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Enhancing learning by retrieval: Enriching free recall with elaborative prompting

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ABSTRACT

It is well-established in memory research that retrieval fosters learning. When applying this effect in education, it is an important question which type of retrieval task works best. Several studies have shown that learning is enhanced by linking new information with prior knowledge. A potential approach to making retrieval more effective, therefore, is to enrich retrieval instructions with the requirement to elaborate on the learning contents and link them to what is already known. In this study, we compared a free recall condition, as used in many studies on learning by retrieval, with a prompted recall condition in which learners were required to recall the information and apply it to their lives. Fifty-six undergraduate students were randomly assigned to one of these two conditions. They learned from a video-recorded lecture. One week later, learning outcomes were assessed by a posttest measuring fact recall and comprehension of the contents from the video lecture. Learners in the prompted recall group, compared to the free recall group, used more elaborative strategies in response to the recall task and achieved better comprehension scores. The effect on comprehension was mediated by the use of elaborative strategies. This pattern of results supports the constructive retrieval hypothesis, stating that retrieval is most effective when it involves constructive elaboration of the contents being learned. Our findings also encourage the use of pedagogical tasks in classroom teaching that combine elaboration and retrieval.

1. Introduction

Many studies have shown that retrieval enhances learning. When students receive instruction over some information via a lecture or reading assignment, practicing to recall that information afterward increases the chances that it will be recalled again in the future. Information that students practice recalling is retained significantly better than information that they do not practice recalling (McDaniel, Thomas, Agarwal, McDermott, & Roediger, 2013; Wheeler & Roediger, 1992). Furthermore, practicing to recall information enhances later retention even when compared to alternative, non-retrieval-based strategies that involve additional exposure to the material, such as copying the information (Carpenter et al., 2016), re-reading it (Roediger & Karpicke, 2006; Roediger, Agarwal, McDaniel, & McDermott, 2011), or organizing it in a new way (Coane, 2013; Goossens, Camp, Verkoeijen, Tabbers, & Zwaan, 2014).

A large number of studies has confirmed that retrieval is an effective tool for learning a variety of information (for recent reviews, see Carpenter, 2012; Delaney, Verkoeijen, & Spirgel, 2010; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Roediger, Putnam, & Smith, 2011; Rowland, 2014), and can be readily applied to enhancing students learning in their courses (Carpenter, Pashler, & Cepeda, 2009; Carpenter, Sachs, Martin, Schmidt, & Looft, 2012; Carpenter et al., 2016; Goossens et al., 2014; Jaeger, Eisenkraemer, & Stein, 2015; Karpicke, Blunt, Smith, & Karpicke, 2014; McDaniel, Anderson, Derbish, & Morrisette, 2007; McDaniel, Wildman, & Anderson, 2012; Roediger et al., 2011). Given these findings, practice testing has often been advocated as a pedagogical tool that should be implemented to enhance learning in educational settings (Carpenter, 2014; Pashler et al., 2007; Roediger & Pyc, 2012).

Studies exploring the benefits of retrieval typically use a fairly

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straightforward test such as free recall, cued recall, or multiple-choice, and find that retrieval is beneficial for learning. Less common, however, are efforts to modify the retrieval task in a way that produces even greater benefits on learning. Some studies have shown that higher doses of retrieval practice — that is, practicing to recall term-definitions to a criterion of three correct recalls, instead of just one — can increase the effectiveness of retrieval for both long-term retention and savings in re-learning (Rawson & Dunlosky, 2011, 2013; see also). The long-term benefits of repeated retrieval are also greater when students engage in retrieval attempts that are distributed in time, or "spaced out," relative to the same number of retrieval attempts that occur in closer proximity (e.g., Carpenter & DeLosh, 2005; Carpenter & Yeung, 2017; Pashler, Zarow, & Triplett, 2003; Pavlik & Anderson, 2005; Pyc & Rawson, 2012; Rawson & Dunlosky, 2013; Rawson, Vaughn, & Carpenter, 2015). Finally, retrieval practice can be more effective when students practice answering higher-order questions of the type that require comprehension and application, as opposed to relatively discrete fact-based questions (Jensen, McDaniel, Woodard, & Kummer, 2014).

Thus, the effectiveness of retrieval may be enhanced by spacing out repeated retrieval attempts, or by asking deep comprehension questions. Implementing these techniques in instructional settings may not be completely straightforward, however. These factors have the effect of making retrieval more challenging, which could create undesirable consequences. There is some evidence that if retrieval is too difficult, it may be ineffective, or even *counter*-effective, for some learners (e.g., see Carpenter et al., 2016; Karpicke et al., 2014; van Gog & Sweller, 2015).

An alternative approach to optimizing retrieval practice is to allow learners to retrieve the information while applying a deliberate strategy designed to maximize retention. Such a strategy can take the form of an attempt to expand upon the information being retrieved by drawing connections between concepts, or by connecting the material to prior knowledge. Studies have shown that linking new information with prior knowledge through *elaborative interrogation* — coming up with an explanation for a stated fact or concept — results in superior learning compared to simply reading the information (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Willoughby & Wood, 1994). Along these lines, Hinze, Wiley, and Pellegrino (2013, Experiment 2) found that, after encoding a series of scientific texts but before attempting to recall those texts, participants who were given instructions to expect an inference-based final test (e.g., involving "how" and "why" questions over processes and applications from the texts) performed better on a one-week delayed final test than those who were given instructions to expect a detail-based final test (e.g., involving "what" questions over terms and functions from the texts). In a subsequent experiment (Experiment 3) participants achieved significantly higher final test performance when they read a text followed by instructions to explain, rather than simply recall, the content from it.

Similar findings have been obtained from several studies on journal writing as a type of follow-up activity to seminar or lecture sessions (e.g., Berthold, Nückles, & Renkl, 2007; Nückles, Hübner, & Renkl, 2009; Nückles, Hübner, Dümer, & Renkl, 2010). In these studies, a learning condition quite similar to the free-recall conditions in studies of retrieval practice was used, in that learners were required to write minutes (i.e., a protocol) about what they had learned in the previous session. However, a pure free-recall type of protocol writing was usually found to be the worst option with respect to final learning outcomes. Instead, it was superior to enrich the instructions by providing prompts designed to increase such learning strategies as elaboration. In particular, prompts such as "Which examples can you think of that illustrate, confirm, or conflict with the learning contents?" fostered learning (e.g., Berthold et al., 2007; Nückles et al., 2009, 2010).

The effects of such elaborative strategies have not been systematically explored in studies of retrieval practice. Furthermore, many studies of retrieval practice have measured direct retention of relatively simple materials such as word pairs (see Rowland, 2014), so it is unknown whether the use of elaborative strategies consistently enhances retrieval-based learning of more complex materials. Indeed, a major limitation of the literature on retrieval practice is that the learning outcomes in most studies have been restricted to measures of direct retention of fairly simple materials (see Carpenter, 2012). We currently know much less about the power of retrieval to enhance the arguably more important outcomes of understanding and comprehension of complex, educationally-relevant learning contents (for discussions on this topic, see Butler, 2010; Carpenter, 2014; Pellegrino, 2012).

To that end, the current study was designed to explore the effects of an elaborative retrieval strategy on both retention and comprehension of complex, educationally-relevant material. Based on previous work showing that the learning of new information is enhanced when it can be linked with prior knowledge (Pressley et al., 1987; Willoughby & Wood, 1994), and studies of the *constructive retrieval hypothesis* (Hinze et al., 2013) demonstrating that learning is enhanced under conditions in which retrieval encourages the construction of inferences between concepts, it might be expected that retrieval-based learning is particularly effective when the retrieval conditions promote the construction of inferences based on prior knowledge.

The current study used this approach to explore learning from lectures — an educationally-realistic but seldom-used task in studies of retrieval practice (but see Butler & Roediger, 2007; Szpunar, Jing, & Schacter, 2014). After viewing a 30-min video-recorded lecture, one group of participants (the Free Recall Group) was instructed to freely recall all of the information they could remember from the video lecture, while the other group (the Prompted Recall Group) was given the same instructions supplemented with the additional instruction to provide examples from their own lives that related to the material they were recalling. One week later, both groups of participants returned for a final test containing both fact-based and comprehension-based questions from the video lecture.

Adopting a constructive retrieval view, we formulated the following hypotheses. We assumed that enriching a free-recall task with an elaborative prompt would increase the participants' use of elaborative strategies in initial recall (*Strategy Hypothesis);* testing this hypothesis can also be seen as a type of manipulation check, that is, determining whether the prompt actually elicited the intended elaboration strategies. We assumed that an elaborative prompt would enhance comprehension of the learning contents (*Learning-Outcomes Hypothesis*). We also tested the effects on fact learning. The central hypothesis of this study is that the expected effect on comprehension is mediated by the elaboration strategies employed during recall (*Mediation Hypothesis*). We aimed to test the robustness of the expected mediation effect, that is, if there were variables correlating with learning outcomes, we included them in the mediation model to clarify their role in the learning outcomes.

2. Methods

2.1. Participants

Fifty-six undergraduate students (age: $M = 23.16$, $SD = 3.42$) of different majors participated in this study. Participants were given course credit for participation. All participants were aware of taking