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Neural correlates of prospective and retrospective memory

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Abstract

This study examines the event-related brain potential (ERP) correlates of retrieval processes in prospective and retrospective memory (i.e., recognition and cued-recall). In contrast to previous research that has compared performance on tasks measuring prospective and retrospective memory, the stimulus materials and encoding and response demands of the prospective and retrospective components of the tasks were reasonably well matched for the two forms of memory. This resulted in the primary difference between the assessments of prospective and retrospective memory being the requirement for self-initiated retrieval in prospective memory. Analyses of mean amplitude measures revealed modulations of the ERPs typically associated with prospective memory (i.e., N300 and prospective positivity) and retrospective memory (i.e., FN400, parietal positivity and frontal slow waves). Partial least squares analyses revealed one latent variable related to the retrieval of a previously studied item that contrasted retrospective hits and prospective hits from ongoing activity trials and prospective lures; and one latent variable uniquely associated with prospective hits. These findings indicate that similar neural processes support retrieval in prospective and retrospective memory and that the realization of intentions is additionally dependent on processes that are uniquely related to prospective memory.

Keywords: Delayed intentions; ERPs; Partial least squares analysis

Over the course of an average day we are required to both remember the details of past experiences (i.e., retrospective memory; Tulving, 1983) and realize intentions that must be delayed for some period of time while engaged in other activities (i.e., prospective memory; Meacham & Leiman, 1982). As an example, suppose that you are working diligently on the revision of a paper when a student appears at your door with a number of questions related to an upcoming examination. You welcome the student while attempting to and then succeeding in recalling her name (an instance of retrospective remembering). During the conversation, the telephone rings, you answer the phone and it is a collaborator calling to discuss the details of the revision. You ask the collaborator if you can return her call in a few minutes. After answering the student's questions and wishing her well on the exam, you turn to the phone and place the call to your colleague (an instance of prospective remembering). Alternatively, and as is sometimes the case, you might return to the process of revising the paper, resulting in the intention to return the call going unrealized.

The preceding example highlights some of the similarities and differences between prospective and retrospective memory. Both can involve the recovery of a variety of contextual details from memory. For instance, in retrieving the name of a student one might also recover details related to the class in which she is enrolled, a previous conversation, or her performance on an earlier examination. Similarly, in remembering to return a phone call one would need to recall which of many possible collaborators needed to be contacted, and the contact information for that individual. A second similarity is that information supporting a prospective or retrospective memory judgment is typically not actively maintained in short-term memory. In laboratory-based tasks measuring retrospective

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memory researchers typically engage individuals in some intervening activity between encoding and retrieval, such as counting backwards or solving anagrams, making it difficult to maintain information in short-term memory; in prospective memory tasks individuals are engaged in an ongoing activity that often requires fairly deep processing, making it difficult to continuously rehearse the intention.

This example also highlights differences between prospective and retrospective memory. For instance, retrieval from retrospective memory is generally instigated as the result of an explicit external (e.g., a student appearing at one's office door) or internal (e.g., thinking "what is her name") agent. In contrast, retrieval from prospective memory, when it is event-based, is instigated by the detection of a cue (e.g., finishing the conversation) that does not necessarily prompt realization of the intention (i.e., finishing a conversation could prompt a number of activities; Craik, 1986; Ellis, 1996). In addition to differences in the conditions under which memory retrieval is prompted in prospective and retrospective memory, there are often differences in encoding between these two forms of memory. Encoding in retrospective memory can be either intentional (e.g., trying to commit to memory the names of students at the beginning of a semester) or incidental (e.g., encoding the details of a conversation following a class; see Brown & Craik, 2000). However, encoding in prospective memory would by necessity seem to always be intentional (i.e., one has the expectation upon forming an intention that it will be realized in the future).

Consistent with these intuitions regarding similarities between prospective and retrospective memory, data from several studies have demonstrated that a number of variables influence the efficiency of these two forms of memory in comparable ways. For instance, low frequency words are more often recognized than high frequency words in recognition memory tasks (Hintzman, 1988) and lead to higher levels of prospective responding when used as cues in prospective memory tasks (Einstein & McDaniel, 1990; McDaniel & Einstein, 1993). The efficiency of both prospective and retrospective memory is also modulated by the degree of study-test congruity, with recognition accuracy and prospective responding being higher when semantic meaning is congruent from study to test occasions (Marsh, Hicks, & Hancock, 2000; Meier & Graf, 2000; Tulving & Thompson, 1973).

In addition to studies demonstrating convergence between prospective and retrospective memory, evidence from a growing literature indicates that these two forms of memory can be dissociated. Data from a recent study utilizing a factor analytic approach demonstrated that measures of retrospective memory (i.e., free recall and recognition) and working memory (i.e., digit span and sentence span) loaded highly on one factor, while a measure of prospective memory loaded on a second factor in a sample of healthy older adults and individuals with Alzheimer's disease (Maylor, Smith, Della Sala, & Logie, 2002). Consistent with this finding, other evidence indicates that age-related differences in prospective memory persist when variance common to working memory and explicit recall of cue-intention associations is controlled (West & Craik, 2001). Neuropsychological studies of individuals with acquired brain damage also indicate that prospective memory can be impaired in participants who demonstrate intact performance on recognition and recall tasks (Bisiacchi, 1996; Palmer & McDonald, 2000).

1. ERPs, retrospective memory and prospective memory

ERPs have been used to examine the temporal dynamics of the neural processes underlying retrospective memory in studies utilizing recognition and cued-recall tasks (see Allan, Wilding, & Rugg, 1998; Rugg, 1995) as well as prospective memory (West, Herndon, & Crewdson, 2001). Modulations of the ERPs elicited during recognition memory have been associated with the contribution of familiarity to recognition of a previously studied item, the recollection of a previous item, and monitoring the produce of a memory search (Allan et al., 1998; Rugg, 1995); likewise, modulations of the ERPs elicited during cued-recall have been related to the retrieval of an associate from memory and the recovery of contextual information related to a studied pair (Allan & Rugg, 1998). Modulations of the ERPs elicited during prospective memory have been associated with the detection of prospective cues and the retrieval of intentions from memory (West et al., 2001; West & Ross-Munroe, 2002).

The recognition of a previously studied item in retrospective memory tasks is consistently associated with a series of modulations that arise as early as 200 ms after stimulus onset and are distributed over the parietal and frontal regions of the scalp (i.e., old–new effect, FN400, frontal slow wave). The parietal old–new effect reflects greater positivity for old items than new items between 300 and 800 ms after stimulus onset that is greater in amplitude over the left than right hemisphere (Paller & Kutas, 1992; Rugg & Nagy, 1989). Between 300 and 600 ms the parietal old–new effect is greater in amplitude for hits and misses than new items (Rugg et al., 1998a) and is similar in amplitude for items that were encoded at deep and shallow levels during encoding (Rugg et al., 1998a, 1998b). Together these findings have led to the suggestion that the early old–new effect is associated with the contribution of item familiarity or implicit memory to recognition. Between 600 and 800 ms the parietal old–new effect is greater in amplitude for deeply encoded items than shallowly encoding items (Rugg et al., 1998a) and for old items that are presented in the same format at study and test relative to old items that are transformed between study and test (Curran, 2000; Donaldson & Rugg, 1998). These findings have led to the proposal that the later portion of the parietal old–new effect is associated with recollection (Rugg et al., 1998a). In addition to the early portion of the parietal old–new effect, a second positivity has also been observed over the frontal region of the scalp between 300 and 500 ms after stimulus onset that has been associated with familiarity