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Covert retrieval in working memory impacts the phenomenological characteristics remembered during episodic memory☆

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ABSTRACT

Much research has investigated the qualitative experience of retrieving events from episodic memory (EM). The present study investigated whether covert retrieval in WM increases the phenomenological characteristics that participants find memorable in EM using tasks that distract attention from the maintenance of memoranda (i.e., complex span; Experiment 1) relative to tasks that do not (i.e., short or long list lengths of simple span; Experiments 1 and 2). Participants rated the quality of the phonological, semantic, and temporal-contextual characteristics remembered during a delayed memory characteristics questionnaire (MCQ). Whereas an advantage of the complex over simple span items was observed for each characteristic (Experiment 1), no such difference was observed between short and long trials of simple span (Experiment 2). These results are consistent with the view that covert retrieval in WM promotes content-context bindings that are later accessible from EM for both objective performance and subjective details of the remembered information.

1. Introduction

Retrieval from episodic memory (EM) is often accompanied by rich phenomenological details during the experience of mentally reliving the original event. Much research has explored the underlying processes that give rise to this experience of conscious recollection (Gardiner, 1988; Tulving, 1985), especially the conditions in which the remembered information was originally processed in working memory (WM). WM refers to the immediate memory system that maintains, updates, and manipulates information for brief intervals of time in the service of ongoing cognition. WM and EM are often strongly aligned both conceptually and empirically, as much work has shown that performance on their respective measures is significantly correlated (Unsworth, 2010; Unsworth & Spillers, 2010), especially recollection-based EM (Unsworth & Brewer, 2009). Some recent work has suggested that mechanisms underlying active maintenance of information in WM may not only promote later retrieval from EM, but also the experience of conscious recollection of the original event (Loaiza, Duperreault, Rhodes, & McCabe, 2015). In particular, we have proposed that measures of WM often entail the consistent covert retrieval of memoranda in order to keep them available despite other distracting events (Loaiza & McCabe, 2012; McCabe, 2008).[1] Consequently, we have observed improvements in objective EM performance (e.g., free recall) as a function of opportunities to covertly retrieve memoranda in WM. The experiments in the current

☆ The data and analysis scripts are available on the Open Science Framework at: https://osf.io/mu6an/.

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[1] It should be noted that in previous work we had specified covert retrieval as attentional refreshing (e.g., Loaiza & McCabe, 2012). However, in order to avoid any conflation of terms with other researchers using similar terminology but perhaps referring to different functions (e.g., Camos, Lagner, & Barrouillet, 2009; Johnson, 1992), we will use covert retrieval here. Much work remains to be done regarding how similar these proposed mechanisms are.

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paper sought to determine whether subjective details associated with an event (i.e., phonological, semantic, and temporal-contextual) are likewise more phenomenologically memorable as a function of covert retrieval in WM.

Complex span tasks are often used to measure WM capacity, or the degree to which a person can maintain and manipulate information effectively. For example, the operation span task (Turner & Engle, 1989) requires participants to solve basic arithmetic problems (e.g., $4 \times 7 = 29$?) that are interspersed among to-be-remembered information (e.g., concrete words). Simple span tasks such as word span instead successively present memoranda without any distraction or processing activity. Historically, complex span tasks were thought to measure WM capacity to a greater extent than simple span tasks due to the additional demands of the secondary task, whereas simple span tasks may only test passive storage of information. This view was largely predicated on the finding that complex span tasks predict performance on other measures of higher-order cognition, such as fluid intelligence, more strongly than simple span tasks (Engle, Tuholski, Laughlin, & Conway, 1999; Kane et al., 2004).

However, further work has suggested that longer trial lengths of simple span tasks (i.e., more than four memoranda) may also reliably measure WM capacity (Unsworth & Engle, 2006; Unsworth & Engle, 2007a; Unsworth & Engle, 2007b). In their dual-component model, Unsworth and Engle (2007a), Unsworth and Engle (2007b) proposed that WM capacity reflects the contributions of active maintenance of a limited amount of information in primary memory and the cue-based search and retrieval of secondary memory. In particular, attention must be devoted to sustaining the activation of memoranda or task goals in primary memory, and switching attention away from their maintenance to distraction or new incoming memoranda requires their retrieval from secondary memory. Accordingly, simple span tasks that present many more items than can be maintained in primary memory may be more similar to complex span tasks than previously considered to the extent that they also reflect the contribution of these two underlying functions. In support of this notion, Unsworth and Engle (2006) found that performance on simple span tasks resembled that of complex span tasks when the simple span tasks were more difficult in nature. Specifically, longer list lengths of simple span were more strongly correlated with fluid intelligence than shorter list lengths of simple span (Unsworth & Engle, 2006; Unsworth & Engle, 2007b). Using latent variable analysis, Unsworth and Engle (2006) also showed that the variability common to these same long list lengths of simple span loaded on a different factor than short list lengths of the same simple span task. This suggests that the distinctions typically made between simple and complex span tasks are not as straightforward as originally thought. Instead, Unsworth and Engle have argued that both simple and complex span tasks measure the same mechanisms, but to different degrees. Complex span and long simple span trials require retrieval from primary and secondary memory on each trial, whereas short simple span trials only require retrieval from primary memory. Thus, a cue-dependent search of secondary memory is necessary to retrieve the memoranda that have been displaced from active maintenance in primary memory due to distraction (complex span tasks) or new incoming memoranda (long simple span tasks).

McCabe (2008) further investigated this hypothesis by considering immediate and delayed retrieval from simple and complex span tasks. Specifically, McCabe administered trials of word span and operation span with two to four memoranda per trial. In addition to immediately recalling the words at the end of the trials, participants were also asked to try to recall the words after a delay. The results of his first experiment showed that while immediate recall of memoranda from simple span was predictably greater than that of complex span, the reverse was true for delayed recall, such that memoranda from complex span were more likely to be recalled than simple span. We henceforth refer to this finding of greater EM performance for complex span than simple span as *the McCabe effect*. The McCabe effect was also demonstrated even when immediate recall was precluded randomly for half the trials, thereby negating any possible differences in overt retrieval during the recall phase of the trials.

McCabe (2008) originally interpreted these findings in accordance with the dual-component model: given that the distraction phase of complex span tasks (e.g., arithmetic problems) displaces the memoranda from primary to secondary memory, participants must engage in covert retrieval to reactivate them so they are not forgotten by the end of the trial. This repeated covert retrieval from secondary memory during the interim between the distraction (i.e., the arithmetic problems) and the memoranda (i.e., the words) of complex span tasks in turn promotes strong cues for those items to be later accessed during delayed recall. Conversely, the simple span trials never exceeded the limits of primary memory (i.e., about four memoranda), and thus those items should remain within primary memory without being displaced. Accordingly, no controlled search of secondary memory is necessary for short list lengths of simple span, whereas complex span tasks necessitate covert retrieval that in turn promotes stronger retrieval cues to access that information later on during EM (McCabe, 2008). The most important evidence that supported the covert retrieval account was the finding that delayed recall declined as a function of serial position for the complex span but not the simple span trials. This is in line with the prediction that the memoranda presented earliest in the trials, which presumably had the most opportunities to be covertly retrieved during WM, were likewise the most likely to be recalled from EM.

Loaiza and McCabe (2012) further investigated the tacit prediction that long list lengths of simple span may also require covert retrieval because the earliest presented items should have been displaced from primary memory by new incoming memoranda within the same trial. That is, if long list lengths of simple span (i.e., eight words to recall) also require covert retrieval to keep the memoranda active in WM, then they should exhibit a similar McCabe effect as the complex span items in EM. Thus, both complex span and long trials of simple span should exhibit greater recall than short trials of simple span. However, Loaiza and McCabe showed that this was not the case in either delayed free or cued recall: there was no McCabe effect for the long list lengths of simple span, even the first four memoranda that are presumably displaced from and must be retrieved back into primary memory. This result conflicted with the suggestion that long simple span and complex span trials are similar in their requirement of covert retrieval to sustain the activation of the memoranda in WM. Instead, the distraction during complex span may serve as a unique opportunity to covertly retrieve the memoranda back into conscious awareness, and such opportunities are not available during simple span regardless of the list length. Loaiza and McCabe further investigated the use of internally-generated and externally-provided temporal-contextual cues under the notion that opportunities to covertly retrieve memoranda during complex span encourage the binding