

# The contribution of familiarity to associative memory in amnesia

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## Abstract

In Experiment 1, using the remember/know paradigm with control participants, we compared the contribution of recollection and familiarity to associative recognition for compound stimuli and for unrelated word pairs. It was demonstrated that familiarity makes a greater contribution to associative recognition of compound stimuli than to associative recognition of unrelated word pairs. In Experiment 2, we examined associative recognition memory in medial temporal lobe amnesics, diencephalic amnesics, and control participants for the stimuli employed in Experiment 1. Whereas associative recognition for compounds and unrelated words was nearly identical in control participants, associative recognition was higher for compounds than for unrelated word pairs in amnesic patients. This pattern was observed in the medial temporal amnesic group as well as in the diencephalic amnesic group. These results suggest that associative recognition in amnesia is enhanced to the extent that performance can be supported by study-induced familiarity for the studied pair.

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## 1. Introduction

Patients with global amnesia evidence a dense impairment in the conscious retrieval of recently experienced events. This deficit is revealed on explicit tasks of memory, which ask patients to intentionally retrieve recent experiences in the form of recall or recognition. To date, the majority of studies investigating explicit memory in amnesia have focused largely on patients' item memory (i.e., the form of memory that provides the basis for remembering that a stimulus or event has been encountered). Only recently have investigators extended the study of explicit memory in amnesia from item memory to associative memory (i.e., the form of memory that represents relationships among items or informational elements). This extension has been motivated by the view that the hippocampus – a structure typically damaged in patients with medial-temporal lobe (MTL) amnesia – plays a special role in relating or binding together differ-

ent components of a learning event (Eichenbaum, Alvarez, & Ramus, 2000; Fried, MacDonald, & Wilson, 1997; Giovanello, Schnyer, & Verfaellie, 2004; Henke, Buck, Weber, & Wieser, 1997; Mitchell, Johnson, Raye, & D'Esposito, 2000; Yonelinas, Hopfinger, Buonocore, Kroll, & Baynes, 2001b). By this view, patients with hippocampal lesions should be more impaired in associative memory than in item memory.

To test this prediction, Stark, Bayley, and Squire (2002) equated item recognition between hippocampal patients and control participants and then examined whether associative recognition was matched as well. When item recognition was equated between groups by providing hippocampal patients with eight study exposures, no impairment in associative recognition was observed for the patient group. However, patients' item recognition appeared to be limited by ceiling effects, possibly masking a disproportionate impairment in associative recognition in the patients. When ceiling effects are avoided, a disproportionate deficit in associative memory does seem to be apparent: Turriziani, Fadda, Caltagirone, and Carlesimo (2004) demonstrated that associative recognition was impaired in a group of MTL patients, some of whom had damage limited to the hippocampus, even when item recognition was matched.

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We obtained similar results in a mixed group of MTL patients (Giovanello, Verfaellie, & Keane, 2003).

Although a disproportionate deficit in associative, relative to item, recognition in hippocampal patients is consistent with the view that the hippocampus plays a critical role in binding, such findings may alternatively be understood with reference to the notion that item and associative memory differentially draw on distinct cognitive processes. Studies in normal participants demonstrate that recognition memory for item and associative information have different rates of forgetting (Hockley, 1992), have different time courses of retrieval (Gronlund & Ratcliff, 1989), are differentially affected by word frequency (Clark, 1992), and have different receiver operating characteristics (Yonelinas, 1997). Many of these differences have been interpreted to reflect the differential contribution of recollection (i.e., intentional retrieval) and familiarity (i.e., the feeling that an item was previously encountered because of its ease of processing) to associative compared to item recognition. Direct support for this interpretation comes from a study by Hockley and Consoli (1999) who, using the remember/know paradigm (Tulving, 1985), demonstrated that associative recognition is based on conscious recollection to a greater extent than is item recognition, and conversely, that item recognition is based on familiarity to a greater extent than is associative recognition. Thus, a deficit in associative recognition in hippocampal amnesia may be a manifestation of a deficit in recollection-based memory.

The notion that hippocampal lesions may interfere with associative recognition because of the demands of such tasks on recollection, accords well with the proposal by Aggleton and Brown (1999) that recollection is mediated by the hippocampus, while familiarity is supported by perirhinal cortex. However, we found associative memory was also disproportionately impaired in patients with large MTL lesions—lesions encompassing both the hippocampus and surrounding cortical areas (Giovanello et al., 2003). Aggleton and Brown's model predicts that such patients should have impairments in both recollection and familiarity, as indeed has been shown (Verfaellie & Treadwell, 1993; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). However, these studies have also found that recollection is more severely affected than familiarity in such patients. Such a pattern may arise because the perirhinal cortex provides two-thirds of the input to the hippocampus. Extensive lesions including perirhinal cortex will disrupt familiarity-based processing, but recollection-based processing may be more severely impaired because it will be affected directly by hippocampal damage, as well as indirectly by virtue of the fact that the hippocampus will be receiving degraded information from the damaged perirhinal cortex (see Norman & O'Reilly, 2003 for a similar argument). Thus, a disproportionate impairment in recollection compared to familiarity in patients with large MTL lesions is consistent with Aggleton and Brown's model (1999), and may form the basis of the disproportionate impairment in associative relative to item memory in these patients, as well as in patients with restricted hippocampal lesions.

If amnesic patients' impairment in associative memory is due to the higher demands placed on recollection than on

familiarity, then it follows that amnesic patients should be less impaired when associative memory can be supported by familiarity. Familiarity-based associative memory may be promoted by requiring participants to process stimulus configurations integratively, as integrative processing enhances the internal organization of a stimulus, which in turn mediates familiarity (Mandler, Graf, & Kraft, 1986). Empirical evidence that integrative processing can lead to familiarity-based associative recognition comes from a study by Yonelinas and colleagues (Yonelinas, Kroll, Dobbins, & Soltani, 1999) who examined memory for facial stimuli—stimuli that consist of configurations of stimulus elements. They examined participants' ability to discriminate between previously studied faces and recombined faces (which were created by rearranging features of studied faces) presented either in upright or in upside down positions. For face presented upright, which are typically encoded as an integrated unit, familiarity made a significant contribution to performance. In contrast, for faces presented upside down, which are not typically encoded as a coherent whole, the contribution of familiarity was greatly reduced. Thus, familiarity can contribute to recognition of associations that are meaningfully integrated.

The goal of the current study was to create conditions in which familiarity contributes to recognition of verbal associations and to examine whether amnesic patients' associative memory impairment is attenuated under these conditions. To promote familiarity-based associative memory, the current study employed compound stimuli (e.g., "pinpoint"). Compounds are unique, having both integrative features (e.g., idiosyncratic meanings not completely predicted by the meanings of the constituent words), as well as some preservation of the distinct constituent components (e.g., as evidenced by increased false alarm rates to novel compounds consisting of studied components not previously seen together). Thus, compound words are uniquely suited to create conditions in which familiarity contributes to associative recognition.

To date, several studies investigating associative memory in amnesic patients have employed compound stimuli such as compound words (Reinitz, Verfaellie, & Milberg, 1996), bisyllabic words (Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996; Stark & Squire, 2003), and nonword compounds (Stark & Squire, 2003). However, the goal of these studies was to address the relative impairment in associative as compared to item recognition in patients with amnesia, rather than to compare performance across different types of verbal associations. In the one study that used a variety of verbal associative stimuli (Stark & Squire, 2003) such a comparison is made difficult by floor effects in several conditions. Therefore, it remains unclear whether amnesic patients' associative recognition performance is less impaired for meaningfully integrated material (i.e., material for which familiarity may contribute to performance), as compared to non-integrated material (i.e., material for which familiarity contributes minimally to performance). Such a finding would provide evidence that when associative recognition is supported by familiarity, amnesic patients' performance can be enhanced.

To evaluate this possibility, we compared the contribution of recollection and familiarity to associative recognition of compound stimuli and unrelated word pairs in individuals with intact

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