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Electrophysiological evidence for retrieval mode immediately after a task switch



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ABSTRACT

It has been suggested that retrieving episodic information can involve adopting a cognitive state or set: retrieval mode. In a series of studies, an event-related potential (ERP) index of retrieval mode has been identified in designs which cue participants on a trial-by-trial basis to switch between preparing for and then completing an episodic or non-episodic retrieval task. However, a confound in these studies is that along with task type the content of what is to be retrieved has varied. Here we examined whether the ERP index of retrieval mode remains when the contents of an episodic and non-episodic task are highly similar – both requiring a location judgement. In the episodic task participants indicated the screen location where words had been shown in a prior study phase (left/right/new); whereas in the perceptual task they indicated the current screen location of the word (top/middle/bottom). Consistent with previous studies the ERPs elicited while participants prepared for episodic retrieval were more positive-going at right-frontal sites than when they prepared for the perceptual task. This index was observed, however, on the first trial after participants had switched tasks, rather than on the second trial, as has been observed previously. Potential reasons for this are discussed, including the critical manipulation of similarity in contents between tasks, as well as the use of a predictable cue sequence.

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Introduction

Episodic memory retrieval involves a number of processes. Most frequently researchers focus on the downstream consequences of the interaction between a retrieval cue and a memory representation. Another important factor, however, is the cognitive state of the individual before a retrieval cue is encountered or generated. Tulving (1983) argued that in order for a person to remember a particular episode they need to enter a cognitive set where stimulus items are treated as retrieval cues – known as retrieval mode. Neuroimaging methods have been useful in studying retrieval mode due to the difficulty in assessing cognitive states using behavioural methods alone. Retrieval mode is thought to be a sustained cognitive set that is entered when there is a requirement to retrieve episodic information and, consequently, can be revealed by contrasting neural activity while people are preparing to complete different kinds of task e.g. episodic versus non-episodic (Rugg and Wilding, 2000).

A series of positron emission tomography (PET) and functional magnetic resonance (fMRI) studies have indicated that the right prefrontal cortex is involved in the initiation and/or maintenance of retrieval mode (Lepage et al., 2000; Nyberg et al., 1995; Velanova et al., 2003). This is also consistent with the findings in a study by Düzel et al. (1999, 2001)

who recorded direct current (DC) potentials while participants switched between completing separate blocks of an episodic task (old/new recognition judgement) and a semantic task (animacy judgement). Each block had four words and a cue was presented prior to the first word to indicate which task participants should complete. Electrical activity was more positive-going at a right frontopolar site during episodic than semantic retrieval. This difference emerged around the time that the task cue was presented, increased until the second word and was then maintained for the rest of the block. Extended analysis by Düzel et al. (2001) found that the DC potential differences observed between the episodic and semantic tasks could be modelled by a generator in the right prefrontal cortex. They interpreted this difference as an index of retrieval mode.

Further event-related potential (ERP) studies have been conducted using designs where activity has been contrasted on a trial-by-trial basis to determine with increased specificity the dynamics of retrieval mode. Morcom and Rugg (2002) used this type of design and the same tasks as Düzel et al. (1999, 2001). Neural activity was time-locked to the cue denoting which task participants should prepare to complete before test words appeared 1.6 s later. They found that neural activity elicited by the episodic cue was relatively more positive-going than the semantic cue at right fronto-central scalp locations, from approximately 500 ms post-cue until the onset of the test word. This effect was evident on the second successive trial after a task switch (hereafter a 'stay' trial) but not on the first trial of a task (a 'switch' trial). Morcom and Rugg (2002) suggested that the adoption of

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retrieval mode takes time and may not be completed until at least one item has been presented which requires a response.

Since these studies a further three similar ERP studies have been conducted. Herron and Wilding (2004) asked the participants to switch between three different tasks: semantic (a moving/non-moving judgement) or one of two episodic tasks (recover spatial information or encoding task from the study phase). Both of the episodic preparatory cues elicited a greater relative positivity compared to the semantic cue over right-frontal electrode locations from around 800 ms until the onset of the test word (2300 ms after the preparatory cue). These findings further corroborate the interpretation of this effect as a neural index of processes linked with retrieval mode due to it being present across two different episodic tasks relative to the semantic task and invariant between the episodic tasks. Consistent with the findings of Morcom and Rugg (2002), Herron and Wilding (2004) also found that this effect was present on stay trials only. In a further paper (Herron and Wilding, 2006a), in which the preparatory period was extended to 4000 ms, they again found that ERPs following episodic and semantic cues diverged on stay trials at right-frontal scalp locations. This suggests that time to prepare is not the only determinant in the adoption of retrieval mode. Wilckens et al. (2011) also found divergences between an episodic cue (old/new recognition) and a semantic cue (animacy task) on stay trials only. However, in contrast to all previous studies it was the semantic cue which generated more positive-going ERPs than the episodic cue. This discrepancy might be due to a different reference electrode being used or the use of pictures in this study compared to words in all other studies.

A key observation for the work reported here is that in order to assess retrieval mode researchers have manipulated the tasks participants complete, but these tasks have also differed in terms of the content that is to be retrieved subsequently. In the studies by Düzel et al. (1999, 2001), Morcom and Rugg (2002) and Wilckens et al. (2011) participants made an old/new recognition judgement (episodic task) and an animate/inanimate decision (semantic task). The tasks used by Herron and Wilding (2004, 2006a) required participants to make a left/right/new judgement (episodic), an animacy/pleasantness/new decision (episodic; 2004 paper only) or a moving/not moving/unsure choice (semantic). Therefore it is unclear whether the neural differences that have been observed between episodic and semantic cues reflects retrieval mode, the consensual interpretation, or the differences between the contents of what is to be retrieved.

The aim of this study was to assess the possibility that differences between contents are responsible for the divergences in preparatory activity described above, rather than reflecting preparation for episodic retrieval per se. This was accomplished by manipulating retrieval mode by having only one of the two tasks requiring episodic retrieval, as has been done previously, but crucially keeping the contents of the tasks very similar. To achieve this, one task entailed the recovery of location information from a study phase (episodic task) and required a location judgement (left/right/new). The other task also involved a location judgement but this time of the current screen location of the test word (perceptual task) and a top/middle/bottom decision was required. These tasks both entailed a location judgement that was similar, rather than identical, to minimise conflict between the response options given that they were usually incongruent between the tasks. If the activity that has been observed previously, the right-frontal greater relative positivity elicited by episodic cues in comparison to non-episodic cues, is an index of retrieval mode, then it should also be evident in this study. The absence of this effect would challenge current accounts of the processes engaged during preparation for episodic retrieval.

Method

Participants

Forty-eight individuals participated in the study for payment of £15 after giving informed consent. All were right-handed native English

speakers aged 18–30 and 35 were females. Sixteen participants were excluded from the experiment: 11 failed to contribute sufficient artefact free trials in the conditions of interest (≥ 16 ; see Evans et al., *in press*, for related test item data), and 5 fell below the threshold for behavioural performance (defined as $< .6$ source discrimination, see below). Thus 32 participants (24 females) were included in the study.

Design

Stimuli consisted of 240 concrete nouns selected from the MRC psycholinguistic database (Coltheart, 1981) with Kucera–Francis frequencies of 1–9 per million. All words had between 3 and 9 letters and were presented in Times New Roman font in white letters on a black background. The words were randomly assigned to one of 20 lists each containing 12 words. There were 10 study–test cycles. Within each cycle, one list was shown at study and again at test along with a second list. No lists were repeated across cycles. Half of the study words were presented on the left half of the monitor and half on the right. The designation of words to the left or right side of the screen was counterbalanced across participants and presented in a randomised order.

During the test phase words were shown slightly above, at, or below fixation, with an equal number at each location. Each of these words was preceded by one of two preparatory cues, indicating which task participants were to complete, and these were denoted by the capital letters O and X. The mapping of these letters to task was counterbalanced across participants. Each test cue type was always presented for two consecutive trials. The test stimuli were presented on a monitor 1.2 metres from the participant and subtended a maximum visual angle of 2.1° vertically and 2.5° horizontally. The old/new status of words and the assignment of words to the episodic or perceptual task were fully counterbalanced.

Procedure

Each study–test block started with a message on screen indicating the number of the block participants were about to complete. At study participants were asked to indicate whether the word appeared on the right or left side of the screen. A fixation asterisk was presented for 1000 ms, then a word for 300 ms. The monitor was then blanked until a response was made, after which the monitor remained blank for a further 500 ms before the start of the next study trial. Participants responded with their index and middle fingers, counterbalanced across left and right hand. Left side location judgements were always associated with the leftmost of the two fingers.

At test each trial started with a preparatory cue indicating which task participants should prepare to complete. One cue indicated that participants should prepare to decide whether the word was new (not shown at study) or had appeared on the left or right side of the screen – the episodic task. The other cue directed participants to prepare to indicate whether the test word had just appeared toward the top, middle or bottom of the monitor – the perceptual task. Each task required one of three responses; episodic task: left/right/new and perceptual task: top/middle/bottom. The preparatory cue stayed on screen for 300 ms, followed by a fixation asterisk for 2000 ms, then the test word for 300 ms. The monitor was then blanked until participants made a response, and remained blank for a further 500 ms before the next preparatory cue was shown. Participants were asked to pay attention to the preparatory cue in order to identify the impending task requirements and to respond accordingly. Participants responded using the same fingers as at study, with the addition of the index finger of the other hand to indicate new or below fixation. They were encouraged to balance speed and accuracy equally.

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