The role of mediator strength in learning from retrieval

Shana K. Carpenter [a,*], Kam Leung Yeung [b]

[a] Department of Psychology, Iowa State University, United States
[b] Department of Psychology, University of North Florida, United States

ARTICLE INFO

ABSTRACT

Previous studies have provided support for the idea that information activated during retrieval can act as a mediator that facilitates later recall of a target. Evidence for this has been obtained from a paradigm involving independent cues in which participants initially learn cue-target pairs through retrieval (*Mother: _____*) or restudying (*Mother: Child*), and later show stronger benefits of retrieval over restudy in recalling targets from final test cues that are strongly related to the original cue (*Father: _____*) compared to cues that are unrelated to the original cues (*Birth: _____*). The current study used a new paradigm to explore the role of mediators in learning from retrieval by comparing the advantage of retrieval over restudying for cue-target pairs that varied in mediator strength (i.e., the strength of the strongest first associate to the cue). Across three experiments, items higher in mediator strength (e.g., *Chalk: Crayon*, with *Chalk* producing its strongest first associate *Board* at a rate of .69) produced stronger testing effects than items lower in mediator strength (e.g., *Soup: Onion*, with *Soup* producing its strongest first associate *Chicken* at a rate of .10). Item analyses revealed that mediator strength was positively associated with final test recall of items learned through retrieval but not through restudying, and this relationship held after controlling for other linguistic properties of the cues.

© 2016 Elsevier Inc. All rights reserved.

Introduction

Several decades of research have shown that the process of retrieving information from memory, as compared to restudying it, produces significant enhancements in later memory for that information (for recent reviews, see Carpenter, 2012; Delaney, Verkoeijen, & Spirgel, 2010; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Kornell & Vaughn, in press; Roediger, Putnam, & Smith, 2011). The *testing effect*—also referred to as retrieval practice—has been demonstrated in hundreds of studies with a wide range of verbal materials, ranging from fairly simple word lists and word pairs (Carpenter, Pashler,

Wixted, & Vul, 2008; Finn & Roediger, 2011; Kang & Pashler, 2014; Karpicke & Zaromb, 2010; Kuo & Hirshman, 1997; Peterson & Mulligan, 2013; Pyc & Rawson, 2010; Vaughn & Rawson, 2011; Vaughn, Rawson, & Pyc, 2013; Zaromb & Roediger, 2010), to more complex phrases and text passages (Agarwal, Karpicke, Kang, Roediger, & McDermott, 2008; Butler, 2010; Hinze & Wiley, 2011; Hinze, Wiley, & Pellegrino, 2013; Kubik, Söderlund, Nilsson, & Jönsson, 2014; Roediger & Karpicke, 2006).

The benefits of retrieval have been demonstrated in both laboratory studies (see Rowland, 2014, for a recent meta-analysis), and in classroom-based studies using realistic course materials (Carpenter, Pashler, & Cepeda, 2009; Carpenter et al., 2016; Goossens, Camp, Verkoeijen, Tabbers, & Zwaan, 2014; Jaeger, Eisenkraemer, & Stein, 2015; Karpicke, Blunt, Smith, & Karpicke, 2014; McDaniel, Anderson, Derbish, & Morrisette, 2007;

McDaniel, Wildman, & Anderson, 2012). The consensus from these studies is that retrieval is a powerful mnemonic, often producing sizeable benefits on long-term memory under a variety of conditions (for recent boundary conditions to the effect, however, see Carpenter et al., 2016, and Kelly, Carpenter, & Sjolund, 2015).

Numerous empirical demonstrations of the testing effect currently outweigh our theoretical understanding of it, however. Compared to many studies that have demonstrated the benefits of retrieval, there is a shortage of studies designed to explore the more difficult question of *why* retrieval benefits memory. According to one recent account, the *elaborative retrieval hypothesis* (Carpenter, 2009, 2011), the act of retrieving a target from a cue activates cue-relevant information that becomes incorporated with the successfully-retrieved target, providing a more elaborate representation that consists of additional retrieval pathways that can be used to access the target at a later time. This activation of cue-relevant information is less likely to occur during restudy of cue-target pairs, because the target is readily available and does not need to be searched for in memory.

In one study exploring this hypothesis (Carpenter, 2011), participants learned weakly-related cue-target pairs (e.g., *Mother: Child*) by studying a list of these pairs, followed by a cued recall test (*Mother: _____*) without feedback, or a restudy opportunity over the pairs. A later final test over the same cue-target pairs demonstrated that items learned through cued recall were retained better than items learned through restudy. For different groups of participants, the final test involved cued recall of the targets from new cues that had not been shown before. Some participants received new cues that were strongly related to the original cue but not to the target. For example, according to word association norms (Nelson, McEvoy, & Schreiber, 2004), the forward associative strength between the original cue *Mother*, and the word *Father*, is .60. Other participants received new cues that were never presented and were not related to the original cue but were weakly related to the target. For example, the forward associative strength between *Mother* and *Birth* is 0, but the forward strength between *Birth* and *Child* is .02.

The purpose of providing these new cues was to evaluate whether the information activated during retrieval contributes to later retention. If the process of recalling a target from a cue (*Mother: _____*) activates cue-related information, then a word or concept closely related to the cue (*Father*) may become activated, and if the target is successfully recalled, this *mediator* could provide an additional retrieval cue to facilitate later retrieval of the target. Mediator cues like *Father* would therefore be expected to facilitate retrieval of tested items more so than restudied items, as the activation of mediators would ordinarily be less likely to occur during restudy. In contrast, a word that is unrelated to the original cue (*Birth*) would be less likely to become activated during retrieval. According to this hypothesis, the relative advantage for tested items over restudied items, therefore, would be stronger for mediator cues (*Father*) than for unrelated cues (*Birth*). This interaction was indeed observed in Carpenter's

(2011, Experiment 2) study, lending support to the idea that information activated during retrieval facilitates later retrieval of target items.

One recent study replicated and extended this effect by demonstrating that the interaction reflecting the effects of elaborative retrieval—i.e., a larger advantage of testing over restudying for mediator cues compared to unrelated cues—is stronger when lists are repeated at long lags compared to short lags (Rawson, Vaughn, & Carpenter, 2015). The effects of elaboration during retrieval are expected to be stronger when items are repeated at long lags because the extended list renders the target item less accessible such that the activation of cue-relevant, non-target information during retrieval is more likely to occur. Indeed, final test performance in this study revealed the same two-way interaction reported by Carpenter (2011, Experiment 2), in addition to a three-way interaction demonstrating that the elaborative retrieval effect was stronger for items learned at long lags compared to short lags.

Previous studies have explored the role of elaboration in the testing effect by manipulating the type of cue provided during a final test—one that is either strongly associated with the original cue—i.e., a mediator—or one that is not associated with the original cue (Carpenter, 2011; Rawson et al., 2015). Important to theoretical development is the use of different methods that can measure a given construct and provide converging evidence to support it, or boundary conditions to identify its limits. To that end, the current study used a new paradigm to explore the role of mediators in learning from retrieval. Instead of manipulating the type of independent cue given on the final test, the current study used the original cues via the standard testing effect paradigm, and varied the strength of association between the cue and mediator.

Some words have stronger mediators than others. For example, according to Nelson et al.'s (2004) norms, the word *Chalk* produces its strongest forward associate *Board* at a rate of 69%. The word *Soup*, on the other hand, produces its strongest forward associate *Chicken* at a rate of only 10%. Thus, a strong forward associate—i.e., the mediator—would be more likely to be activated when *Chalk* is the cue than when *Soup* is the cue. If activation of these mediators contributes to later retrieval of the target, then the testing effect might be expected to be stronger for word pairs with stronger mediators (*Chalk – Crayon*) than for word pairs with weaker mediators (*Soup – Onion*).

To test this hypothesis, we assembled a unique set of 44 items (see Appendix) that varied in mediator strength but for which a number of other cue properties was controlled. Mediator strength was defined as the forward strength between the cue and its strongest associate, according to the norms of Nelson et al. (2004). For example, the cue *Ball* produces the mediator *Bat* 19% of the time, and the cue *Bird* produces the mediator *Fly* 21% of the time. Mediator strength across the 44 items ranged from 10% (for the cue *Soup*) to 69% (for the cue *Chalk*). For each cue, we used Nelson et al.'s norms to select a target word that was not the mediator and was weakly associated with its cue at a forward strength of about 2%, on average. Backward