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Failure to observe renewal following retrieval-induced forgetting

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ABSTRACT

Recent studies have pursued the nature of inhibition observed in retrieval-induced forgetting (RIF) tasks. In a RIF paradigm, participants are trained on category–exemplar pairs in Phase 1. Then, some exemplars from select categories (Rp+ items) receive further practice in Phase 2. At test, impaired recall for non-practiced exemplars of the practiced categories (Rp− items) is observed relative to exemplars from non-practiced categories (Nrp items). This difference constitutes RIF. Prior reports of spontaneous recovery from RIF indicate that RIF represents a lapse rather than a loss of memory. Empirical analogs and theoretical considerations suggest that RIF should also be reversible through a change of context between Phase 2 and testing (i.e., renewal). We conducted two experiments using human participants to evaluate the context dependency of RIF. In both experiments, Phases 1 and 2 occurred in distinctly different contexts with subsequent testing occurring in either the Phase 1 context or the Phase 2 context. RIF was observed in both experiments. Experiment 1 additionally found that the magnitude of RIF was not reduced by testing in the Phase 1 context relative to testing in the Phase 2 context. Experiment 2 further tested context dependency of RIF by (1) increasing the dissimilarity between the two contexts and (2) inserting a retention interval between Phase 2 and test for half of the participants in each test context condition. The data again indicated no effect of the context manipulation. Thus, no renewal from RIF was observed in either experiment; moreover, these null findings were supported by Bayesian analyses. These results are compared with analogous inhibitory processes in the animal memory literature that typically show both physical and temporal context dependency.

1. Introduction

Researchers in the field of memory have long studied the nature of forgetting as well as its benefits (e.g., Ebbinghaus, 1885/1964; Jenkins and Dallenbach, 1924; McGeoch, 1932; Tulving and Psotka, 1971). Intuitively, one may appreciate the adaptive value of forgetting. In order to effectively cope in a dynamic environment, memories must be constantly revised and re-prioritized, with retrieval of momentarily less appropriate memories being suppressed. This flexibility is essential for everyday functioning. For example, it would be maladaptive if every time a person went shopping, he remembered every item he had ever bought at that store. Research has supported the popular speculation that forgetting is an active, purposeful mechanism that prevents unessential information from interfering with the retrieval and processing of immediately critical information (e.g., Anderson et al., 1994; Wixted, 2005).

One phenomenon that provides evidence for this view is known as retrieval-induced forgetting (RIF). In the standard design for RIF developed by Anderson et al. (1994), participants study multiple category–exemplar pairs (e.g. metal-mercury) from multiple categories (e.g. metals, colors, animals, etc.) each containing a unique set of exemplars in Phase 1 (the study phase). Then half of the exemplars from half of the categories are practiced using a category–stem cued recall task (e.g. metal-me___) in Phase 2 (the retrieval practice phase). These exemplars belong to the retrieval-practice positive condition (Rp+). Non-practiced exemplars from practiced categories constitute the retrieval-practice negative condition (Rp−), while exemplars from non-practiced categories serve as a baseline, constituting the no retrieval-practice condition (Nrp). During the test phase, which usually occurs after a brief retention interval, participants are prompted to complete a recall task in which they are provided with category names, and must recall as many exemplars as possible from each category. Within this paradigm, Rp+ words are recalled more frequently than both Rp− and Nrp words, which is unsurprising given they were subject to retrieval practice during Phase 2. However, the less intuitive but more interesting finding is that Rp− words are recalled less frequently relative to the baseline Nrp words. This provides evidence that the retrieval practice of Rp+ items not only facilitates later

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recall of Rp+ exemplars, but results in the decreased recall of Rp− items (i.e., RIF; e.g., Anderson et al.; for recent reviews, see Anderson et al., 2000; Storm, 2010; Storm and Levy, 2012)

Several accounts of RIF have been proposed. Anderson and colleagues (e.g., Anderson et al., 1994, Anderson & Spellman 1995) have favored an active inhibitory mechanism which suppresses retrieval of non-practiced exemplars belonging to the same category as the practiced exemplars. That is, they suggest that during Phase 2 the retrieval of an incorrect item (that was cued by the immediate practice category), followed by recognition that the item is incorrect, results in active suppression of subsequent retrieval of that item. This inhibits future recall of the item (i.e., Rp−), thereby reducing interference with future retrieval of the practiced (i.e., Rp+) items. Rp− items presumably are not recognized as incorrect until it is noticed that they do not fit the exemplar stem provided on that retrieval practice trial, whereas Nrp items are rarely recalled during retrieval practice because they are unrelated to the categories undergoing retrieval practice. This active inhibition account is widely accepted (for reviews, see Anderson, 2003; Anderson and Levy, 2010), but there is also some research implicating mechanisms that differ from the specific inhibitory mechanism postulated by Anderson and colleagues (for reviews, see Raaijmakers and Jakab, 2012, 2013; Verde, 2012, 2013). However, an in-depth discussion of the competing accounts of RIF is beyond the scope of this paper.

Retrieval-induced forgetting presents an interesting analogy to other, more extensively studied phenomena that are reported in both the human and animal learning literature. Specifically, the RIF preparation parallels those used to study retroactive associative outcome interference (for reviews of these parallels, see Ortega-Castro and Vadillo, 2013; Vadillo et al., 2013). Retroactive outcome interference is often observed when pairings of X-O1 in Phase 1 are followed by pairings of X-O2 in Phase 2 (where X is a cue and O1 and O2 are two distinctly different outcomes). At test, participants will ordinarily respond to X in a manner consistent with the more recent pairings (i.e., X-O2). Pavlovian extinction serves as a well-known example of this type of interference, in which the conditioned stimulus (CS) serves as X, the unconditioned stimulus (US) serves as O1, and non-reinforcement serves as O2. After undergoing the phases described above, subjects will initially fail to respond to CS X as a result of recent nonreinforced presentations. This can be viewed as similar to RIF in which Phase 2 (i.e., retrieval practice) enhances subsequent retrieval of a potentially interfering association that at test inhibits retrieval of associations acquired in Phase 1 which were not practiced in Phase 2, but share a common element (i.e., category) with a practiced association.

Research in the animal literature has shown that retroactive associative outcome interference is often attenuated by shifts in the physical or temporal context between Phase 2 and testing (for a review, see Bouton, 2010). For example, Bouton and Peck (1992) demonstrated the effects of varying the time between Phase 2 and testing using a counterconditioning paradigm. In a traditional counterconditioning preparation, a CS is paired with an appetitive or aversive US (O1) in Phase 1, and is then paired with a US of the opposite valence (O2) in Phase 2. Although the rat's response to the CS at test following counterconditioning ordinarily reflects the second-learned CS-O2 association, these researchers found that if a long retention interval was inserted between Phase 2 and testing, subjects' responding was more consistent with the CS-O1 training experience. This observation indicates that retroactive outcome interference is attenuated by a long retention interval (i.e., spontaneous recovery). Turning to changes in physical context, Peck and Bouton (1990) demonstrated sensitivity of retroactive outcome interference to shifts in physical context between Phase 2 and testing. Again using a counterconditioning design, Phases 1 and 2 were delivered in distinctly different contexts (A and B, respectively), followed soon thereafter by a test in Context A or B. Testing in the Phase 1 context (A) caused greater recovery of the behavior reflecting the CS-O1 pairings relative to testing in the Phase 2 context (B); this is known as ABA renewal.

The effects of spontaneous recovery and renewal are not confined to counterconditioning preparations. Researchers as early as Pavlov (1927) found that when responding to a CS is extinguished, responding to that CS recovers over long intervals between extinction (Phase 2) and testing. Moreover, recovery from extinction in the form of ABA renewal of extinguished responses has also been demonstrated (e.g., Bouton and Bolles, 1979; Bouton and King, 1983). That is, if an association is acquired in Context A during Phase 1 and extinguished in Context B during Phase 2, testing in Context A tends to result in stronger responding (i.e., ABA renewal) than is observed with testing in Context B (i.e., ABB baseline control condition).

To date, the published research best supports the account of outcome interference and recovery therefrom that was proposed by Bouton (1993). This model proposes that the CS acquires an excitatory association with the US during Phase 1 and an inhibitory association with the US during Phase 2. At test, the test context acts as a discriminative stimulus that determines which of these two competing associations will be expressed. Miller and Laborda (2011) updated Bouton's model by adding a role for the relative strengths of the acquisition memory and extinction memory. This model provides an elegant explanation of interference between associations that share a common element, as well as attenuation of this interference through shifts in physical and temporal context between training and testing. Research within this framework has established that extinction appears to represent inhibitory processes (Pavlov, 1927), rather than an erasure of acquired associations as proposed by Rescorla and Wagner (1972). For a more general discussion of this account that includes other types of associative interference, see Miller and Escobar (2002). Although there is a general consensus regarding the role of inhibitory mechanisms in outcome interference, there is some debate concerning the details of this account. For example, Bouton's model specifically posits the establishment of inhibitory cue-outcome associations, whereas Anderson and Spellman (1995) argue that it is the activation of the exemplar (or outcome) representation that is inhibited independent of any particular association.

To summarize the most critical points with respect to the current study, it has been established that retroactive associative outcome interference is context-specific (e.g., Peck and Bouton, 1990). Likewise, it has been demonstrated that long retention intervals can reduce the effects of outcome interference (Bouton and Peck, 1992; Pineño and Matute, 2000). Recent research has examined the validity of analogies between RIF and retroactive outcome interference. These studies have suggested that the same or at least similar mechanisms that are responsible for outcome interference may also be responsible for RIF (Ortega-Castro and Vadillo, 2013; Vadillo et al., 2013). Vadillo et al. used an associative outcome interference design in which experimental participants (undergraduates) received X-O1 presentations in Phase 1, X-O2 presentations in Phase 2, and were then tested on the rate of learning of a new Y-O1 association in Phase 3, relative to participants who received control training for outcome interference in which there was no common element across Phases 1 and 2. They found that associative interference between outcomes O1 and O2, based on their mutual associations to X, impaired acquisition (or at least expression) of a new association involving O1 (i.e., Y-O1), presumably because of attenuated activation in Phase 3 of the representation of the target outcome (O1). Their observations suggest similarities between the outcome interference observed in their contingency learning task and RIF in that both appear to arise from active inhibition of the representation of O1 as hypothesized by