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Memorable objects are more susceptible to forgetting: Evidence for the inhibitory account of retrieval-induced forgetting☆

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ABSTRACT

Retrieval of target information can cause forgetting for related, but non-retrieved, information – retrieval-induced forgetting (RIF). The aim of the current studies was to examine a key prediction of the inhibitory account of RIF – interference dependence – whereby 'strong' non-retrieved items are more likely to interfere during retrieval and therefore, are more susceptible to RIF. Using visual objects allowed us to examine and contrast one index of item strength –object typicality, that is, how typical of its category an object is. Experiment 1 provided proof of concept for our variant of the recognition practice paradigm. Experiment 2 tested the prediction of the inhibitory account that the magnitude of RIF for natural visual objects would be dependent on item strength. Non-typical objects were more memorable overall than typical objects. We found that object memorability (as determined by typicality) influenced RIF with significant forgetting occurring for the memorable (non-typical), but not non-memorable (typical), objects. The current findings strongly support an inhibitory account of retrieval-induced forgetting.

In our everyday interactions with the world we are required to retrieve information from memory about stimuli that populate our world, such as faces or objects. Successes in remembering are always welcome but can come at the cost of interfering with other memories (e.g., Roediger, 1973; Tulving & Arbuckle, 1963). For instance, when shopping at the local grocery store we might try to remember which fruits were on our shopping list (which we forgot to bring). In a moment of intuition we remember oranges were on our list but when we go home with our bag of oranges we realize that we had forgotten to buy the apples that were also on our list - why? At least two decades of research on remembering and forgetting has shown that the act of remembering information can cause forgetting of related information (e.g., Anderson, Bjork, & Bjork, 1994).

One paradigm used to examine the costs of remembering on related information is the *retrieval practice paradigm* introduced by Anderson et al. (1994). In a typical retrieval practice experiment, participants study categories of related items (e.g., Fruit – apple, banana, orange, strawberry; Vehicle – car, bicycle, airplane, bus). Participants then perform retrieval practice on half of the items from half of the categories (e.g., Fruit – ap__, Fruit – ba__), establishing three item types which differ in retrieval status: practiced items from the practiced category (Rp + items; Fruit – apple, banana); unpracticed items from the practiced category (Rp − items; Fruit – orange, strawberry); and unpracticed items from the unpracticed category (Nrp items; all items from the Vehicle category). Memory for the three item types is then tested in a memory retrieval test. Typically, two findings occur. First, as might be expected, the practiced (Rp + items, e.g., apple, banana) items are facilitated in comparison to the unpracticed items from the unpracticed categories (Nrp items, e.g., vehicles) – the *retrieval practice effect*. Secondly, and more surprisingly, recall of unpracticed items from the practiced categories (Rp − items, e.g., orange, strawberry) are impaired in comparison to the also unpracticed but unrelated Nrp items (i.e., Vehicle – car, bicycle, airplane, bus). This phenomenon is called the *retrieval-induced forgetting* (RIF) effect (see Murayama, Miyatsu, Buchli, & Storm, 2014 for a recent review).

One explanation of RIF posits an important role for inhibitory processes (e.g., Anderson et al., 1994; Anderson & Spellman, 1995), which may be acting either at the level of the item's semantic (e.g., Anderson & Spellman, 1995; Johnson & Anderson, 2004; also see Anderson, 2003, for review), or episodic (e.g., Racsmány & Conway,

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2006) representation. According to this account, inhibitory processes suppress the representation of competing memories below baseline levels of activation and the suppression lingers beyond the original moment of competition (e.g., Anderson & Spellman, 1995; Anderson, Green, & McCulloch, 2000), resulting in RIF on final memory tests. Specifically, during retrieval practice, attempts to retrieve the Rp + item in response to the practice cue also leads to activation of related Rp − items and these latter items interfere with successful retrieval of Rp + items. In order to resolve this unwanted interference, inhibitory processes act directly on the memory representations of Rp − items to suppress them (e.g., Anderson & Spellman, 1995; Levy & Anderson, 2002; see Storm & Levy, 2012, for a review).

In contrast, non-inhibitory accounts of RIF (e.g. associative blocking: J.R. Anderson, 1983; Butler, Williams, Zacks, & Maki, 2001; encoding specificity: Perfect et al., 2004; competitor interference: e.g., Jakab & Raaijmakers, 2009; Raaijmakers & Jakab, 2013; Verde, 2013; and context-based accounts: Jonker, Seli, & MacLeod, 2013) do not appeal to inhibitory mechanisms in order to explain RIF. Despite their diversity, a common theme among most non-inhibitory theories is that RIF is due to the strong practiced memories (i.e., Rp + items) blocking or interfering with the retrieval of weaker non-practiced memories (i.e., Rp − items). As retrieval strengthens the association between a retrieval practice cue and the practiced item (e.g., Fruit – cherry), it simultaneously weakens the association between this cue and other related but non-practiced memories (e.g., Fruit – kiwi). As a result, RIF will occur whenever a strong practiced item blocks retrieval of weaker non-practiced items, such as when an Rp + item is strengthened through retrieval practice.

Four specific predictions of the inhibitory account of RIF differentiate it from non-inhibitory accounts: cue independence, retrieval dependence, strength independence, and interference dependence (see Anderson, 2003, and Storm & Levy, 2012, for reviews). Cue independence predicts that RIF occurs regardless of whether the original cue (e.g., Fruit__), or a different cue (e.g., Blood__), is used to retrieve the Rp − item (e.g., cherry), as inhibition acts at the level of the item's memory representation (e.g., Anderson & Bell, 2001; Anderson & Spellman, 1995; Ciranni & Shimamura, 1999; Johnson & Anderson, 2004; Levy, McVeigh, Marful, & Anderson, 2007; MacLeod & Saunders, 2005; Veling & Van Knippenberg, 2004; but see also Perfect et al., 2004; Jonker et al., 2013, for failures to replicate). Second, the retrieval dependence prediction is based on the assumption that RIF should only be observed when practice involves active retrieval; specifically, that it is the act of retrieval itself which is key to activating inhibitory processes rather than simply strengthening Rp + items (e.g., Anderson, Bjork, & Bjork, 2000; Saunders, Fernandes, & Kosnes, 2009; but see Jakab & Raaijmakers, 2009). The *attempt* to retrieve appears to be the critical component for the emergence of RIF as opposed to successful retrieval (e.g., Storm, Bjork, Bjork, & Nestojko, 2006). Third, according to the strength independence prediction, the presence, or size, of RIF is independent of how memorable the practiced (Rp +) items are (e.g., Anderson, Bjork, & Bjork, 2000; Ciranni & Shimamura, 1999; but see Raaijmakers & Jakab, 2012), and further strengthening of practiced items has been found to have minimal effects on RIF (e.g., Macrae & MacLeod, 1999).

The fourth, and most pertinent, prediction for the current experiments is the *interference dependence* prediction. According to this prediction, items that create the greatest degree of interference (i.e., retrieval competition) during retrieval practice are the most likely to be inhibited and, therefore, show RIF on a delayed memory test. If an item has weak potential to interfere, there will be less or, indeed, no need at all for inhibition and, as a result, little or no RIF would emerge (e.g., Anderson et al., 1994). Therefore, the ‘strength’ of the Rp − items (and not the strength of the Rp + items) can predict whether RIF emerges or not (e.g., Anderson et al., 1994).

Surprisingly, there is little work examining the interference dependence prediction. Such paucity is partly due to the difficulty in defining ‘strength’ of the competing (Rp −) items. One approach to testing the interference dependence prediction has been to use semantic manipulations of item strength, such as taxonomic frequency of words (e.g., Anderson et al., 1994; Williams & Zacks, 2001), and dominant vs. non-dominant word meanings (e.g., Shivde & Anderson, 2001). Such studies utilising manipulations of competitor strength have typically found evidence consistent with the inhibitory account; specifically, that semantically or taxonomically strong competitors (e.g., Fruit – orange) are more susceptible to RIF compared to taxonomically weak competitors (e.g., Fruit – tomato; Anderson et al., 1994; but see Williams & Zacks, 2001).

Other studies have manipulated item strength within the experimental episode (e.g., Jakab & Raaijmakers, 2009; Storm, Bjork, & Bjork, 2007). For instance, using a directed forgetting manipulation prior to a retrieval practice phase, Storm et al. (2007) found that items in a list which participants were instructed to remember showed more RIF compared to list items which participants were instructed to forget. However, other studies have failed to detect differences between episodically strong and weak competitors (e.g., Jakab & Raaijmakers, 2009; Williams & Zacks, 2001). According to Storm and Levy (2012), studies with negative evidence for the interference dependence prediction may have been confounded with alternative explanations (see Raaijmakers & Jakab, 2013, for further discussion). Meanwhile, in a meta-experimental review, Spitzer (2014) showed that baseline item strength (as opposed to the strengthening of Rp + items) predicts the presence and magnitude of RIF in studies using a recognition task during the test phase.

A particularly fertile ground for examining strength effects in memory is object recognition. Visual objects are both perceptually and semantically rich stimuli with robust long-term memory representations (e.g., Brady, Konkle, Alvarez, & Oliva, 2008) compared to verbal materials (e.g., Nelson, Reed, & Walling, 1976). As study materials, objects offer the possibility to examine and contrast different types of strength effects in memory.

Effects of item strength are very common in object recognition. Some strength effects concern semantically represented object colour. For instance, object identification is often more efficient (i.e., faster and more accurate) for objects that appear in typical colours, such as yellow bananas or red strawberries, as opposed to purple bananas and orange strawberries (e.g., Tanaka & Presnell, 1999). Other strength effects in object recognition concern the shape typicality of objects. For instance, objects typical of their category, such as dining chairs, are identified faster and more accurately at the basic level (e.g., chair), than are non-typical objects, such as artistic forms of chairs (e.g., Jolicoeur, Gluck, & Kosslyn, 1984; Murphy & Brownell, 1985; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tanaka & Taylor, 1991). Therefore, visual objects can be ‘strong’ study items if they are typical exemplars of their category. In this sense, item ‘strength’ for visual objects parallels the strength in terms of taxonomic frequency in words.

Meanwhile, visual objects that are non-typical of their category can also be strong study items – this time, not because of how well they represent their category (as in the case of words) – but because of their unique visual features, which make them more distinctive than objects that are more typical of their category (e.g., Rosch et al., 1976). In this sense, item ‘strength’ for visual objects, unlike what is possible with words, is related to purely visual characteristics. Thus, findings from object recognition suggest that, not only are strength effects possible with rich complex visual stimuli, but that using objects as stimuli provide one avenue for examining different types of ‘strength’ effects in memory: ones resulting from the category *typicality* of an object, and another resulting from the *memorability* of an object.

Using recognition of objects to examine RIF requires a paradigm that is appropriate for pictorially rich stimuli. As visual objects do not easily lend themselves to memory *recall*, which is widely used with word stimuli, the current experiments utilised a *recognition practice*