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Retrieval practice does not safeguard memories from interference-based forgetting

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ABSTRACT

Retrieval enhances long-term retention. However, reactivation of a memory also renders it susceptible to modifications as shown by studies on memory reconsolidation. The present study explored whether retrieval diminishes or enhances subsequent retroactive interference (RI) and intrusions. Participants learned a list of objects. Two days later, they were either asked to recall the objects, given a subtle reminder, or were not reminded of the first learning session. Then, participants learned a second list of objects or performed a distractor task. After another two days, retention of List 1 was tested. Although retrieval enhanced List 1 memory, learning a second list impaired memory in all conditions. This shows that testing did not protect memory from RI. While a subtle reminder before List 2 learning caused List 2 items to later intrude into List 1 recall, very few such intrusions were observed in the testing and the no reminder conditions. The findings are discussed in reference to the reconsolidation account and the testing effect literature, and implications for educational practice are outlined.

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Retrieval practice or testing is one of the most powerful memory enhancers. Testing that follows shortly after learning benefits long-term retention more than studying the to-be-remembered material again (Roediger & Karpicke, 2006a, 2006b). This effect has been shown using a variety of materials and paradigms, such as text passages (e.g., Roediger & Karpicke, 2006a), paired associates (Allen, Mahler, & Estes, 1969), general knowledge questions (McDaniel & Fisher, 1991), and word and picture lists (e.g., McDaniel & Masson, 1985; Wheeler & Roediger, 1992; Wheeler, Ewers, & Buonanno, 2003). Testing effects have been observed in traditional lab as well as educational settings (Grimaldi & Karpicke, 2015; Larsen, Butler, & Roediger, 2008; McDaniel, Anderson, Derbish, & Morrisette, 2007). Testing not only improves long-term retention, it also enhances subsequent encoding (Pastötter, Schicker, Niedernhuber, & Bäuml, 2011), protects memories from the buildup of proactive interference (PI; Nunes & Weinstein, 2012; Wahlheim, 2014), and reduces the probability that the tested items intrude into subsequently studied lists (Szpunar, McDermott, & Roediger, 2008; Weinstein, McDermott, & Szpunar, 2011). The reduced PI and intrusion rates are assumed to reflect enhanced list discriminability or improved within-list organization. Enhanced list discriminability in turn helps participants distinguish different sets or sources of information and allows them to circumscribe the search set during retrieval to the relevant list (e.g., Congleton & Rajaram, 2012; Halamish & Bjork, 2011; Szpunar et al., 2008).

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If testing increases list discriminability, then it should also protect the tested list(s) from RI and intrusions from material that is encoded after retrieval practice. However, testing also necessarily reactivates a memory, and according to the reconsolidation account reactivation re-introduces plasticity into the memory trace, making it especially vulnerable to modifications (e.g., Dudai, 2004; Nader, Schafe, & LeDoux, 2000; for a recent review, see e.g., Hupbach, Gomez, & Nadel, 2013). Increased vulnerability to modification would suggest increased rather than reduced RI and intrusions. The few studies addressing this issue have yielded mixed results, with some suggesting that retrieval practice diminishes RI (Halamish & Bjork, 2011; Potts & Shanks, 2012), and others showing that retrieval practice can exacerbate the potential negative effects of post-retrieval learning (e.g., Chan & LaPaglia, 2013; Chan, Thomas, & Bulevich, 2009; Walker, Brakefield, Hobson, & Stickgold, 2003).

Chan and colleagues (Chan & Langley, 2011; Chan et al., 2009; Thomas, Bulevich, & Chan, 2010) assessed the effects of testing on suggestibility in a misinformation paradigm. After watching a television episode, participants answered cued-recall questions about it (retrieval practice) or performed an unrelated distractor task. Then, all participants read a narrative, which summarized the video but also contained some misleading information. A final cued-recall test revealed that participants in the retrieval practice condition recalled more misleading details and fewer correct details than participants in the distractor condition; that is, retrieval increased the misinformation effect (retrieval-enhanced suggestibility, RES). Chan et al. (2009) discuss two mechanisms that can explain this finding. First, since testing can potentiate subsequent new learning (e.g., Izawa, 1967; Tulving & Watkins, 1974), initial testing might have improved encoding of the misinformation. Indeed, when a modified final test was used, which encouraged the recall of both the correct information and the misinformation, participants in the retrieval practice condition recalled more misinformation than participants in the distractor condition (Chan et al., 2009). Second, retrieval might have rendered the memory more susceptible to interference by misinformation, an explanation that is in line with the reconsolidation account. Indeed, Chan and LaPaglia (2013) found reduced recognition of the correct information when retrieval preceded the presentation of misinformation (cf. Walker et al., 2003 for a similar effect in procedural memory).

In contrast to Chan and colleagues' findings, a study by Potts and Shanks (2012) suggests that testing protects memories from the negative influences of post-retrieval encoding of related material. Potts and Shanks asked participants to learn English–Swahili word pairs (List 1, A–B). One day later, one group of participants took a cued recall test of List 1 (testing condition) immediately before learning English–Finnish word pairs with the same English cues as were used in List 1 (List 2, A–C). Additionally, several control groups were implemented: one group was tested on List 1 without learning a second list, one group learned List 2 without prior retrieval practice, and one group did not participate in this session at all. On the third day, all participants took a final cued-recall test of List 1. Although retrieval practice per se did not enhance List 1 memory (i.e., no testing effect in the groups that did not learn List 2), it protected memory from RI (see Halamish & Bjork, 2011 for a similar result in a one-session study). Crucial for assessing the reconsolidation account is the comparison between the groups that learned List 2 either after List 1 recall or without prior List 1 recall. Contrary to the predictions derived from the reconsolidation account, final List 1 recall was enhanced when retrieval of List 1 preceded learning of List 2.[1] While this clearly shows that testing counteracts RI, it would be premature to conclude that testing prevented the disruption of memory reconsolidation, because (a) retrieval practice without List 2 learning led to minimal forgetting between Day 2 and 3, while retrieval practice followed by List 2 learning led to significant memory decline, and (b) a reactivation condition that is independent from retrieval practice is missing. One could argue that repeating the cue words in List 2 likely reactivated memory for the original associations. It has been shown that the strength of reactivation (Detre, Natarajan, Gershman, & Norman, 2013) and the specific reminder structure (Forcato, Argibay, Pedreira, & Maldonado, 2009) determine whether or not a memory will be affected by post-reactivation procedures.

The current study re-evaluates the question of how testing affects RI and intrusions. It uses a reconsolidation paradigm (Hupbach, Gomez, Hardt, & Nadel, 2007; Hupbach, Hardt, Gomez, & Nadel, 2008; Hupbach, Gomez, & Nadel, 2009; Hupbach, Gomez, & Nadel, 2011) to assess how testing in comparison to other reactivation procedures affects declarative memory. This paradigm will allow for a direct evaluation of the hypotheses that testing makes declarative memories vulnerable to interference, or that testing protects memories from the potential negative effects of subsequently learned material, as suggested by the list-separation hypothesis (e.g., Congleton & Rajaram, 2012; Halamish & Bjork, 2011; Szpunar et al., 2008). This question has important practical implications. For instance, when students test their memory while preparing for an exam, will such testing increase or reduce interference and intrusions from information that is learned afterwards?

Experiment

The aim of the present study is to assess how retrieval practice affects RI and intrusions in a reconsolidation paradigm. The paradigm consists of three sessions, separated by 48 h delays. In Session 1, participants learn a list of everyday objects. In Session 2, participants are either reminded of the first learning episode or not, and then learn a second list of objects. In prior studies, only subtle reminders were used (e.g., Hupbach et al., 2007): Participants in the reminder group returned to the same room, and they worked with the same experimenter as in Session 1. Additionally, they were asked to describe the general experimental procedure of Session 1. Participants in the no-reminder condition were seen in a different room

[1] Intrusion levels are not reported by Potts and Shanks (2012) but can be assumed to be generally low given that List 1 and List 2 contained quite different materials, i.e., Swahili vs. Finnish words.

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