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The future can shape memory for the present

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Abstract

A recent study demonstrates that memory for ostensibly irrelevant events can be enhanced when new information reveals that those events are important. These findings emphasize that memories are malleable, such that new information can update the priority and content of existing memory traces.

It has long been known that we remember information that has some personal importance or distinctiveness in the moment. We may remember a surprise party, or a stolen wallet, even years after their occurrence, whereas more mundane moments from our lives are often forgotten almost as soon as they occur. Indeed, memory encoding – the transformation of an experience into memory – is best described as the sum of the processes enlisted while an event was initially experienced [1]. Thus, if we think deeply about the meaning of information, if it connects to our sense of self, or if it triggers an emotional reaction, we will remember it better [2].

Yet there are many real-world examples in which the importance of a moment only becomes apparent with hindsight. For example, that brush with a stranger takes on new meaning after noticing a wallet is missing. Synaptic [3] and behavioral tagging [4] hypotheses have proposed mechanisms that would allow this new information to strengthen previously weak memories, but evidence of such effects within human episodic memory has been lacking. Now, a recent study by Dunsmoor and colleagues [5] presents intriguing evidence that new information can affect the likelihood that a prior event is retained in memory.

Dunsmoor and colleagues [5] designed a task in which participants viewed images of tools and animals. Approximately five minutes later, participants viewed different images of tools and animals, and this time received a mild shock when images from one of those categories were presented. Then, participants viewed yet another set of tools and animals. Not surprisingly, given the strong association between emotional responses and memory enhancement [6], participants remembered items from that second block better if they were from the category that was associated with the mild shock. The surprising finding is that participants also remembered items from the first block better if they were from the category

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that would later be associated with the mild shock. Although tools and animals had seemed equally important (or unimportant) at the moment of encoding, the later knowledge that one of those categories was connected to a shock altered the priority of that category in memory.

The novelty of this finding lies in the re-prioritization of the memory traces. It has been well documented that consolidation processes – those that unfold in the minutes and hours after an initial encounter with information – can retroactively enhance the likelihood that information will be remembered [7]. It has also been demonstrated that these processes can be selective, aiding in the retention of some types of information more than others. For instance, emotional information often is more likely to be retained in memory over time than neutral information [6–7]. However, in these prior demonstrations of retroactive memory enhancements, the information most likely to be retained in memory also was the information prioritized during encoding. What Dunsmoor and colleagues demonstrate is that there can be a window of time during which the relative strength of the memory traces can be malleable, suggesting that the prioritization of information during consolidation can be separated from the prioritization of information during encoding. In fact, as hypothesized by tagging theories [3–4], it was relatively weak memory traces that were prioritized when, minutes later, they became associated with the threat of a shock. If memories were initially strong – as occurred in a companion study in which participants studied each image three times rather than only once – this re-prioritization did not occur. As the authors [5] state, “seemingly inconsequential details [may] be stored in memory, at least temporarily, in the event that this information acquires relevance some time later.”

Also consistent with tagging theories [3–4], which propose interactions between encoding and consolidation phases, the effects of this re-prioritization took time to be revealed. Retroactive enhancement was not apparent when memory for the first block of items was tested just minutes after the participants had studied the second (shock-associated) block, but it was present when memory for those items was tested 6 or 24 hours later. This delay-dependence suggests that, once the relevance of information is detected, the decay rate for that information may lessen, leading it to be better retained over time than information not deemed to be as relevant. The delay-dependence of these effects also may be adaptive, allowing time to make sure that a revised prioritization is needed: If the wallet is found in a pocket, the brush with the stranger is inconsequential.

Interestingly, the results suggest that although this retroactive enhancement may require time, it may not require sleep. Although the authors did not measure sleep specifically, the extent of retroactive enhancement was similar after delays that likely did (24-hr) and did not (6-hr) include sleep. This pattern diverges from other forms of retroactive enhancement for low-priority items that have been shown to be optimized over a night of sleep [8]. It also diverges from another type of delay-dependent memory enhancement revealed by the authors: a proactive memory enhancement. Specifically, items from the shock-associated category were remembered well when they were encoded after that association had been learned, but at a time when no shock electrodes were attached and thus the threat was no longer present. This proactive enhancement occurred only after the 24-hour delay, raising the possibility that the sleeping brain may enable this generalization (see [9] for related discussion).

These findings raise intriguing questions about how events are related in memory, and how those relations influence which memories become re-prioritized (see Box 1). The results also add to a growing literature linking memory's adaptiveness to its malleability. Although past research has convincingly demonstrated that new information can interfere with or distort the remembered content of a past event [10], the results of Dunsmoor and colleagues [5] raise the possibility that new information also might lead to hindsight biases by distorting the meta-memorial importance of a past event. When recounting the story of the stolen wallet, we may remember knowing – at the moment the stranger brushed into us – that something was amiss.

Box 1

Questions for future research

Several key questions about the details of this effect (see Figure I) will need to be answered through further research.

Question 1 (Q1): What must a second event have in common with a first to elicit re-prioritization? Dunsmoor and colleagues chose conceptually and categorically related events, presented in an overlapping context (computer screen in laboratory). Are these necessary and sufficient characteristics?

Question 2 (Q2): Over what time frame will new information elicit re-prioritization? In their experiment, only minutes intervened, but in daily life, we may not realize the importance of an event until hours or even days later.

Question 3 (Q3): What types of 'importance' will trigger re-prioritization? Their experiment demonstrated that re-prioritization can occur when information becomes emotionally salient. Emotional tagging has been proposed to elicit specialized mechanisms for memory prioritization [7]. Would the same effects occur if the new information were significant for a different reason: a professor tells you at the end of class that today's material will be covered on tomorrow's exam, for example?

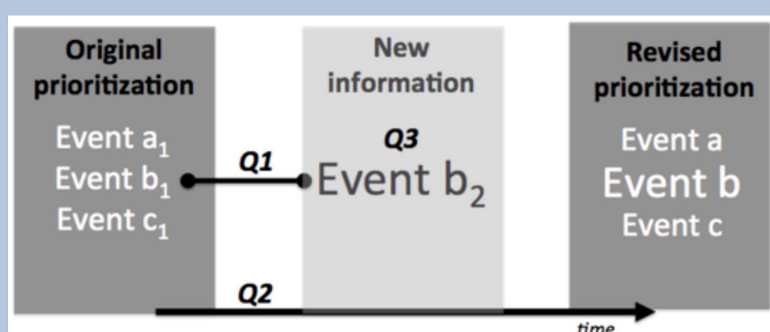

Figure I.
Schematic of the effect demonstrated by Dunsmoor and colleagues, noting open questions (Q1–Q3).

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