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Attention-related activity during episodic memory retrieval: a cross-function fMRI study

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Abstract

In functional neuroimaging studies of episodic retrieval (ER), activations in prefrontal, parietal, anterior cingulate, and thalamic regions are typically attributed to episodic retrieval processes. However, these activations are also frequent during visual attention (VA) tasks, suggesting that their role in ER may reflect attentional rather than mnemonic processes. To investigate this possibility, we directly compared brain activity during ER and VA tasks using event-related fMRI. The ER task was a word recognition test with a retrieval mode component, and the VA task was a target detection task with a sustained attention component. The study yielded three main findings. First, a common fronto-parietal-cingulate-thalamic network was found for ER and VA, suggesting that the involvement of these regions during ER reflects general attentional processes. This idea is compatible with some of the interpretations proposed in the ER literature (e.g. postretrieval monitoring), which may be rephrased in terms of attentional processes. Second, several subregions were differentially involved in ER versus VA. For example, the frontopolar cortex and the precuneus were more activated for ER than for VA, possibly reflecting retrieval mode and processing of internally generated stimuli, respectively. Finally, the study yielded an unexpected finding: some medial temporal lobe regions were similarly activated for ER and VA. This finding suggests that the medial temporal lobes may be involved in indexing representations within the focus of consciousness, regardless of whether they are mnemonic or perceptual. Overall, the present results suggest that many of the activations attributed to specific cognitive processes, such as episodic memory, may actually reflect more general cognitive operations.

Keywords: Episodic retrieval; Visual attention; Functional MRI (fMRI); Prefrontal cortex; Parietal cortex; Hippocampus

1. Introduction

Episodic memory retrieval has been the focus of dozens of positron emission tomography (PET) and functional MRI (fMRI) studies. These studies have associated episodic retrieval (ER) with activations in a distributed network of brain areas, including prefrontal cortex (PFC), parietal, anterior cingulate, thalamic, precuneus, and medial temporal lobe (MTL) regions (for reviews, see [6,52]). In general, episodic memory researchers have attributed the involvement of these different regions to distinct aspects of ER. For example, right PFC activations have been attributed to the evaluation of recovered information (postretrieval monitoring: e.g. [28,50,51]), lateral parietal activations, to the processing of spatial aspects of the study episode [62], and anterior cingulate activations, to the initiation of retrieval operations [9].

These accounts illustrate the widespread practice in functional neuroimaging of interpreting activations only in terms of the particular cognitive function being investigated. Yet, when one reviews functional neuroimaging data across several cognitive functions, it is obvious that the same brain regions can be activated by different functions [11]. For example, many of the regions activated during ER tasks, including PFC, parietal, anterior cingulate, and thalamic regions, also tend to be activated during visual attention (VA) tasks (for reviews, see [25,29]). Moreover, these regions are generally assumed to be critical components of a brain network for attention [41,48]. Since ER tasks normally require attention, whereas attention tasks rarely require episodic memory, it is more parsimonious to assume that some of the PFC, parietal, anterior cingulate, and thalamic activations during ER reflect general attentional operations rather than specific mnemonic processes.

On the other hand, it is also possible that particular PFC and parietal subregions recruited by ER tasks are not the same ones recruited by VA tasks. For example, activations

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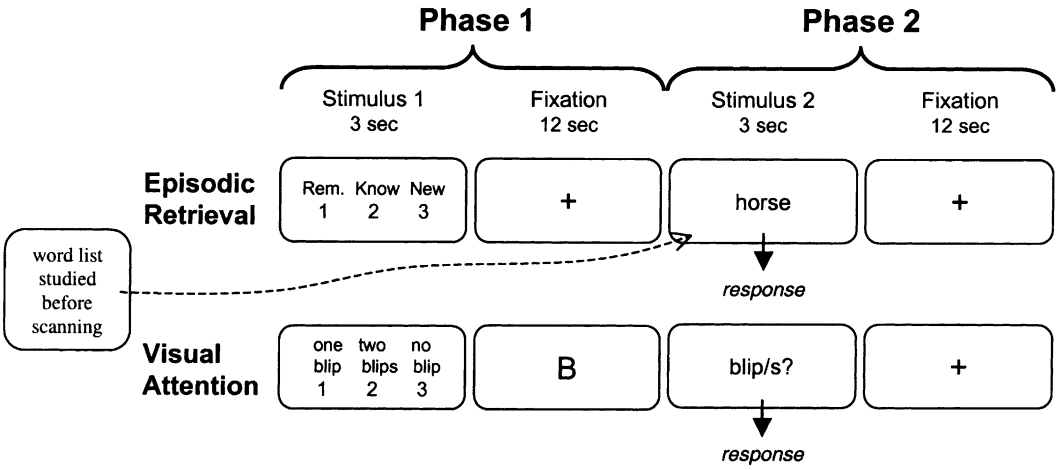

Fig. 1. Behavioral methods.

in left PFC tend to be more frequent during ER tasks than during VA tasks [11]. Also, frontopolar activations (e.g. Brodmann Area—BA 10) are among the most common during ER, but are rarely found during VA [11]. Beyond PFC, precuneus and MTL regions are often activated during ER but they are uncommon during VA [11]. However, these differences are suggested by cross-study comparisons (e.g. [11]), which are typically confounded with differences in stimuli, imaging methods, and significance thresholds. In order to clearly identify similarities and differences between the activation patterns for ER and VA, it is necessary to compare these two functions within-subjects and under similar conditions. Several functional neuroimaging studies have compared different cognitive functions within-subjects [4,7,35,43,44,49], but a direct comparison between episodic memory and attention has never been attempted. This was the goal of the present study.

The paradigm is summarized in Fig. 1. Subjects studied a list of words before scanning, and during scanning they randomly performed ER and VA trials. Each trial consisted of two phases. During the first phase of ER trials, participants generated the mental set of ER (retrieval mode, [61]), and during the second phase, they made a Remember/Know/New response to a word cue. During the first phase of VA trials, participants sustained attention to a symbol on the screen to determine if it blipped once, twice, or never during a 12 s interval, and during the second phase, they made the Once/Twice/Never response. Because only no-blip trials were included in the analyses, the memory component of the VA condition was minimal.

We made two predictions. First, we expected overlapping activations for ER and VA in PFC, parietal, anterior cingulate, and thalamic regions [11]. Given that sustained attention has been associated with a right lateralized fronto-parietal network (for reviews, see [17,54]), we expected overlaps to occur primarily in the right hemisphere. Second, we expected several regions to be more activated for ER than for VA, including left PFC, frontopolar, precuneus, and MTL regions [11].

2. Method

2.1. Subjects

The subjects were 20 young adults (13 males) Duke University students/staff, with a mean age of 22.6 years (S.D. = 3.68). They were healthy, right-handed, English native speakers, with no history of neurological or psychiatric episodes. All subjects gave informed consent to a protocol approved by Duke University Institutional Review Board.

2.2. Behavioral methods

2.2.1. Materials

The critical materials were concrete words selected from the MRC Psycholinguistic Database (http://www.psy.uwa.edu.au/MRCDataBase/mrc2.html). The words were 4–6 letters in length, and of moderate frequency. Half of the words referred to living things and half to nonliving things.

2.2.2. Procedure

After completing health and MRI screening questionnaires and practicing the tasks to be performed in the scanner, subjects were placed in the scanner and anatomical scans were conducted. Following the anatomical scans and before the functional scans, subjects studied a list of 40 words (36 targets, 2 primacy fillers, 2 recency fillers), presented at a rate of 3 s per word. Subjects made a living/nonliving decision to each word and were also instructed to remember the words for a subsequent memory test. In the scanner, all stimuli were projected using an LCD projector to a screen located about 70 cm behind the subjects' crown, which subjects could see via an angled mirror attached to