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The residual protective effects of enactment

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ABSTRACT

Research has demonstrated the importance of the quality of initial retrieval events (Test 1) for performance on later memory tests (Test 2). We explored whether enacting words at encoding, relative to simply reading them, provided protection against the detrimental effects of a degraded retrieval experience, through the addition of motor processing to the extant memory representation. Participants encoded a mixed list of enacted and read words, then completed Test 1, and a later Test 2. Encoding and Test 2 were always completed under full attention (FA). Critically though, Test 1 was completed either under FA, or under divided attention (DA) with a distracting task requiring semantic and phonological processing. We predicted a larger enactment effect following DA relative to FA, indicating greater preservation of enacted words from dual-task interference. In Experiment 1, we demonstrated that the enactment effect was indeed larger following DA than FA, indicating greater preservation of enacted words after dual-task interference. In Experiment 2, we showed that this effect was even more potent over longer time scales, which served as a conceptual replication. In Experiment 3, we showed that enactment provides little to no protection when the distracting task requires motor processing, and in Experiment 4, we returned to the phonological distracting task and showed that in contrast with enactment, generation at encoding *does not* afford the same protection to memory. Taken together, these finding suggest that enactment renders words relatively immune to the detrimental effects of dual-tasking during testing, through the addition of a different kind, rather than a greater degree, of processing to the memory trace at encoding.

1. Introduction

While much research has been dedicated to the development of strategies that improve memory encoding, recent work has also highlighted the importance of retrieval rehearsal through testing, in improving later memory performance (e.g. Whitten & Bjork, 1977; Roediger & Karpicke, 2006a, 2006b). Specifically, the experience of retrieving studied material, called retrieval practice, leads to better later retention than having the opportunity to restudy that information (Roediger & Karpicke, 2006a, 2006b). Such findings highlight the importance of the quality of a retrieval experience in dictating later memory success. It follows from these findings that any conditions that degrade the quality of a retrieval experience could lead to impairment in later recall. In our day-to-day experiences, we unfortunately, and frequently, find ourselves in situations in which multiple tasks are to be completed consecutively, or even concurrently with one another, and this can compromise retrieval (Fernandes & Moscovitch, 2000; Hicks & Marsh, 2000; Lozito & Mulligan, 2006). As such, retrieval is rarely a process that occurs without at least some competition from other thoughts, tasks, or processes. Given the foregoing research, which indicates that the quality of a retrieval experience is important to later memory, finding ways to protect memory from the negative outcomes associated with dual-tasking during testing is an important endeavor.

Previous work (Dudukovic, DuBrow, & Wagner, 2009) explored whether divided attention (DA) during an initial retrieval phase led to observably poorer memory performance on a later final test. In this work, participants studied 120 images, and their memory for these images was tested using a recognition task, completed either under conditions of full attention (FA), or DA (while simultaneously completing a pattern detection task with auditory stimuli). Participants then returned 2 days later to complete a second recognition task under FA. Results showed that there were robust differences in memory performance, indicating that despite Test 2 being completed under FA, there were lingering detrimental effects from DA during Test 1. Critically, this work was the first to provide evidence that future memory is limited by conditions of dual-task during initial retrieval. This finding is consistent with other work, showing detrimental effects of DA at retrieval when measured after-the-fact, on a final test (Guez & Naveh-Benjamin, 2013; but see Kessler et al., 2014). The aim of the current work was to

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determine whether an encoding strategy exists which would provide protection from dual-task interference during testing, of the sort outlined above.

1.1. Dual-task interference at retrieval

To understand how to protect memory from dual-task interference, one must first understand how DA likely exerts its effects on memory. Previous research has shown that competition for common materials or more recently, for common processing resources between concurrently performed tasks (Fernandes, Wammes, Priselac, & Moscovitch, 2016; Wammes & Fernandes, 2016) can lead to interference with episodic retrieval of previously studied information. Fernandes and Moscovitch (2000) were the first to highlight how DA during retrieval can precipitate failures in the retrieval process. Contrary to prevailing views at the time that retrieval was automatic (Baddeley, Lewis, Eldridge, & Thomson, 1984) or obligatory (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996), Fernandes and Moscovitch (2000) showed that if the distracting task required the same representational system (in this case, words), as was required for the target retrieval task, there was substantial interference with memory performance, relative to when the concurrent task consisted of non-overlapping materials. This finding has since been replicated many times (e.g. Barnes & Dougherty, 2007; Benjamin Clarke & Butler, 2008; Ciaramelli, Ghetti, & Borsotti, 2009; Fernandes & Moscovitch, 2002, 2003; Fernandes, Moscovitch, Ziegler, & Grady, 2005; Fernandes, Pacurar, Moscovitch, & Grady, 2006; Wais, Martin, & Gazzaley, 2012; Wais, Squire, & Wixted, 2010). Subsequent work has expanded upon this material-specific account of interference by providing evidence that decrements in memory can occur under DA at retrieval, when the concurrent tasks overlap in terms of processing requirements (Fernandes & Guild, 2009; Fernandes, Wammes, & Hsiao, 2013; Fernandes et al., 2016; Wammes & Fernandes, 2016).

The foregoing work leads to an alluring possibility: If one could employ encoding strategies that are already known to bolster memory performance under FA (e.g. production, MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010; generation, Slamecka & Graf, 1978; enactment, Cohen, 1981), this extra layer of coding of the memory trace could provide a safety net for when the native processing type (phonological or semantic) is degraded, or rendered unavailable due to dual-task conditions during an initial test. For example, performing relevant actions associated with to-be-remembered information at encoding could add motor information to the representation, and thus provide another processing route through which to access the encoded information at retrieval following a dual-task condition.

1.2. The enactment effect and memory

One subject performed task (SPT), resulting in what is now known as 'the enactment effect', leads to a robust and reliable improvement in memory performance. This SPT encourages participants to complete an action that is associated with to-be-remembered information. This information could be a short clause ('kick the ball'), a word ('ball'), or a visual representation of an object (an image of a ball), to which a participant is asked to execute an action they would commonly perform with that object (Engelkamp & Zimmer, 1997; Knopf, 1991; Senkfor, 2008). The enactment effect has proven to be robust, resulting in exceptionally high recognition memory, even when studying long lists (Engelkamp, Zimmer, & Biegelmann, 1993). Further, it has been shown that enacted items are more resistant to forgetting (Knopf & Neidhardt, 1989) and that enactment can bring online motor processing in addition to the standard phonological and semantic processing typically evoked when trying to encode verbal stimuli (e.g. Lesch & Pollatsek, 1998). As such, enactment is an ideal candidate for a SPT that could protect memory from the negative effects of DA at retrieval.

For our purposes, enactment during encoding was seen as a means of adding a distinct type of processing, or mode of representing target words, over and above simply reading the words during study. Research indicates that the latter would likely engage primarily phonological and semantic representations (Adams, 1994; Jared, Levy, & Rayner, 1999; Lee, Binder, Kim, Pollatsek, & Rayner, 1999; Lesch & Pollatsek, 1998). What we are suggesting is that utilizing a SPT could not only boost memory performance, but also provide some form of protection to the memory trace, in the face of dual-task interference or distraction during a later retrieval phase. Thus, on the basis of previous work (e.g. Dudukovic et al., 2009), it is a logical prediction that DA at retrieval should lead to poorer later memory performance as measured on Test 2. More importantly however, based on the foregoing rationale, enacted words might be *more* preserved under such conditions, relative to read words.

Since it has been suggested that dual-task interference is largely contingent on the degree of cortical overlap between regions of activation for the respective tasks (Klingberg & Roland, 1997), there is a neurological basis for our hypotheses as well. Differences in brain activity have been shown in neuroimaging studies, such that action words involving a particular body part (arm vs. leg. vs. face), when read silently, preferentially activate regions associated with veridical movement of that body part (Hauk, Johnsrude, & Pulvermüller, 2004; Hauk & Pulvermüller, 2011; Pulvermüller, 2005). Further, words that are enacted, relative to those read aloud, showed differential activation in the supramarginal gyrus, which has been associated with perception of limb location in space, as well as processing gestures (Russ, Mack, Grama, Lanfermann, & Knopf, 2003). In addition to the activation of regions largely associated with word processing, enacted words also engaged brain areas related to the movement performed (Masumoto et al., 2006). Accordingly, under DA conditions during retrieval, these additional regions should allow for some preservation of the memory trace when the lexical regions are otherwise occupied (by a distracting task). Indeed, Shebani and Pulvermüller (2013) showed this to be the case in a working memory task, albeit using a distracting task completed during the retention period. They found that motor tapping tasks, completed during the retention interval between encoding and retrieval of arm-related (e.g. clap, grab) or leg-related (e.g. kick, hop) words, impaired their memorability. Specifically, this work demonstrated that hand-tapping resulted in greater reduction in memory for arm-related words than did foot-tapping, while the opposite pattern occurred for memory of leg-related words.

These findings are in line with Engelkamp and Zimmer's (1984, 1985) suggestion that the motor program is an integral part of the representation of an action word or phrase, and is largely independent from other memory subsystems. Thus they invoke multiple codes to explain the benefit enactment provides, akin to Paivio's (1971) dual-code theory, which has been used to explain picture superiority (Paivio, Rogers, & Smythe, 1968). Alternatively, other researchers (Kormi-Nouri & Nilsson, 1998; Kormi-Nouri, Nyberg, & Nilsson, 1994) have argued that enactment improves memory by making enacted items more self-referential, proposing a difference in degree, rather than in kind, between enacted and read items. If our data show that enacted words are more resilient to dual-task interference, our results would be consistent with the former account, as it suggests that the distracting task had interfered with just one of the representational codes, leaving the motor code of the representation intact. However, we note that we do not directly test a self-referential account in the current work.