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Use of explicit memory cues following parietal lobe lesions

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ABSTRACT

The putative role of the lateral parietal lobe in episodic memory has recently become a topic of considerable debate, owing primarily to its consistent activation for studied materials during functional magnetic resonance imaging studies of recognition. Here we examined the performance of patients with parietal lobe lesions using an explicit memory cueing task in which probabilistic cues ("Likely Old" or "Likely New"; 75% validity) preceded the majority of verbal recognition memory probes. Without cues, patients and control participants did not differ in accuracy. However, group differences emerged during the "Likely New" cue condition with controls responding more accurately than parietal patients when these cues were valid (preceding new materials) and trending towards less accuracy when these cues were invalid (preceding old materials). Both effects suggest insufficient integration of external cues into memory judgments on the part of the parietal patients whose cued performance largely resembled performance in the complete absence of cues. Comparison of the parietal patients to a patient group with frontal lobe lesions suggested the pattern was specific to parietal and adjacent area lesions. Overall, the data indicate that parietal lobe patients fail to appropriately incorporate external cues of novelty into recognition attributions. This finding supports a role for the lateral parietal lobe in the adaptive biasing of memory judgments through the integration of external cues and internal memory evidence. We outline the importance of such adaptive biasing through consideration of basic signal detection predictions regarding maximum possible accuracy with and without informative environmental cues.

1. Introduction

The wide range of topics covered in this Special Issue illustrates how Andrew Mayes has been a formative influence across the field of memory research. One of the areas that he has helped to develop most recently relates to the role of the parietal lobe in human memory. Soon after a symposium at the annual meeting of the Memory Disorders Research Society highlighted an intriguing discrepancy between neuroimaging and neuropsychological findings concerning the parietal lobe contribution to memory, Andrew rapidly organized a Special Section of *Neuropsychologia* on the subject (Simons & Mayes, 2008). Containing papers from many of the leading researchers in the area, the Special Section helped to lay the foundations for what has become a major focus in the field.

The reason that this topic has generated such interest is that traditionally, the parietal lobes have not been considered relevant for human memory: patients with parietal lesions often have difficulty with visuospatial attention or visually-guided action (Corbetta & Shulman, 2002; Milner & Goodale, 2008), but do not exhibit severe or even mild amnesia. However, neuroimaging methods like fMRI have revealed consistent involvement of parietal regions in healthy volunteers during performance of memory tasks (Wagner, Shannon, Kahn, & Buckner, 2005). This raises the possibility that subtle memory deficits may be present in parietal patients that are missed by standard neuropsychological testing batteries but may nonetheless impact on the patients' functioning. Consistent with this notion, patients themselves sometimes report that although they can recall previous events, their memories can lack vividness and detail.

In the last few years, a number of groups have investigated empirically whether circumscribed lesions to the parietal lobe areas identified by neuroimaging studies do actually cause a measurable impairment on tests of human memory. For example, Simons et al. (2008) reported results from two fMRI experiments in which parietal lobe activity was observed in healthy volunteers during source memory tasks that involved recollecting the context in which stimuli were previously encountered. Patients with unilateral parietal lobe lesions that overlapped closely with the

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regions activated in the healthy volunteers were then administered the same source memory tasks, exhibiting unimpaired performance (Simons et al., 2008). Similarly intact performance following unilateral parietal lesions has been reported on a number of recognition memory tasks that require participants to distinguish previously encountered "old" items from non-presented "new" items (Davidson et al., 2008; Haramati, Soroker, Dudai, & Levy, 2008). Preserved item recognition and source recollection has also been demonstrated in patients with bilateral parietal lesions, although these patients appear to exhibit reduced trial-by-trial subjective confidence in their accurate recollection (item recognition confidence was unimpaired) (Simons, Peers, Mazuz, Berryhill, & Olson, 2010). This finding might explain observations that parietal lesions are associated with reduced subjective "remember" responses on the remember/know task (Davidson et al., 2008) and diminished vividness and detail in spontaneous autobiographical narratives (Berryhill, Phuong, Picasso, Cabeza, & Olson, 2007). Evidence has also been reported that parietal lesions may be associated with diminished parietal electrophysiological activity but enhanced activity over frontal electrodes relative to controls, perhaps indicating the recruitment of frontally mediated compensatory mechanisms to support accurate memory performance (Ally, Simons, McKeever, Peers, & Budson, 2008).

Among the theories proposed to account for the neuroimaging and neuropsychological results is the *attention to memory* model which, drawing on theories of frontoparietal networks that support attention (Corbetta & Shulman, 2002), posits that the parietal lobe may support the attentional control of memory (Cabeza, Ciaramelli, Olson, & Moscovitch, 2008). According to the model, dorsal parietal regions support top-down attentional processes guided by episodic retrieval goals, whereas ventral parts of the parietal lobe subserve bottom-up attentional processes captured by retrieval output. Thus, the preserved source recollection observed following parietal lobe lesions might be attributable to intact orienting of attention towards the context details required by the task, whereas the reduced "remember" responses and diminished autobiographical detail reported might be due to impaired spontaneous capture of bottom-up attention by salient features of mnemonic representations (Cabeza et al., 2008).

The attention to memory model is supported by much neuroimaging and neuropsychological evidence, but a number of its predictions have been questioned. For example, Hutchinson, Uncapher, and Wagner (2009) highlighted that whereas recent meta-analyses have linked bottom-up attention primarily with the right temporoparietal junction (Corbetta, Patel, & Shulman, 2008), activity relating to memory retrieval is typically observed in more posterior regions in the left lateral parietal lobe (Hutchinson et al., 2009; Vilberg & Rugg, 2008). In addition, the model's suggestion that differences in "remember" response rates and autobiographical recall might be due to reduced attentional capture by behaviorally-relevant mnemonic information was tested by administering to bilateral parietal lesion patients a source memory task that included a manipulation of the behavioral relevance of the mnemonic information required for success (Simons et al., 2010). Even though this experiment included the two patients who exhibited reduced detail in their autobiographical narratives in Berryhill et al. (2007) study, the behavioral relevance manipulation did not disproportionately impair the ability of the patients to recollection source information.

Another patient study did find evidence consistent with predictions of the attention to memory model. Ciaramelli, Grady, Levine, Ween, and Moscovitch (2010) had participants study word-pairs (e.g., BUN–DEER, HOME–LIME) and then undergo a cued old-new recognition memory task in which they were presented with a studied or non-studied cue (e.g., BUN) or a baseline cue (e.g., @@@) that might predict whether a subsequent target word (e.g., DEER) was likely to be old or not. Top-down attention to memory was considered to be engaged when the cue was a studied word that might elicit attentional orienting towards the expected target. On occasions, an old target (e.g., DEER) was preceded by a studied cue that did not predict it (e.g., HOME). Such invalid cueing was considered to engage bottom-up attention to memory. Supporting the predictions of the model, recognition accuracy of patients with dorsal parietal lesions was found not to benefit from the provision of memory cues, and patients with ventral parietal lesions were reported to be slower to respond to invalidly cued targets (Ciaramelli et al., 2010).

The results reported by Ciaramelli et al. (2010) are very interesting and the task used is ingenious. However, there are a number of issues worth considering. First, the task relies on successful associative retrieval in order to cue later item recognition expectations. That is, participants must recover the second word of a paired associate pair (cued by the first word of the pair) to form an expectation about the upcoming recognition target. This is quite an indirect way of assessing top-down influences on memory, because retrieved memories would not normally be characterized as top-down attentional cues. In fact, one memory triggering retrieval of another memory would often be thought of as bottom-up cuing. In addition, it may be that participants are not using the recovered associates as cues to facilitate their recognition of the subsequent target, but instead are simply matching with respect to the lexical item recovered during the preceding paired associate retrieval phase. In other words, if BUN triggers cued recall of DEER and the subsequent recognition target is DEER, there is no need to actually assess DEER for its memory content when a participant could more easily just decide whether the target item DEER lexically matches the previously recalled associate DEER. Consistent with this alternative interpretation, Ciaramelli et al. report that invalid associative cues facilitate correct rejections compared to uncued recognition trials. This implies that participants are making their recognition decision to new items on the basis of lexical mismatch with the recovered associate, and are thus able to reject new items more easily than when uncued.

To address some of these issues, the present study takes a different approach, using a close memory analogue of the Posner visual cueing task to identify whether patients with parietal lobe lesions are intact in their ability to utilize explicit memory cues. In previous work using fMRI, O'Connor, Han, and Dobbins (2010) demonstrated a dissociation between parietal lobe activity associated with episodic retrieval and expectancy violation induced by the cueing procedure. Briefly, the explicit memory cueing task involves studying lists of words followed by a memory test that includes the explicit presentation of valid or invalid anticipatory memory cues ("Likely Old" or "Likely New") before each recognition memory probe. O'Connor et al. found that healthy volunteers show declining recognition accuracy for invalidly versus validly cued trials, which was associated with prominent differential activity in inferior parietal regions in particular. Because cue validity modulated activation even for new materials in this region, it was concluded that the contribution of the region to recognition was linked with memory expectations or their violation and not with successful retrieval of episodic content per se (O'Connor et al., 2010). The present study involves administering a version of this task to patients with parietal lobe lesions with the prediction that lesions that overlap with the areas of activity identified in healthy volunteers will be associated with atypical and perhaps inefficient cue use in patients. The task was also administered to patients with frontal lobe lesions to explore the