabbers, H. K., & Zwaan, R. A. (2014). The benefit of retrieval practice over elaborative restudy in primary school vocabulary learning. *Journal of Applied Research in Memory and Cognition*, *3*, 177–182.

Hudson, J. A. (1990). Constructive processing in children's event memory. *Developmental Psychology*, *26*, 180–187.

Hudson, J. A., & Sheffield, E. G. (1998). Déjà vu all over again: Effects of reenactment on toddlers' event memory. *Child Development*, *69*, 51–67. doi:10.1111/j.1467-8624.1998.tb06132.x

Jaeger, A., Eisenkraemer, R. E., & Stein, L. M. (2015). Test-enhanced learning in third-grade children. *Educational Psychology*, *35*, 513–521.

Karpicke, J. D., Blunt, J. R., & Smith, M. A. (2016). Retrieval-based learning: Positive effects of retrieval practice in elementary school children. *Frontiers in Psychology*, *7*, Article 350. doi:10.3389/fpsyg.2016.00350

Karpicke, J. D., Blunt, J. R., Smith, M. A., & Karpicke, S. S. (2014). Retrieval-based learning: The need for guided retrieval in elementary school children. *Journal of Applied Research in Memory and Cognition*, *3*, 198–206.

Karpicke, J. D., & Roediger, H. L., III. (2008). The critical importance of retrieval for learning. *Science*, *319*, 966–968.

Kornell, N., Hays, M. J., & Bjork, R. A. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 989–998.

Lipko-Speed, A., Dunlosky, J., & Rawson, K. A. (2014). Does testing with feedback help grade-school children learn key concepts in science? *Journal of Applied Research in Memory and Cognition*, *3*, 171–176.

Lipowski, S. L., Pyc, M. A., Dunlosky, J., & Rawson, K. A. (2014). Establishing and explaining the testing effect in free recall for young children. *Developmental Psychology*, *50*, 994–1000. doi:10.1037/a0035202

Marsh, E. J., Fazio, L. K., & Goswick, A. E. (2012). Memorial consequences of testing school-aged children. *Memory*, *20*, 899–906. doi:10.1080/09658211.2012.708757

Memon, A., Wark, L., Bull, R., & Koehnken, G. (1997). Isolating the effects of the cognitive interview techniques. *British Journal of Psychology*, *88*, 179–197. doi:10.1111/j.2044-8295.1997.tb02629.x

Ornstein, P. A., Baker-Ward, L., Gordon, B. N., Pelphrey, K. A., Tyler, C. S., & Gramzow, E. (2006). The influence of prior knowledge and repeated questioning on children's long-term retention of the details of a pediatric examination. *Developmental Psychology*, *42*, 332–344. doi:10.1037/0012-1649.42.2.332

Pashler, H., Cepeda, N. J., Wixted, J. T., & Roher, D. (2005). When does feedback facilitate learning of words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 3–8.

Pipe, M. E., Sutherland, R., Webster, N., Jones, C., & Rooy, D. L. (2004). Do early interviews affect children's long-term event recall? *Applied Cognitive Psychology*, *18*, 823–839. doi:10.1002/acp.1053

Poole, D. A., & Lindsay, D. S. (2001). Children's eyewitness reports after exposure to misinformation from parents. *Journal of Experimental Psychology: Applied*, *7*, 27–50. doi:10.1037/1076-898X.7.1.27

Poole, D. A., & White, L. T. (1991). Effects of question repetition on the eyewitness testimony of children and adults. *Developmental Psychology*, *27*, 975–986. doi:10.1037/0012-1649.27.6.975

Principe, G. F., Ornstein, P. A., Baker-Ward, L., & Gordon, B. N. (2000). The effects of intervening experiences on children's memory for a physical examination. *Applied Cognitive Psychology*, *14*, 59–80.

Roediger, H. L., III, Agarwal, P. K., McDaniel, M. A., & McDermott, K. B. (2011). Test-enhanced learning in the classroom: Long-term improvements from quizzing. *Journal of Experimental Psychology: Applied*, *17*, 382–395. doi:10.1037/a0026252

Roediger, H. L., III, & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, *15*, 20–27. doi:10.1016/j.tics.2010.09.003

Roediger, H. L., III, & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, *17*, 249–255.

Rohrer, D., Taylor, K., & Sholar, B. (2010). Tests enhance the transfer of learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*, 233–239.

Sheffield, E. G., & Hudson, J. A. (2006). You must remember this: Effects of video and photograph reminders on 18-month-olds' event memory. *Journal of Cognition and Development*, *7*, 73–93. doi:10.1207/s15327647jcd0701_4

Tizzard-Drover, T., & Peterson, C. (2004). The influence of an early interview on long-term recall: A comparative analysis. *Applied Cognitive Psychology*, *18*, 727–743. doi:10.1002/acp.1028

Zellner, M., & Bäuml, K.-H. (2005). Intact retrieval inhibition in children's episodic recall. *Memory & Cognition*, *33*, 396–404.