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Correlates of implicit memory for words and faces in event-related brain potentials

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Abstract

Prior research has suggested an ERP correlate of implicit memory for words consisting of a centro-parietal positivity around 400 ms. We attempted (1) to replicate this ERP modulation in a different task, involving only trials with correct responses, and (2) to compare the findings to the domain of faces. Two experiments were conducted with a modified Sternberg task, in which both targets and nontargets were presented repeatedly. In Experiment 1, positive ERP differences between repeated and new nontargets were observed, which were domain-specific in topography and, for words, replicated the previously reported findings. In Experiment 2, the amplitude of the modulation for words, but not for faces, was unaffected by a variation of the level of processing during encoding, supporting the implicitness of the processes underlying the ERP modulation to nontarget words.

Keywords: Implicit memory; Priming; Explicit memory; Levels of processing; Event-related potentials; ERPs

1. Introduction

Repetition priming is a well-known behavioral manifestation of implicit memory and can be observed in numerous indirect memory tasks which, unlike direct tests of memory, do not require the participant to recognize or recall an item as having been seen before (Richardson-Klavehn and Bjork, 1988). Although some progress has been made about the neural implementation of implicit memory, especially the exact time course of the associated brain events is still unclear. Recently, several reports of event-related brain potential (ERP) correlates of implicit memory for words (Joyce et al., 1999; Paller and Gross, 1998; Paller et al., 1998; Rugg et al., 1998, 2000; Rugg and Nieto-Vegas, 1999) have been published which may provide evidence about the time course and—at least to some extent—the underlying brain systems of implicit memory.

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In the present study, we sought to enhance the knowledge about ERP correlates of implicit memory for words by replicating one of these recent findings (Rugg et al., 1998) in a different task and involving only trials with correct responses. Additionally, we aimed at the question of a domain-specific expression of ERP correlates of implicit memory by extending our study to the domain of face recognition. Two experiments were conducted. In the first experiment, we measured memory-related ERP modulations separately for common words and famous faces. In the second experiment, an encoding variation analogous to levels of processing (Craik and Lockhart, 1972) was employed to further test for the implicitness of the observed memory-related ERP modulations.

The recent interest in implicit memory is motivated by striking demonstrations of dissociations between explicit and implicit memory functions (for review, see Richardson-Klavehn and Bjork, 1988; Roediger and McDermott, 1993). For example, the level of processing during encoding (Craik and Lockhart, 1972) modulates explicit memory in direct memory tests, but it has little effect on implicit memory in indirect tests (Jacoby and Dallas, 1981; Roediger and McDermott, 1993). That is, words encoded deeply are better remembered in a direct memory test than words encoded shallowly, but both categories of words show a comparable amount of priming in indirect tests. In contrast, a modality change between study and test impedes implicit memory without necessarily affecting explicit memory (Richardson-Klavehn and Bjork, 1988). The dissociation between implicit and explicit memory is further supported by differences in their neural implementation (for review, see Gabrieli, 1998; Squire and Knowlton, 2000).

It is important to note that there is no direct correspondence between explicit memory, awareness of item repetition and direct testing procedures on one side, and between implicit memory, absence of awareness for item repetition and indirect memory testing on the other side (Rugg, 1995; Schacter, 1987). Thus it is difficult, if not impossible, to assess the absence of awareness, usually considered to indicate the absence of explicit memory, without falling back on some form of direct testing; in fact it is likely that implicit memory and awareness for repetitions co-occur in both direct and indirect tests of memory. Hence, instead of using different kinds of tests, implicit and explicit expressions of memory appear better dissociated by critical variables like the level of processing or modality changes.

Considering the reasonable overlap of implicit and explicit memory in both direct and indirect memory tests, it is not surprising that there is only a small number of studies, usually with verbal material, that demonstrated ERP correlates of implicit memory (Joyce et al., 1999; Paller and Gross, 1998; Paller et al., 1998; Rugg et al., 1998, 2000; Rugg and Nieto-Vegas, 1999, for related findings, see Doyle and Rugg, 1998; Doyle et al., 1996; Rugg et al., 1995; Walla et al., 1999). In general, ERP correlates of memory can be visualized as differences between ERPs to repeated and new stimuli. In order to control for contributions of explicit memory, Paller and colleagues (Joyce et al., 1999; Paller and Gross, 1998; Paller et al., 1998) and Rugg and Nieto-Vegas (1999) employed stimulus transitions that were considered to modulate implicit memory but not explicit memory. In contrast, Rugg et al. (1998) took a different approach by analyzing ERPs to repeated words that had not been recognized in a direct recognition task. The absence of recognition was considered to reflect the absence of explicit memory. Rugg et al. (1998) found a small positivity around 400 ms at parietal electrode sites.

There are two critical issues for the ERP correlate of implicit memory for words as provided by Rugg et al. (1998). Firstly, this ERP modulation was uncovered by analyzing trials with incorrect responses in comparison to trials with correct responses. The interpretation of this ERP modulation as a correlate of implicit memory is therefore confounded with the correctness of response. This raises the possibility that this ERP modulation reflects contributions from error-related brain activity or subthreshold explicit memory, which was too weak to trigger the overt recognition response. Rugg et al. (1998) faced this problem by demonstrating that this ERP modulation was partially unaffected by a variation of the level of processing and unrelated to the accuracy of recognition, indicating that the modulation is in fact a correlate of implicit memory. In line with this idea, a similar ERP modulation was found also in an indirect memory test. Noteworthy however, this ERP modulation was unaffected only at parietal electrode sites. Deeper processing at study led to awareness of word repetition as reflected in higher recognition