



# Impaired perception of mnemonic oldness, but not mnemonic newness, after parietal lobe damage



Kylie H. Hower<sup>a</sup>, John Wixted<sup>b</sup>, Marian E. Berryhill<sup>c</sup>, Ingrid R. Olson<sup>a,\*</sup>

<sup>a</sup> Temple University, Department of Psychology, Philadelphia, PA 19122, USA

<sup>b</sup> University of California at San Diego, Department of Psychology, La Jolla, CA 92093, USA

<sup>c</sup> University of Nevada, Department of Psychology, Reno, NV 89557, USA

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## ABSTRACT

In studies of episodic memory retrieval, recognition paradigms are known to elicit robust activations in the inferior parietal lobe. However, damage to this region does not produce severe deficits in episodic memory performance as indexed by typical accuracy measures. Rather, because problems with memory confidence are frequently reported, the observed deficits may be best described as “metamemory” or subjective memory deficits. Here, we further investigated the inferior parietal lobe’s role in recognition memory as well as metamemory. We tested the hypothesis that the inferior parietal lobe gauges the perceived oldness of items, given several neuroimaging findings suggesting that a portion of the left inferior parietal lobe is sensitive to perceived oldness. We tested two patients with bilateral parietal lobe lesions and matched controls on an old/new recognition task. From these data we constructed receiver operating characteristic (ROC) curves by fitting the data with the unequal-variance signal-detection (UVSD) model. The results revealed no memory impairment in terms of patients’ accuracy. However, patients exhibited lower hit rates and false alarms rates at high confidence levels. Further, patients and controls differed in how they set decision criteria for making recognition responses. Patients’ decision criteria for “old” responses were shifted in a conservative fashion such that they were unwilling to endorse recognized target items with high levels of confidence. These findings provide constraints on models of inferior parietal lobe contributions to episodic memory retrieval.

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## 1. Introduction

Memory researchers have frequently reported activations in the inferior parietal lobe during neuroimaging studies of episodic memory retrieval (for reviews see Cabeza, Ciaramelli, & Moscovitch, 2012; Vilberg & Rugg, 2008; Wagner, Shannon, Kahn, & Buckner, 2005). Recognition memory paradigms, in particular, are among the most frequent to elicit parietal lobe activations (e.g. Cabeza et al., 2012; Hayes, Buchler, Stokes, Kragel, & Cabeza, 2011; Wagner et al., 2005). Several models have been proposed to explain these findings, including the *attention to memory model* (Cabeza, Ciaramelli, Olson, & Moscovitch, 2008), the *memory buffer hypothesis* (Vilberg & Rugg, 2008), the *subjective recollection hypothesis* (Ally, Simons, McKeever, Peers, & Budson, 2008), and *mnemonic accumulator* accounts (Donaldson, Wheeler, & Petersen, 2010; Gold & Shadlen, 2007; McClelland, 2001; Ratcliff, 1978).

Some of these models have encountered the problem that there is little converging evidence for the robust fMRI findings. Although amnesic patients with damage to the hippocampus exhibit severe recognition deficits, damage to the parietal lobe does not lead to severe or consistent recognition memory deficits (for a review of this paradox, see School et al., 2011). Patients do not appear to be amnesic (Berryhill, Phuon, Picasso, Cabeza, & Olson, 2007), and overall free recall and recognition accuracy in episodic memory paradigms are not impaired (Haramati, Soroker, Dudai, & Levy, 2008; Berryhill, Drowos & Olson, 2009; Dobbins, Jaeger, Studer, & Simons, 2012; Drowos, Berryhill, Andre, & Olson, 2010; Simons, Peers, Mazuz, Berryhill, & Olson, 2010).

However, there are often subtle impairments in specific memory processes (reviewed in Table 1). For instance, Berryhill et al. (2007) reported that when patients were asked to freely recall autobiographical events, their recollections lacked the richness and specificity of control participants. Even more compelling is the accruing body of findings showing that patients with parietal lobe damage have diminished memory confidence coupled with intact memory accuracy. For example, Simons et al. (2010) reported that parietal patients showed reduced confidence in their own recollections although their source memory accuracy was at normal

\* Correspondence to: Department of Psychology, Temple University, 1701 N. 13th Street, Philadelphia, PA 19122, USA. Tel.: +1 215 204 7318; fax: +1 215 204 5539.  
E-mail address: [iolson@temple.edu](mailto:iolson@temple.edu) (I.R. Olson).

**Table 1**  
Summary of episodic memory studies conducted in patients with unilateral or bilateral parietal lobe lesions in which memory confidence or vividness was assessed. Confidence is marked as impaired if a decreased number of 'remember' responses were reported. NA=not assessed. Multiple entries refer to experimental results in multi-experiment papers.

Citation	Memory task	Memory performance		Confidence	
		Spared	Impaired	Spared	Impaired
Berryhill et al. (2009)	Audio-visual pairs	✓			✓
Berryhill et al. (2007)	Autobiographical memory; free recall		✓/- fewer episodic details	NA	NA
Berryhill et al. (2007)	Autobiographical memory; cued recall	✓		NA	NA
Berryhill et al. (2010)	Constructed experience episodic future thinking		✓/- fewer episodic details	NA	NA
Davidson et al. (2008)	Source memory; remember/know	✓			✓/- decreased 'remember' responses
Davidson et al. (2008)	Autobiographical memory; remember/know	✓		✓	
Davidson et al. (2008)	Autobiographical memory; cued recall		✓/- fewer episodic details	NA	NA
Drowos et al. (2010)	False memory; recognition		✓/- impaired performance was caused by patients reporting few "old" responses, causing a low rate of false memories.		✓/- decreased high confidence 'old' responses
Drowos et al. (2010)	False memory; recognition		✓/- impaired performance was caused by patients reporting few "old" responses, causing a low rate of false memories.		✓/-decreased high confidence 'old' responses
Simons et al. (2010)	Source memory; recognition	✓			✓
Simons et al. (2010)	Source memory; recognition	✓		✓	
Simons et al. (2010)	Source memory; recognition	✓			✓

levels. In another study, patients were tested on a remember/know false-memory paradigm in which the patients exhibited fewer "remember" responses but gave more "know" responses than controls on lure trials reflecting their lower degree of confidence (Drowos et al., 2010). Consistent with these findings, several studies in healthy individuals have reported that BOLD activations in the lateral parietal cortex increased with increasing subjective confidence ratings of recognition responses (Cabeza et al., 2012; Johnson, Suzuki, & Rugg, 2013; Vilberg & Rugg, 2008; Yonelinas, Otten, Shaw, & Rugg, 2005).

These findings have led some researchers to argue that the parietal cortex plays a key role in metamemory processes (constructed as more subjective processes), rather than core memory processes (more objective processes) (Chua, Schacter, & Sperling, 2009; Elman, Klostermann, Marian, Verstaen, & Shimamura, 2012; Rugg & Vilberg, 2013). Metamemory processes encompass self-monitoring strategies that are engaged during the various stages of memory encoding, storage, and retrieval. In fact, researchers often examine monitoring during memory retrieval by collecting information about participants' retrospective confidence judgments and thresholds for setting response criteria (Modirrousta & Fellows, 2008; Pannu & Kaszniak, 2005). It is hypothesized that such monitoring techniques may interact with core memory processes in order to facilitate overall memory performance; however, it should be noted that there is an on-going debate regarding the nature of the relationship between confidence ratings and memory accuracy (see Roediger, Wixted, & DeSoto 2012 for a review).

Ally et al., 2008 proposed that parietal lobe activity indexes the subjective experience of remembering (termed the *subjective recollection account*). This signal presumably allows participants to distinguish between vividly recollected and vaguely recollected information (Ally et al., 2008). Related to this, Wheeler and Buckner (2003) argued that fMRI findings showing parietal lobe activity during memory retrieval reflect the "perception of oldness" of items. This idea was based on their finding, as well as that of other investigators (Donaldson, Petersen, Ollinger, & Buckner, 2001; Habib & Lepage, 1999; Henson, Rugg, Shallice, Josephs, &

Dolan, 1999; Konishi, Wheeler, Donaldson, & Buckner, 2000; McDermott, Jones, Petersen, Lageman, & Roediger, 2000), showing that a small region of the left inferior parietal lobe is sensitive to perceived oldness, but not perceived newness, of items. Thus, it is possible that the metamemory impairments exhibited by patients with parietal lobe lesions reflect problems perceiving that a test item is actually old. In other words, prior neuroimaging data suggest that the confidence in an item being old does not become sufficiently high until the memory signal is exceptionally strong.

The aim of the current study was to further investigate whether the inferior parietal lobe is critical in metamemory. We tested two well-characterized patients with bilateral parietal lobe lesions on a standard old/new receiver operating characteristic (ROC) paradigm (Egan, 1958; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). ROC analysis is one of the most common ways to study recognition memory and is often coupled with signal detection analyses. We used this approach because it allowed us to assess how patients and controls set their decision criteria for making recognition decisions associated with differing levels of confidence. Generally speaking, confidence varies with the degree of perceived oldness associated with a test item and also with the degree of perceived newness associated with a test item. Our question was whether parietal lesions symmetrically affect the subjective experience of oldness and newness, or whether they instead selectively affect the subjective experience of oldness (while leaving the subjective experience of newness intact).

We predicted that patients with bilateral parietal lobe lesions would show normal memory accuracy coupled with abnormal memory confidence, in line with prior neuropsychological findings (Berryhill et al., 2009; Davidson et al., 2008; Simons et al., 2010). We further predicted that patients would show marked differences in their ROC curves compared to controls due to problems in perceiving, accumulating, or deciding about the oldness of information (in line with the subjective recollection account). If the problem is limited to the perceived oldness of information based on the recollection of episodic detail, then the patients should be reluctant to make high-confidence "old" decisions but should not show a similar reluctance to make high-confidence "new"

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