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Separate mnemonic effects of retrieval practice and elaborative encoding

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ABSTRACT

Does retrieval practice produce learning because it is an especially effective way to induce elaborative encoding? Four experiments examined this question. Subjects learned word pairs across alternating study and recall periods, and once an item was recalled it was dropped from further practice, repeatedly studied, or repeatedly retrieved on repeated recall trials. In elaborative study conditions, subjects used an imagery-based keyword method (Experiments 1–2) or a verbal elaboration method (Experiment 3) to encode items during repeated study trials. On a criterial test 1 week after the initial learning phase, repeated retrieval produced better long-term retention than repeated study even under elaborative study conditions. Elaborative studying improved initial encoding when it occurred prior to the first correct recall of an item, but while repeated retrieval enhanced long-term retention, elaboration produced no measurable learning when it occurred after successful retrieval. Experiment 4 used identical item word pairs (e.g., *castle–castle*) to reduce or eliminate verbal elaboration, and robust effects of repeated retrieval were still observed with these materials. Retrieval practice likely produces learning by virtue of mechanisms other than elaboration.

Introduction

When people reconstruct the past, each act of retrieval changes memory in important ways. Practicing retrieval enhances learning and long-term retention more than does spending equivalent time repeatedly studying (Roediger & Karpicke, 2006b). This finding is counterintuitive in light of a number of conventional ideas about how learning happens. Learning is generally thought to occur during study episodes, when people encode new knowledge and experiences, and retrieval provides the opportunity to measure the learning that occurred during study episodes (Karpicke & Roediger, 2007). The fact that repeated retrieval produces learning is surprising because it represents learning that occurs even after people have carried out encoding processes that are sufficient to support successful retrieval (see Karpicke, in press; Karpicke & Grimaldi, 2012).

This article is concerned with the nature of the mnemonic effects of retrieval practice. One idea about the benefits of retrieval practice is that a retrieval event represents an especially effective elaborative encoding opportunity. This idea has been proposed in one form or another by several authors. McDaniel and Masson (1985) wrote that recall testing produced "an elaboration of an existing memory representation that increases the variability of encoded information" (p. 383). Kang (2010) described the idea that "effortful retrieval promotes the activation of more elaborative information, relative to less effortful retrieval or rereading, hence establishing more retrieval routes and increasing later retention" (p. 1009). In a recent review, Roediger and Butler (2011) summarized the general elaboration perspective: "One idea is that retrieval of information from memory leads to elaboration of the memory trace and/or the creation of additional retrieval routes, which makes it more likely that the information will be successfully retrieved again in the future" (p. 24).

Other authors have been more explicit about the meaning of elaboration and its role in retrieval practice effects.

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Pyc and Rawson (2010) proposed a "mediator effectiveness hypothesis" as an explanation for why tests improve learning. Their idea was that tests enhance the processing of mediating words (words that link together cue and target words in paired-associate situations). For example, when subjects study a word pair like *wingu–cloud*, they may produce a word like *bird* as a verbal elaboration or mediator to help form a link between the cue and target. (We use the terms verbal elaboration and mediator synonymously in this article.) Pyc and Rawson's idea seems most relevant to the learning that occurs from failed retrieval attempts. That is, when subjects attempt retrieval and fail, they are likely to create a new, different elaboration during a subsequent study opportunity (Pyc & Rawson, in press; see too Grimaldi & Karpicke, in press). Nevertheless, the mediator effectiveness idea may also mean that the processing of elaborations or mediators is enhanced during the retrieval process itself, and this enhancement could be considered the operative mechanism responsible for the positive effects of repeated retrieval even in the absence of restudy (referred to as direct effects of retrieval on learning; Roediger & Karpicke, 2006a).

Carpenter (2009, 2011) has been explicit about the role of elaboration during the process of retrieval. The idea is that when people attempt to recall a target (again, in paired associate situations), they produce several words related to the cue and the desired target, and the production of related words is what facilitates long-term recall of the targets. The production of related words has been referred to as elaboration, and the idea bears similarity to the one proposed by Pyc and Rawson (2010). The production of elaborating (mediating) words is thought to enhance recall of the target word, and this type of elaboration is thought to be the mechanism responsible for repeated retrieval effects because "such elaboration seems more likely to occur during retrieval than during restudy" (Carpenter, 2009, p. 1564).

Considered broadly, elaboration refers to the process of encoding more features or attributes to the representation of an event. Typically, the additional features are conceptualized as semantic or meaning-based, and the encoding of additional features is assumed to aid the ultimate discrimination process that occurs during retrieval. Greater elaboration during encoding is thought to produce detailed and distinctive representations, and these enriched descriptions help distinguish elaborated items from other candidate items at the time of retrieval. Consequently, elaboration may enhance memory because it increases the number of retrieval cues that are potentially effective for recovering elaborated items (see Craik, 2002; Craik & Tulving, 1975; Hunt & McDaniel, 1993; Jacoby & Craik, 1979; Lockhart & Craik, 1990; see too Nairne, 2002).

When any condition is found to enhance learning, it is often assumed that the enhancement must have occurred because that condition induced elaboration. The same type of reasoning has been applied to the effects of repeated retrieval practice. Retrieval may involve deep, elaborative processing, and therefore retrieval practice may operate just like any other elaborative study task. This view would preserve the fundamental idea that elaborative studying is the primary mechanism responsible for producing learning. In other words, practicing retrieval might produce learning not because of processes unique to the act of retrieving knowledge, per se, but because of elaborative encoding processes that happen to occur during repeated tests.

Most research on retrieval practice effects has compared the effects of repeated retrieval conditions to repeated study conditions that are matched on total exposure time (Roediger & Karpicke, 2006b). It is possible that the difference between repeated retrieval and repeated study conditions simply reflects the difference that would occur between any elaborative and nonelaborative learning conditions. This perspective leads to a straightforward prediction: If elaboration is the operative mechanism responsible for the effects of repeated retrieval, then it ought to be possible to induce elaboration directly during repeated study events and produce effects that are the same as or similar to those produced by repeated retrieval.

On the contrary, there are reasons to think that the nature of what happens during repeated retrieval is different from what happens during elaborative encoding. First, consider that the effects of retrieval practice continue to occur post-retrieval, after an item has been successfully recovered (Karpicke, 2009; Karpicke & Bauernschmidt, 2011; Karpicke & Roediger, 2008). Prior encoding operations would have already established mnemonic features that are sufficient to support successful retrieval. In addition, once items have been recalled, repeated retrieval is largely successful on future recall tests; rates of intertest retention are quite high and rates of intertest forgetting are low, at least with paired-associate materials (Karpicke, 2009). Once a person can successfully retrieve an item, it is not clear that additional elaboration would be necessary to improve the discrimination problem in subsequent retrieval events.

Instead, the mnemonic benefits of retrieval may be due to processes inherent to the act of retrieval itself. Retrieval involves establishing or delimiting a set of retrieval cues (a search set) and then using those cues to discriminate what target events did or did not occur (Raaijmakers & Shiffrin, 1980, 1981; see too Nairne, 2006; Surprenant & Neath, 2009). The processes involved in using retrieval cues to determine the prior occurrence of events by discriminating among candidates and selecting target responses are assumed to be unique to retrieval. That is, these are not the same processes thought to occur when people engage in elaborative encoding. This theoretical perspective suggests that elaborative study methods may not produce the same effects on long-term retention as those produced by engaging in repeated retrieval.

The four experiments reported here examined the effects of retrieval practice and elaborative encoding on learning and long-term retention. In an initial learning phase, subjects studied and recalled word pairs across a series of study and recall periods and continued until they had recalled each item. This method helps control for item-selection differences between repeated retrieval and repeated study conditions by ensuring that subjects recall all items during the learning phase (Karpicke, 2009;