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Neurophysiological indices of perceptual object priming in the absence of explicit recognition memory

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ABSTRACT

The aim of this study was to identify ERP correlates of perceptual object priming that are insensitive to factors affecting explicit, episodic memory. EEG was recorded from 21 participants while they performed a visual object recognition test on a combination of unstudied items and old items that were previously encountered during either a 'deep' or 'shallow' levels-of-processing (LOP) study task. The results demonstrated a midline P150 old/new effect which was sensitive only to objects' old/new status and not to the accuracy of recognition responses to old items, or to the LOP manipulation. Similar outcomes were observed for the subsequent P200 and N400 effects, the former of which had a parietal scalp maximum and the latter, a broadly distributed topography. In addition an LPC old/new effect typical of those reported in past ERP recognition studies was observed. These outcomes support the proposal that the P150 effect is reflective of perceptual object priming and moreover, provide novel evidence that this and the P200 effect are independent of explicit recognition memory process(es).

1. Introduction

The term 'priming' is used to describe a phenomenon whereby stimuli that have been previously encountered are processed more rapidly, fluently and/or accurately than those that have not (Tulving et al., 1990; Wiggs and Martin, 1998). Priming can occur in the absence of conscious or explicit memory and is thus considered a form of implicit memory; this conceptual framework is supported by a variety of observations, including that priming can be preserved in amnesic patients (Graf et al., 1984; Milner et al., 1968).

Behavioural studies conducted with non-clinical groups have shown that perceptual priming and explicit memory appear to operate according to different principles. For example, perceptual object priming is enhanced when the key surface features of an object remain static across repetitions (i.e., form-specific priming, Biederman et al., 1991) or repeated objects are perceived as a coherent whole (i.e., 'possible' rather than 'impossible', Schacter et al., 1991). In contrast, episodic memory of objects is improved following conceptual or deep encoding as evoked by the levels-of-processing (LOP) manipulation (Schacter et al., 1990).

Such observations have led some to propose that priming is subserved by brain network(s) that are independent of the medial temporal lobe (MTL) system (Squire and Zola-Morgan, 1991). However, it is widely acknowledged that the validity of explicit and implicit memory dissociations, particularly in non-clinical populations, is threatened if explicit memory retrieval strategies are used in priming tests (Henson, 2003). A primary aim of the current study is to employ event-related potentials (ERPs) to investigate neurophysiological indices of perceptual object priming in the absence of conscious episodic recognition memory. In doing so we aim to extend distinct ERP findings from object priming (e.g. Eddy et al., 2006; Schendan and Kutas, 2003, 2007) and episodic recognition (e.g. Rugg et al., 1998; Rugg and Curran, 2007) studies.

Tulving and Schacter (1990) proposed that perceptual priming depends on a Perceptual Representation System (PRS); where representations, of global form (e.g., structural representations) are activated across exposures, independent of explicit memory. According to this model, such reinstatement is a 'bottom-up', automatic process which results in more fluent processing of the perceptual features of previously encountered stimuli. Schacter (1994) posited that the PRS consists of three domain-specific subsystems each of which processes distinct forms of stimuli (i.e., visual words, visual objects, and auditory words) and in the current study we investigate putative ERP correlates of the visual object subsystem.

ERPs, due to their high temporal acuity, are ideal for studying rapidly changing cognitive processes, such as perceptual priming and episodic

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memory. Most ERP studies of priming have incorporated verbal stimuli, and those using objects have primarily focussed on conceptual or semantic object priming (Barrett and Rugg, 1990; Holcomb and McPherson, 1994; McPherson and Holcomb, 1999). However, a few perceptual priming studies incorporating objects show that early ERP repetition effects rely upon form-specific exposures (Eddy et al., 2006; Schendan and Kutas, 2003, 2007) and thus provide evidence to suggest a PRS function.

Using an indirect priming task, Schendan and Kutas (2003) observed an enhanced vertex P150 (140–250 ms) effect for objects repeated in the same viewpoint relative to those repeated in different views and those for new objects. Schendan and Kutas (2003) proposed these outcomes to be reflective of perceptual processing, and the "recruitment of a structural description PRS" (p. 131). Further, Schendan and Kutas (2007) in another indirect priming task reported a reduced (i.e., less positive) right posterior P200 effect (224–240 ms) for repeated objects (repeated in the same or complementary fragment) relative to non-repeated fragmented objects and fragmented objects initially presented intact. On the basis that the old/new difference occurred between old objects repeated in the same (or complementary) format and new objects, the authors posited the P200 effect to be a perceptual implicit memory effect that was dependent on the same processes (of good continuation and closure) being repeated across exposures.

Eddy et al. (2006) incorporated colour photographs of common objects into a rapid masked priming paradigm and similarly found at posterior sites that identical repetitions (in the prime and target positions) elicited a reduced early effect (P190, 100–250 ms) relative to unrepeated pictures which was slightly larger over the right hemisphere. The authors attributed this effect to feature processing occurring in the visual cortex. At the same interval an opposite effect occurred at anterior sites, with repeated pictures demonstrating an enhanced N190 relative to unrepeated pictures. Eddy et al. (2006) speculated that this represented a polarity inversion (of the P190) indicative of the effects of one neural generator.

Although the above studies have yielded novel observations and identified potential ERP indices of perceptual object priming a crucial weakness of Schendan and Kutas' (2003, 2007) designs are that neither precluded that at least some degree of explicit memory "contamination" contributed to the priming results. Hence sensitivity of the aforementioned P150 and/or the later P200 effects to explicit memory process(es) cannot be definitively excluded. While Eddy et al.'s (2006) rapid masked priming paradigm overcomes the threat of explicit memory: because primes are presented briefly and are masked; their short retention interval between prime and target (i.e., 50 ms) does not test whether outcomes characterise priming that extends beyond very short periods (see Henson, 2003 for a discussion on very short- versus long-term priming). A methodological design which would enable exclusion of contamination of explicit memory and investigate priming that is preserved across minutes (rather than milliseconds) could extend the findings of Schendan and Kutas (2003, 2007) and Eddy et al. (2006) and perhaps more definitively identify ERP correlate(s) of perceptual object priming process(es) *per se*.

The design of an episodic word recognition study reported by Rugg et al. (1998) appears effective in this regard. These authors employed a levels-of-processing (LOP) manipulation during encoding trials and this resulted in higher recognition accuracy for deeply- versus shallowly-encoded words. Moreover, the relatively higher number of shallowly-encoded words which were not correctly recognised at test permitted for this condition computation of group-average ERPs with sufficient trial numbers. Hence explicit memory contamination can be excluded as a potential contributant to these missed-word ERPs (Henson, 2003). The analyses of Rugg et al. (1998) focussed exclusively upon relatively later latency intervals corresponding to ERP components widely associated with episodic recognition; the N400 (300 to 500 ms) and the late positive complex (LPC; 500 to 800 ms). During the N400 interval at parietal electrodes, ERP amplitudes differed according to their old/new status rather than recognition accuracy or the LOP manipulation. The authors posited this effect to be a correlate of implicit memory, in the absence of conscious recognition. Frontal ERPs during this interval, as well as an effect during the 500 to 800 ms interval, were proposed to be reflective of explicit recognition memory.

Hence a design and comparisons such as those reported by Rugg et al. (1998) could prove useful in further investigations of the vertex P150 and right occipito-temporo-parietal P200 components proposed by Schendan and Kutas (2003, 2007) and Eddy et al. (2006) to reflect perceptual object priming. Specifically, examination of unrecognised object ERPs could permit exclusion of the possibility that explicit memory modulates one or both of these components. Such an outcome might enable new insights into the perceptual object priming and the operations of the PRS via investigation of the neurophysiological correlates of these.

2. Method

2.1. Participants

Twenty-two participants were recruited from the Griffith University, School of Psychology first year subject pool and received course credit for consenting to and taking part in the study. Institutional ethics approval was obtained prior to conducting the study. The data of one participant were discarded due to insufficient numbers of trials with which to form reliable ERPs. The remaining 21 participants (19 females and two males) had a mean age of 21.48 years (SD = 5.22 years). All participants were right handed, had English as their first language, and did not report a history of brain injury.

2.2. Object recognition test

2.2.1. Stimuli and task

A group of 154 objects were randomly drawn from the Snodgrass and Vanderwart (1980) pool of 260 black and white line drawings of common objects. These objects were then randomly allocated into three groups (of 48 objects each) and these were rotated across conditions (shallow, deep, new) and participants. Therefore, every object served equally often as a deep and shallow encoding object and a new object. The remaining 10 objects were included at the beginning and end of the study (4 fillers) and test (6 fillers) lists to avoid primacy and recency effects. A total of 100 objects were presented at study, and 150 objects at test.

The study employed an object recognition test, using a study/test paradigm. A LOP manipulation was used at the study phase, with 48 objects allocated to the perceptual or 'shallow' task and 48 to the semantic or 'deep' task. The perceptual task (termed here as the X task) was to judge whether the left outer most edge was higher than the right outer most edge of an object. The possible responses were "yes", "no" or "same". The semantic task (termed here as the O task) was to incorporate the name of the object into a meaningful sentence and say the sentence aloud. Shallow and deep trials were randomly interspersed in the study list, as well as new trials in the test list.

Objects were shown centrally on a computer screen, with black lines on a white background. All objects fitted into an 11 cm × 11 cm space. The maximum visual angle subtended was 3° horizontally and .5° vertically. Each trial of the study phase commenced with the presentation of the pre-item cue (viz., either an X or O character), for 1000 ms, indicating whether the perceptual (X) or semantic (O) task be subsequently performed. An object followed for 600 ms, and then finally a question mark appeared for 3500 ms, during which the participant made a verbal response. The total time of each study trial was 5100 ms. An intercom was used to listen to the verbal responses made by the participant during the study task and these were recorded manually by the researcher.

Each test phase trial consisted of a fixation asterisk for 2100 ms, followed by a blank screen for 100 ms, an object for 300 ms, and finally a question mark for 2300 ms, during which the participant indicated whether the object appeared in the previous study phase by pressing