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The effect of focal cortical frontal and posterior lesions on recollection and familiarity in recognition memory

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ABSTRACT

Recognition memory can be subdivided into two processes: recollection (a contextually rich memory) and familiarity (a sense that an item is old). The brain network supporting recognition encompasses frontal, parietal and medial temporal regions. Which specific regions within the frontal lobe are critical for recollection vs. familiarity, however, are unknown; past studies of focal lesion patients have yielded conflicting results. We examined patients with focal lesions confined to medial polar (MP), right dorsal frontal (RDF), right frontotemporal (RFT), left dorsal frontal (LDF), temporal, and parietal regions and matched controls. A series of words and their humorous definitions were presented either auditorily or visually to all participants. Recall, recognition, and source memory were tested at 30 min and 24 h delay, along with "remember/know" judgments for recognized items. The MP, RDF, temporal and parietal groups were impaired on subjectively reported recollection; their intact recognition performance was supported by familiarity. None of the groups were impaired on cued recall, recognition familiarity or source memory. These findings suggest that the MP and RDF regions, along with parietal and temporal regions, are necessary for subjectively-reported recollection, while the LDF and right frontal ventral regions, as those affected in the RTF group, are not.

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1. Introduction

Dual-process theories of recognition memory suggest that two processes are involved in our ability to recognize an item as old: recollection and familiarity (Jacoby, 1991; Mandler, 1980; Yonelinas, 2001). Recollection is a vivid memory, rich in contextual detail, that enables mental time travel to an earlier, specific episode, considered definitive of human episodic memory (Tulving, 2002). Familiarity is a sense that an item is old in the absence of re-experiencing contextual detail.

One common way to assess recollection and familiarity is to asks participants to give a subjective estimate of whether a recognized item is "remembered" or "known" – referred to as the remember/know paradigm (Tulving, 1989). Participants are given specific instructions on what a "remember" and what a "know" response constitutes. For example, according to the commonly used instructions by Rajaram (1993), remember responses are accompanied by a conscious recollection of one or more aspects of what happened or what was experienced at the time the item was presented. Know responses on the other hand are to be used in situations where the participant recognizes an item as old, but does not remember any aspects of the encoding event. This procedure, however, has been criticized for being subjective (for a comprehensive review of some of these criticisms see Yonelinas, 2002). A more objective way to assess recollection memory is to use source memory paradigms; the experimenter presents items during study in distinct contexts and then asks participants during recognition to recall the context in which the item was presented during study (M. K. Johnson, Hashtroudi, & Lindsay, 1993). While this method tests objectively the ability of participants to accurately remember a specific contextual source, it limits the test to only one aspect of the contextual detail of an item, referred to as *noncriterial recollection* (Parks, 2007).

Numerous studies have assessed the dissociation of recollection and familiarity at the level of brain function (for review, see Rugg & Vilberg, 2013). Functional neuroimaging studies have identified two brain networks: one active during recollection and the other during familiarity tasks. The core recollection network consists of the hippocampus, the parahippocampal gyrus, the ventral parietal cortex, the retrosplenial and posterior cingulate cortex and the medial prefrontal cortex (PFC). The core familiarity network, on the other hand, consists of the perirhinal cortex, the dorsal parietal cortex, the lateral and anterior PFC and the retrosplenial cortex (J. D. Johnson, Suzuki, & Rugg, 2013). Based on review of animal and human research, Ranganath and colleagues delineated connectivity within and between the posterior medial (PM; parahippocampal and retrosplenial cortex) and anterior temporal (AT; perirhinal) memory networks where by functional connectivity extends outside the medial temporal regions to temporal, parietal, and prefrontal cortical regions (Ranganath & Ritchey, 2012; Ritchey, Libby, & Ranganath, 2015). Thus, damage in regions outside the core recollection/familiarity networks could affect performance on recollection, familiarity and source memory.

The specific cortical subregions activated within the frontal lobes vary substantially across functional neuroimaging studies and in fact it has been reported that there is little overlap between studies (Skinner & Fernandes, 2007). Some overlap has been reported in the left anterior and dorsal regions for recollection, but some studies have also reported activations in the right dorsolateral and superior regions. Familiarity activations within the frontal lobes have varied with some overlap in the right dorsolateral prefrontal cortex (Skinner & Fernandes, 2007). While the fMRI literature is relatively more consistent with respect to the parietal lobe, with dorsal activations associated with familiarity and ventral activations associated with recollection, there is some variability within these regions; while activations can be bilateral, left lateralization has been reported more consistently (Vilberg & Rugg, 2008). Finally, both objective and subjective recollection tasks have reported temporal lobe activations outside the MTL. Activation in the inferior temporal gyrus have been reported during both objective and subjective recollection tasks, while subjective recollection tasks can also activate the middle temporal gyrus (Spaniol et al., 2009).

By testing the necessity (as opposed to the engagement) of different brain regions to a task, lesion studies have the potential to resolve these discrepancies. However, the few focal lesion studies that have been reported on the topic are not conclusive. Considering the prefrontal cortex, some have reported deficits only in recollection (Anderson et al., 2011; Hay, Moscovitch, & Levine, 2002; Levine et al., 1998; Wheeler & Stuss, 2003), others have reported deficits only in familiarity (Aly, Yonelinas, Kishiyama, & Knight, 2011; Duarte, Ranganath, & Knight, 2005; MacPherson et al., 2008) and one study reported deficits in both recollection and familiarity (Kishiyama, Yonelinas, & Knight, 2009). The discrepancy in findings may be due to the fact that the patients in these studies had lesions affecting different subregions within the frontal lobes. In their meta-analysis, Skinner and Fernandes (2007) concluded, based on both lesion and neuroimaging data, that both recollection and familiarity are mediated by the right dorsolateral PFC, but additional PFC regions mediate recollection, such as the anterior frontal and superior frontal regions, bilaterally. Thus, one could predict that damage to the right dorsolateral PFC should cause deficits in both recollection and familiarity, but additional regions within the PFC, either to the left dorsolateral PFC or damage to anterior and superior frontal regions to either hemisphere, should cause only recollection deficits. The lesion literature to date, however, does not provide clear support for these predictions. While deficits in recollection have been reported after right frontal damage (Anderson et al., 2011; Hay et al., 2002; Levine, Freedman, Dawson, Black, & Stuss, 1999), other studies have failed to report such an effect (Aly et al., 2011; Duarte et al., 2005; MacPherson et al., 2008; Wheeler & Stuss, 2003). Furthermore, while damage to regions outside the right dorsolateral PFC has been reported to cause deficits in recollection, as predicted (e.g. medial polar regions and right ventral regions as found by Levine et al., 1999; Wheeler & Stuss, 2003), deficits in familiarity have also been reported outside this region (e.g. Aly et al., 2011; Duarte et al., 2005 found deficits in familiarity after left PFC damage).

All of the above mentioned studies used subjective measures of recollection and familiarity. Frontal lobe damage has been shown to cause deficits in objective measures of