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Reviewing erroneous information facilitates memory updating

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ABSTRACT

Reviewing information stored in memory will generally strengthen that information, so it seems reasonable that reviews should make it harder to replace the information in memory if it is later found to be erroneous. In Experiment 1, subjects learned three facts about each of 12 topics. On Day 2, the same facts were either reread, tested, or not reviewed; then the facts were "corrected" with new replacement facts. A test on the replacement facts given 1 week later disclosed that both rereading and testing the to-be-replaced Day-1 facts *enhanced* memory for the Day-2 facts which supplanted them, although rereading (but not testing) the Day-1 facts also led to more intrusions of Day-1 facts on the final test. In Experiment 2, subjects were unexpectedly asked (in the final test) to recollect both original and replacement facts; old facts were often retrieved, especially when reviewed. It is suggested that review may promote development of a secondary retrieval route for the corrected information.

1. Introduction

People sometimes find that information they have stored in memory is erroneous, making it important to correct that information. What mental activity best allows this replacement to take place? At first blush, one might assume that reviewing the misinformation would be the very last thing one should do, since the review could only strengthen the erroneous information and make it harder to replace in memory. The question of whether this is so is the subject of the current article.

The question holds both practical and theoretical interest. From a practical standpoint, the need to overcome misconceptions is common and in some cases even vital. For example, science educators have long recognized the challenge of overcoming intuitive misunderstandings which students bring to many areas of science (Chi, Slotta, & De Leeuw, 1994; Garrett & Fisher, 1926). Recently, Prasad, Gall, and Cifu (2011) reported that of the articles published in 2009 in the *New England Journal of Medicine* that made claims about medical practice, 13% concluded that a reversal of current medical practice was called for. This implies that physicians cannot practice medicine effectively without frequently correcting information they have previously stored in memory when they learn that it has been overturned by subsequent research.

Theoretically, the question of whether information known to be erroneous is removed or overwritten in memory has been of interest for many years (Bjork & Woodward, 1973; Seifert, 2002; Wilkes & Leatherbarrow, 1988), and may speak to very basic questions about the nature of memory traces and the processes that create and modify them. Additionally, within the cognitive neuroscience field there is growing interest in whether a phenomenon termed *reconsolidation* may underlie certain memory-correction phenomena in humans, as will be discussed further below.

In the remainder of the introduction, we describe a number of experimental results in the literature that have some bearing on how review or retrieval of memory con-

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tents might affect the ability to overwrite misinformation with new, corrective information. As we shall see, none provides any direct answers to the question posed here, but they do suggest alternative hypotheses and possible mechanisms.

1.1. Effects of review/retrieval on new learning

How and why might review or retrieval of information affect the ability to overwrite it?

From an associationist perspective, the most obvious possibility would be that any intervention that strengthens an old memory will obstruct the storage of any potential competing associations. Reviewing memories generally strengthens them, and retrieving memories tends to strengthen memories more than merely restudying them (see Roediger and Karpicke (2006), for a review).

On the other hand, the literature also contains some hints that when people learn information, testing that information may reduce the interfering effects observed upon subsequent learning. Tulving and Watkins (1974) taught subjects an A–B list of paired associates, followed by an A–C list. Different groups of subjects were tested on the first and/or the second list (immediately after the learning of the lists). Finally, after an intervening task, an MMFR-type test[1] was given, requiring subjects to try to recall both B and C items. When there had been no immediate test on either the B list or the C list, subjects recalled 24% of the C items in the final recall. This was boosted up to 44% when the B list had been tested. When the C list was also tested, testing of the B list as well improved the recall of C (raising it from 28% to 50%). Similar effects were found in a comparable within-subject experiment. Although the results appeared robust, the authors expressed puzzlement over their findings, saying "as far as we can tell there are no mechanisms postulated in the classical interference theories... that would prepare one for the observation that testing of recall of A–B pairs [promotes the] learning of A–C pairs." (p. 191).

Seemingly related effects have been observed more recently with recall of word lists. Szpunar, McDermott, and Roediger (2008) taught subjects multiple lists of words. Half of the subjects were tested on each list after it was presented, and the other half were not. Then all subjects were shown a final list of words and then tested on that list, and after a half hour, a final cumulative recall test (on all the lists) was given. Testing on all of the lists prior to the final list substantially enhanced recall of that final list, both on the test given immediately after study of the list and on the final cumulative test. Also, there were fewer intrusions of items from the earlier lists on the test of the final list. However, re-exposure to the prior lists, unlike testing, did not produce the effect. The authors concluded that testing has a powerful effect of "segregating" the lists.

1.2. Reconsolidation-inspired studies

Another potentially related set of studies has been inspired by the phenomenon of reconsolidation. This refers to the observation (chiefly seen in animal studies) that activating a memory (by placing a rat who had been trained in a maze back into the maze) launches a cascade of intracellular events paralleling those occurring after initial formation of memories, rendering the memory trace labile and vulnerable to time-dependent interference from receptor antagonists (e.g., Przybyslawski & Sara, 1997).

Aiming to construct a human analogue of the reconsolidation effect, Hupbach, Gomez, Hardt, and Nadel (2007) had students interact with a set of objects on Day 1, placing them in a basket. On Day 2, some were given a reminder of the general episode (without however recalling the specific objects), and then interacted with a second set of objects. On Day 3, subjects were given a test requiring them to try to report as many objects as possible from the set they encountered on Day 1. The subjects who were given a reminder of the first session on Day 2 tended erroneously to report items from the Day-2 list. There was also a reduction in the number of Day-1 items reported on the final test, although this reduction was not significant. A subsequent follow-up study by Hupbach, Gomez, and Nadel (2009) used a final recognition test, and found that the Day-2 reminder of the initial exposures to objects produced a tendency to mis-report Day-2 items as having been presented on Day 1.

1.3. Implications

Based on the diverse sets of studies described above, one can envision a number of hypotheses about how reviewing some factual information might potentially affect the later processing and storage of replacement information. Given the results of Tulving and Watkins (1974) and Szpunar et al. (2008), it might be that testing (but perhaps not rereading) information to be corrected might render it less likely to interfere with contradictory information to be learned later. The mechanisms for this are not clear, but it seems conceivable that retrieval might strengthen linkages between the memory contents and the context in which they were encoded (something that may be used as a retrieval cue), and this in turn might reduce the confusability of the two sets of information (cf. Jang & Huber, 2008). Alternatively, if Hupbach, Nadel and colleagues are correct that reminding of a previous encoding event triggers reconsolidation which renders the old traces more malleable, this might directly facilitate corrective learning.

1.4. Current research

The goal of the current studies is to ask how review or retrieval of previously learned factual information affects the ability to acquire new information which contradicts the initially learned informed. Factual information was used rather than word lists, along with nontrivial retention intervals, in order to insure that the results would have direct relevance to correction of misinformation in real-world settings. Within each of the studies presented below, we also compared the effects of reviewing information with the effects of testing this information. To make the time intervals meaningful, subjects performed three ses-

[1] This refers to a test in which people are given the stimulus term (A) and asked to produce both of the response terms (B and C) as best they can.