ERP ‘old/new’ effects: memory strength and decisional factor(s)

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Abstract

Event-related potentials (ERPs) were recorded while subjects made old/new recognition judgments on new unstudied words and old words which had been presented at study either once (‘weak’) or three times (‘strong’). The probability of an ‘old’ response was significantly higher for strong than weak words and significantly higher for weak than new words. Comparisons were made initially between ERPs to new, weak and strong words, and subsequently between ERPs associated with six strength-by-response conditions. The N400 component was found to be modulated by memory trace strength in a graded manner. Its amplitude was most negative in new word ERPs and most positive in strong word ERPs. This ‘N400 strength effect’ was largest at the left parietal electrode (in ear-referenced ERPs). The amplitude of the late positive complex (LPC) effect was sensitive to decision accuracy (and perhaps confidence). Its amplitude was larger in ERPs evoked by words attracting correct versus incorrect recognition decisions. The LPC effect had a left > right, centro-parietal scalp topography (in ear-referenced ERPs). Hence, whereas, the majority of previous ERP studies of episodic recognition have interpreted results from the perspective of dual-process models, we provide alternative interpretations of N400 and LPC old/new effects in terms of memory strength and decisional factor(s).

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1. Introduction

A common finding of many event-related potential (ERP) studies of recognition memory is that presentation of old/repeated items elicits more positive-going ERPs than does presentation of new/unrepeated items (reviewed in [23,34,35]). Such ERP ‘old/new effects’ typically onset approximately 300–400 ms post-stimulus, last 300–600 ms and, when words are used as stimuli, are generally of greatest magnitude at left parietal and adjacent centro-parietal electrodes. On the basis of differing scalp topographies (e.g. [43]) and differential sensitivities to manipulation of a number of experimental variables (e.g. word frequency and repetition lag [33]), ERP old/new effects are now assumed to comprise dissociable early and late effects which reflect the modulation of the N400 and a subsequent late positive component (or complex). There are incongruities in the literature over the name given to this late positive component of the ERP old/new effect with P3, P100, P600 and late positive complex (LPC) having been used by different authors. Without attempting to resolve the issue of whether or not these labels all represent the exact same entity, the term LPC will be used here in reference to this ERP component. Further support for the N400-LPC old/new effect distinction is provided by evidence from a number of intracranial ERP studies (e.g. [13]) which indicate that the N400 and LPC are generated by different neural populations.

Over the past decade most authors have interpreted ERP old/new effects from the perspective of dual-process models (e.g. [19,27]) of recognition memory. Generally, these models stipulate that recognition comprises familiarity which is often assumed to be a context-insensitive, automatic process bereft of the phenomenological experience of remembering; and recollection, a context-sensitive, strategic, recall-like process involving the conscious retrieval of specific information about the encoding episode. Attempts to relate components of ERP old/new effects to putative familiarity and recollection processes have sometimes possessed low discriminatory power, and must still be considered speculative until further supporting evidence is obtained. It is also noteworthy that some authors have concluded that results from a number of ERP studies of episodic memory provide scant support for dual-process models [35]. Furthermore, these
models have been found to be unsatisfactory on a number of grounds (e.g. [17]) and alternative approaches have been posited (e.g. [10,18]). Thus, while the results of many ERP studies of episodic recognition have been interpreted in the context of dual-process models, alternative memory models warrant further consideration in the interpretation of ERP old/new effects.

It has been proposed that a N400 component in ERPs recorded at parietal electrodes is sensitive to implicit memory processes [41], and also that it is unlikely that the N400 old/new effect reflects activity associated with the explicit discrimination of old from new items [23,34]. The latter proposal was made on the basis of the failure of a number of investigations to obtain an N400 old/new effect when the study-test interval exceeds some time between 2 and 15 min (e.g. [25,37]). In addition, a N400-like component with a more frontal distribution, the ‘FN400’ (following [6]), has been proposed to index familiarity [6,7,41]. However, as noted above, ERP data need not be associated with approaches that distinguish between putative familiarity and recollection processes. For example, an alternative framework is provided by global matching models [16] which assume that the recognition decision is based on the summed strength of all matches between the cue(s) and all traces in a single global memory system. Separate episodic and non-episodic systems are not proposed. Instead the memory system can be cued with both item and contextual information so in contrast to the concept of familiarity the matching operation is generally thought to be context-dependent. Some memory models propose a relatively rapid change of contextual representations over time [15]. Thus, the observed susceptibilities to temporal decay of single item recognition performance (e.g. [14]) and of the N400 old/new effect, may be the consequences of such contextual change. The strength of the global match is a continuous variable, and the same is often thought to be true of dual-process familiarity (e.g. [55]). We will hereafter refer to any such continuous or graded variable (as distinct from a categorical variable, such as recollection) as strength. Differences between this and other notions of familiarity will be highlighted where such is often thought to be true of dual-process familiarity (e.g. [55]).

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