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Research report

Mental reinstatement of encoding context improves episodic remembering

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ABSTRACT

This study investigates context-dependent memory retrieval. Previous work has shown that physically re-experiencing the encoding context at retrieval improves memory accessibility. The current study examined if mental reconstruction of the original encoding context would yield parallel memory benefits. Participants performed a cued-recall memory task, preceded either by a mental or by a physical context reinstatement task, and we manipulated whether the context reinstated at retrieval overlapped with the context of the target episode. Both behavioral and electrophysiological measures of brain activity showed strong encoding-retrieval (E-R) overlap effects, with facilitated episodic retrieval when the encoding and retrieval contexts overlapped. The electrophysiological E-R overlap effect was more sustained and involved more posterior regions when context was mentally compared with physically reinstated. Additionally, a time-frequency analysis revealed that context reinstatement alone engenders recollection of the target episode. However, while recollection of the target memory is readily prompted by a physical reinstatement, target recollection during mental reinstatement is delayed and depends on the gradual reconstruction of the context. Taken together, our results show facilitated episodic remembering also when mentally reinstating the encoding context; and that such benefits are supported by both shared and partially non-overlapping neural mechanisms when the encoding context is mentally reconstructed as compared with physically presented at the time of retrieval.

1. Introduction

Episodic memory is influenced by the current spatiotemporal context (Godden & Baddeley, 1975; Tulving, 1983), as evident when previous episodes are suddenly remembered when visiting specific places. Such benefits of context are explained by the encoding specificity principle, which states that increasing the overlap between encoding and retrieval (E-R) conditions improves the likelihood of successful remembering (Tulving & Thomson, 1973; see also Morris, Bransford, & Franks, 1977). However, while in some situations the retrieval cues are external and provided by the environment, in many others the retrieval cues must be self-generated, as when mental reconstruction of the original encoding episode

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is used to guide retrieval of the sought-after memory traces. The present study employed electrophysiological recordings of the brain to investigate such mental reinstatement of the original encoding context and associated consequences for episodic remembering.

There is substantial evidence that physically re-experiencing the original encoding context at retrieval is beneficial for memory performance (e.g., Murnane, Phelps, & Malmberg, 1999; Smith & Vela, 2001). Importantly, the concept of context is not limited to the spatial–temporal information, but includes other aspects and circumstances (e.g., Roediger & Guynn, 1996). For example, it has been shown that memory improves when the cognitive context (Marian & Neisse, 2000), the physiological context (Miles & Hardman, 1998), or the mood context (Lewis & Critchley, 2003) experienced during encoding are reinstated at retrieval. More recently, benefits have been demonstrated even if a different, but conceptually similar context, is re-experienced at retrieval (Smith, Handy, Angello, & Manzano, 2014). Collectively, these data underscore the importance of E-R context overlap and show that when details of the study episode are reinstated at retrieval, memories become easier to access.

The original encoding context may also be reinstated at retrieval by means of mental imagery. Previous behavioral studies have shown that mental reinstatement, of the original encoding room, can reduce the forgetting caused by retrieving in a room different from the encoding room (Chu, Handley, & Cooper, 2003; Smith & Vela, 2001). Additionally, mentally reconstructing the original encoding context may provide an effective memory strategy to improve remembering in both forensic (e.g., Drohan-Jennings, Roberts, & Powell, 2010; Hershkowitz, Orbach, Lamb, Sternberg, & Horowitz, 2002) and clinical settings (e.g., Mystkowski, Craske, Echiverri, & Labus, 2006). While the abovementioned work does suggest that remembering may also benefit from mental imagery of the encoding context, little is currently known about the underlying neurocognitive mechanisms subserving such benefit. The present study introduces a new experimental paradigm to assess and compare the potential benefits of mental and physical context reinstatement, and aimed at elucidating the extent to which such facilitation effects are mediated by the same or different neural mechanisms. Crucially, we used electrophysiological recordings of brain activity to gain insight into the temporal dynamics of context reinstatement and its influence on remembering.

According to the neurobiological models of memory, episodic remembering involves the reinstatement of the cortical patterns that were active at the time of encoding (e.g., Marr, 1971; Norman & O'Reilly, 2003). A growing body of recent literature has provided support for this idea by showing that retrieval success co-varies with neural encoding patterns being reactivated at the time of retrieval (e.g., Bosh, Jehee, Fernández, & Doeller, 2014; Gordon, Rissman, Kiani, & Wagner, 2014; Nyberg, Habib, McIntosh, & Tulving, 2000; Staresina, Henson, Kriegeskorte, & Alink, 2012; Wheeler, Petersen, & Buckner, 2000; Wing, Maureen, & Cabeza, 2015). Moreover, memory performance increases as a function of the original encoding context being reinstated at retrieval (e.g., Diana, Yonelinas, & Ranganath, 2013; Staudigl, Vollmar, Noachtar, & Hanslmayr, 2015). In the present study, we examine the extent to which these beneficial effects generalize to situations where the original encoding context is mentally rather than physically reinstated.

Previous work has shown that imagery and perception share neural machinery (e.g., Ganis, Thompson, & Kosslyn, 2004), suggesting that many cognitive processes function comparably in these operations. Moreover, recent research has demonstrated that the neural mechanisms mediating episodic memory may also support scene perception and scene imagination (for a review, Maguire & Mullally, 2013). For example, patients with hippocampal damage cannot vividly recall scenes from their past nor construct scenes from their imagination (Hassabis & Maguire, 2007; Mullally, Hassabis, & Maguire, 2012), suggesting that hippocampus, a brain structure crucial for episodic memory, is also engaged during scene processing irrespective of whether the scene is perceived or imagined. This has been corroborated by research with healthy participants, showing a common region within the hippocampus that respond to both perceived and reconstructed scenes (Zeidman, Mullally, & Maguire, 2015). Together this indicates that mental and physical context reinstatement may share, at least to some degree, the same underlying neural mechanisms, which supports the prediction that mental context reinstatement may lead to similar benefits in memory as physical context reinstatement.

We employed a paradigm with an incidental encoding of context (Smith & Vela, 2001), where the E-R context overlap and the nature of the context reinstatement were manipulated. Participants encoded word pairs presented on a physical scene representative of an everyday context (e.g., library, train-station). A cued-recall test was employed at retrieval where memory for all the word pairs was tested. Prior to the presentation of each retrieval cue, participants were engaged in a context reinstatement task, where a previously encoded context was either mentally reconstructed (mental reinstatement) or perceptually presented (physical reinstatement). After context reinstatement, participants were asked to retrieve the second word of the pair when given the first word (word cue). Importantly, recall of the word pair was tested after the reinstatement of the matching context, i.e., the context the word pair was encoded in, (E-R overlap) or a different context (E-R non-overlap). Because we temporally separated the context reinstatement from the cued-recall time window (Fig. 1) we could examine the neural correlates of a) episodic remembering facilitated by an E-R overlap (in the word cue time window) and b) context-induced target retrieval (in the preceding context reinstatement time window).

In the word cue time window, we examined the E-R overlap ERP effects for mental and physical context reinstatement. The presentation of the word cue prompts retrieval of the full word pair. Thus, a potential benefit of the E-R overlap should be observable in the ERP correlates of memory retrieval. Memory retrieval in cued-recall tests has typically been characterized by positive slow waves with a widespread topographical distribution (e.g., Allan & Rugg, 1997, 1998; Fay, Isingrini, Ragot, & Pouthas, 2005; Hellerstedt & Johansson, 2014, 2016; Hellerstedt, Johansson, & Anderson, 2016; Rugg & Curran, 2007; Rugg et al., 1998), which most likely reflect a combination of retrieval processes, such as searching for and