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Research report

Behavioural and neural evidence for the impact of fluency context on conscious memory

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ARTICLE INFO

Article history:
Received 14 June 2016
Reviewed 19 August 2016
Revised 4 November 2016
Accepted 12 April 2017
Action editor Emrah Duzel
Published online 21 April 2017

Keywords:
Perceptual fluency
Masked priming
Recognition memory
Context
fMRI

ABSTRACT

It has been recently suggested that fluency may impact recognition memory performance when the fluency context varies from trial-to-trial. Surprisingly, such an effect has proved difficult to detect in the masked priming paradigm, one of the most popular means to increase fluency-based memory judgements. We conducted a functional magnetic resonance imaging (fMRI) experiment in which participants encoded words at study and, at test, performed a recognition memory task within a masked priming procedure. In order to optimise the chances of finding priming effects on recognition memory performance, we used low-frequency words, which have been shown to increase hits relative to false alarms and enhance masked priming effects. Fluency context was manipulated by either mixing primed and unprimed trials [Random context (RC) experiment] or blocking primed and unprimed trials [Blocked context (BC) experiment]. Behaviourally, priming affected high-confidence memory performance only in the RC experiment. This behavioural effect correlated positively with neural priming in several recognition memory regions. Moreover, we observed a functional coupling between the left middle temporal gyrus and the left parietal and posterior cingulate cortices that was greater for primed relative to unprimed words. In contrast, in the BC experiment, despite similar activity in recognition-memory-related regions, we did not find any significant correlations between neural and behavioural priming. Finally, we observed striking differences in the neural correlates of masked priming between the RC and BC experiments not only in location but also in direction of the neural response. Possible implications of these findings are discussed.

1. Introduction

Within dual-process frameworks, recognition memory decisions can be based on two distinct kinds of memory: familiarity and recollection. Familiarity is often described as a fast-acting and relatively automatic process, whereas recollection is believed to be an all-or-none threshold process, in which contextual information associated with the encoding of an item is retrieved in addition to the memory for the item

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http://dx.doi.org/10.1016/j.cortex.2017.04.008

itself (e.g., Mandler, 1980; Mayes, Montaldi, & Migo, 2007; Yonelinas, 1994).

The seminal work of Jacoby and colleagues (e.g., Jacoby & Dallas, 1981; Jacoby & Whitehouse, 1989) showed that recognition memory judgements can also sometimes be based on the relative ease with which an item is processed. Several lines of evidence seem to converge on the idea that fluently-processed items are more likely to be endorsed as "old" regardless of the item's true study status, leading to illusions of recognition (e.g., Jacoby & Whitehouse, 1989; Whittlesea, 1993; Whittlesea, Jacoby, & Girard, 1990). Within the recognition memory context, the masked priming paradigm has particularly stood out as a powerful means to artificially enhance fluency. In this procedure, participants make recognition judgements on test items that are preceded by brief and masked presentations of the same (primed) or different (unprimed) item, effectively preventing any conscious identification of these items (also called "primes"). Typically, the probability of making an "old" judgement to the test item (e.g., "sugar") is increased when preceded by a matched prime (e.g., "sugar") than by a non-matched prime (e.g., "lamp") (e.g., Jacoby & Whitehouse, 1989; Rajaram & Roediger, 1993; Westerman, Lloyd, & Miller, 2002).

Early manipulations of fluency during recognition memory tests were shown to affect familiarity but not recollection (e.g., Kinoshita, 1997; Rajaram & Geraci, 2000; Rajaram, 1993). These studies employed a Remember/Know (R/K) procedure which provides rough estimates of familiarity (K responses) and recollection (R responses), and showed that the bias to respond "old" was only observed when recognition judgements were subsequently associated with a K response. These behavioural data linking fluency and familiarity have been also supported by research using event-related potentials (ERPs) (e.g., Leynes & Zish, 2012; Taylor & Henson, 2012; Wolk et al., 2004; Woollams, Taylor, Karayanidis, & Henson, 2008), and, more recently, functional magnetic resonance imaging (fMRI) (e.g., Dew & Cabeza, 2013). In Dew and Cabeza's fMRI study, a masked priming paradigm was used in the scanner and the authors showed that activity in the perirhinal cortex was reduced for primed false alarms (i.e., unstudied items incorrectly given an "old" response) relative to both unprimed false alarms and primed/unprimed correct rejections (i.e., unstudied items correctly given a "new" response). Moreover, the degree of attenuation of perirhinal activation was negatively correlated with the behavioural tendency to call an item "old". The observation that activity in the perirhinal cortex is modulated by fluency for new, unstudied items is remarkable, especially given the abundant evidence linking perirhinal cortex reductions to objective familiarity memory. Dew and Cabeza concluded that perirhinal activity reductions found for false alarms may reflect fluency rather than familiarity memory per se, because there could not have been objective memory for false alarms since the words had not been studied before.

Some recent studies, however, have also indicated that recollection memory may be as susceptible to fluency manipulations as familiarity (e.g., Kurilla & Westerman, 2008; Taylor & Henson, 2012; Wang, Li, Gao, Xu, & Guo, 2015). For example, Taylor and Henson (2012) used a modified masked priming procedure and showed that when previously studied test targets (e.g., guitar) were preceded by conceptually-related masked primes (e.g., piano), the incidence of R responses was increased relative to when prime and target were the same word. The authors speculated that because the study task involved a high degree of elaboration, the concept of the prime could have possibly been one of the concepts spontaneously generated during the study phase; the combined activation of the prime and target may have increased the probability of retrieval of the entire episodic trace, resulting in recollection. Their interpretation was supported by a subsequent fMRI study in which activity in recollection-related parietal structures correlated with the size of the behavioural priming effect (Taylor, Buratto, & Henson, 2013). Importantly, the increase in R judgements following priming occurred for hits but not for false alarms. This further indicated that priming increased retrieval of internal source information, rather than leading to an illusory feeling of memory as occurs with fluency-driven familiarity (which tends to increase both hits and false alarms to a similar level).

Regardless of whether fluency affects familiarity, recollection, or both, it has been argued that reliance on fluency during recognition memory judgements is largely dependent on the level of fluency associated with the surrounding stimuli. For example, Westerman (2008) observed that participants were more likely to respond "old" in contexts in which only a few items were primed relative to when, for example, all items had been primed. The finding that an increase in "old" responding is only detectable when the fluency context includes sparse primed items at test led Leynes and Zish (2012) to investigate the role of fluency context during recognition memory. They presented a series of words at study and participants were asked to count the number of vowels in each word. Later, at test, ERPs were recorded while participants engaged in a recognition memory test for old and new words, half of which were presented slightly blurred whereas the other half were presented in a clear typeface. Critically, the authors manipulated fluency context by testing a group of participants for whom clarity was varied randomly, and a separate group for whom blurry and clear words were presented in separate blocks. The results indicated that recognition memory accuracy was higher for clear than blurry words when clarity was varied randomly, whereas accuracy was equivalent when clear and blurry words were blocked. Furthermore, blocking clarity revealed a posterior negative ERP component (280–400 msec) that was sensitive to both old/new and clear/blurry. Conversely, when clarity was randomised across trials, repetition influenced the FN400, a putative ERP correlate of familiarity (Mecklinger, 2000), but not the earlier posterior negativity. The authors concluded that recognition was supported by familiarity when clarity varied randomly, whereas it was based on repetition fluency when clarity was blocked. They speculated that repetition fluency (old *vs* new words) combined with perceptual fluency (clear *vs* blurry words), and the mixing of these fluency signals (old and clear) made those items stand out relative to the surrounding items, leading to feelings of familiarity (see also Bruett & Leynes, 2015). Importantly, this effect could only occur when the context allowed for variations in fluency levels, since assessing whether a word is fluent requires some type of benchmark.