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Hemispheric asymmetries in the activation and monitoring of memory errors

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ABSTRACT

Previous research on the lateralization of memory errors suggests that the right hemisphere's tendency to produce more memory errors than the left hemisphere reflects hemispheric differences in semantic activation. However, all prior research that has examined the lateralization of memory errors has used self-paced recognition judgments. Because activation occurs early in memory retrieval, with more time to make a decision, other memory processes, like strategic monitoring processes, may affect memory errors. By manipulating the time subjects were given to make memory decisions, this study separated the influence of automatic memory processes (activation) from strategic memory processes (monitoring) on the production of false memories. The results indicated that when retrieval was fast, the right hemisphere produced more memory errors than the left hemisphere. However, when retrieval was slow, the left hemisphere's error-proneness increased compared to the fast retrieval condition, while the right hemisphere's error-proneness remained the same. These results suggest that the right hemisphere's errors are largely due to activation, while the left hemisphere's errors are influenced by both activation and monitoring.

1. Introduction

False memories constitute events that are remembered that never occurred, or occurred much differently than they are remembered. False memories are best known to the general public as a potential consequence in eyewitness settings (Wells et al., 2000) or psychotherapeutic techniques like recovered memory therapy (Shobe & Kihlstrom, 1997). However, their occurrence is also important in understanding the mechanisms of human memory. Much is still unclear about the fundamental processes of memory, and by closely evaluating the origin and maintenance of false memories, we can better understand the nature of memory processes. Furthermore, a thorough understanding of the mechanisms underlying false memories can lead to techniques to minimize their effects.

False memory is commonly studied with the Deese/Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). Subjects study a list of words (e.g., *sour*, *candy*, *sugar*, *bitter*, *good*, *taste*, *tooth*, and *nice*) that are all related to a single unpresented *lure word* (e.g., *sweet*). Following this study period, subjects are asked to either recall or recognize the words on the list. False memory arises when subjects falsely believe that unstudied lure words such as *sweet* were presented in the study phase.

Recently, the study of false memories using the DRM paradigm has been extended to examine the disparities in error rates between the brain's hemispheres in order to understand the semantic activation processes that occur in each hemisphere (Bellamy & Shillcock, 2007; Ben-Artzi, Faust, & Moeller, 2009; Fabiani, Stadler, & Wessels, 2000; Faust, Ben-Artzi, & Harel, 2008; Ito, 2001; Westerberg & Marsolek, 2003). Studies have shown that the right hemisphere produces more lure errors than the left hemisphere (Bellamy & Shillcock, 2007; Westerberg & Marsolek, 2003). Further, Westerberg and Marsolek (2003) found that participants were more confident in rejecting the lure words presented to the left hemisphere than the right hemisphere.

In general, researchers have interpreted these findings as support for a prominent theory of semantic processing, fine-coarse coding theory (Beeman, 1998; Jung-Beeman, 2005). This theory suggests there are differences in semantic networks between the brain's hemispheres, such that the left hemisphere activates a relatively fine semantic network, while the right hemisphere activates a relatively coarse semantic network. The left hemisphere's fine semantic network quickly focuses on the dominant or contextually-relevant meaning of a concept and inhibits the concept's subordinate meanings. In contrast, the right hemisphere activates a diffuse semantic network that includes several alternate meanings of a concept. Because the right hemisphere's semantic networks are more diffuse than those in the left hemisphere, they are more likely to enable the activation of distantly related meanings when a concept is encountered. The right hemisphere's tendency to produce more lure errors than the left hemisphere in the DRM paradigm can be explained by the fine-coarse coding theory. Specifically, due to the diffuse semantic

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networks in the right hemisphere, studying words associated with a lure item will be more likely to activate the lure's representation in the right hemisphere than the left hemisphere, leading the right hemisphere to make more errors (Bellamy & Shillcock, 2007; Ben-Artzi et al., 2009; Faust et al., 2008; Ito, 2001; Westerberg & Marsolek, 2003).

Fine-coarse coding theory describes hemispheric differences in DRM lure errors in terms of semantic memory activation differences between the brain's hemispheres. However, theories of false memory typically propose that there are two processes that underlie lure errors (Brainerd, Reya, & Kneer, 1995; Roediger, Watson, McDermott, & Gallo, 2001). For simplicity, we describe the constructs posited by activation–monitoring theory (Roediger et al., 2001) because, like fine-coarse coding theory, it proposes semantic memory activation plays a role in producing lure errors. In addition, activation–monitoring theory proposes that people sometimes employ strategic monitoring processes to determine whether or not a memory is authentic. These monitoring processes typically have the effect of reducing lure errors because subjects can evaluate a variety of types of memorial information and determine whether a test item was experienced as part of a specific encoding episode or context. Thus, activation–monitoring theory suggests that lure error rates result from both semantic memory activation and monitoring processes while only semantic memory activation is used to explain false memory by fine-coarse coding theory.

Importantly, evidence favors two-factor theories of false memory over those that argue a single factor (e.g., semantic memory activation) underlies false memory (e.g., Arndt & Gould, 2006; Benjamin, 2001). Further, prior studies of hemispheric differences in false memory (Bellamy & Shillcock, 2007; Ben-Artzi et al., 2009; Faust et al., 2008; Ito, 2001; Westerberg & Marsolek, 2003) have not taken specific steps to dissociate activation- and monitoring-based influences on lure errors. Thus, although it is possible that hemispheric asymmetries in memory errors are only caused by differences in semantic memory activation between the brain's hemispheres as fine-coarse coding theory suggests (Bellamy & Shillcock, 2007; Ben-Artzi et al., 2009; Ito, 2001; Westerberg & Marsolek, 2003), it is also possible that those asymmetries arise from both activation and monitoring processes, or solely from monitoring processes (Faust et al., 2008).

The possibility that monitoring processes can explain part or all of hemispheric differences in false memory is supported by evidence that the right hemisphere evaluates less specific information than the left hemisphere (Dobbins, Simons, & Schacter, 2004; Mitchell & Johnson, 2009). Specifically, the right hemisphere evaluates item familiarity, while the left hemisphere monitors memory for contextual and semantic information (Dobbins et al., 2004). Given these differences in monitoring abilities between the hemispheres, monitoring processes can explain why the right hemisphere produces more lure errors than the left hemisphere. Specifically, since left hemisphere monitoring processes evaluate more detailed information, the left hemisphere will be able to limit lure errors better than the right hemisphere. Thus, because both activation and monitoring processes differ between the brain's hemispheres, and both activation and monitoring can explain hemispheric differences in false memory, a full understanding of hemispheric differences in false memories requires separating their contributions to false memory. This separation of activation and monitoring processes was the primary goal of the present study.

Critical to the present investigation of hemispheric differences in false memory is that semantic memory activation and memory monitoring processes tend to become available at different time points during retrieval (Heit, Brockdorff, & Lamberts, 2004). Semantic memory activation is generally characterized as being available early in memory retrieval because it is a reflection of automatic access to a concept's representation in semantic memory (Neely, 1977). Monitoring, on the other hand, generally requires conscious and intentional deliberation because a person is attempting to access and retrieve evidence from memory that an event was encountered in a particular encoding context. As a result, monitoring processes are typically only available later in retrieval. In order to separate the contribution of activation- and monitoring-based processes to hemispheric differences in memory errors, we manipulated retrieval time in addition to the visual field of test item presentation. Specifically, subjects were cued to respond 500 ms after the onset of the test item in the fast retrieval condition, and 2500 ms after the onset of the test item in the slow retrieval condition. Given that semantic memory activation is available early in retrieval and monitoring is increasingly available as retrieval proceeds in time (Heit et al., 2004), lure error rates in the fast retrieval condition should mainly reflect the influence of activation, while lure error rates in the slow retrieval condition should reflect the effects of both activation and monitoring. Thus, lure errors in the fast retrieval condition should provide an assessment of how activation influences hemispheric differences in false memory. Similarly, because activation influences performance in both the fast and slow retrieval conditions, but monitoring only influences performance in the slow retrieval condition, the *difference* between lure errors in the fast and slow retrieval conditions should provide an assessment of how monitoring processes influence hemispheric differences in false memory. We now turn to specify the expected outcomes from this study if hemispheric differences are driven (a) only by activation-based processes, (b) only by monitoring-based processes, or (c) if hemispheric differences in false memory are due to a combination of activation and monitoring processes.

If activation alone produces hemispheric differences in false recognition, as fine-coarse coding theory and previous research suggest (Bellamy & Shillcock, 2007; Ben-Artzi et al., 2009; Ito, 2001; Westerberg & Marsolek, 2003), we would expect the results in the fast retrieval condition to parallel the results in the slow retrieval condition. Based on fine-coarse coding theory's premise that the left hemisphere has more focused semantic networks while the right hemisphere has more diffuse semantic networks, the right hemisphere should produce more errors than the left hemisphere in the fast retrieval condition. Further, when participants are given more retrieval time to employ monitoring strategies, this hemispheric difference in lure errors should not change.

If monitoring alone produces hemispheric differences in lure errors, we would expect the hemispheres to produce similar levels of lure errors in the fast retrieval condition, and that hemispheric differences in lure errors would only emerge in the slow retrieval condition. This prediction occurs because monitoring processes are only able to influence lure error rates when participants have time to deliberate. Based on the respective monitoring capabilities of each hemisphere, the left hemisphere's detail-based monitoring should produce a greater decline in error rates between the fast and slow retrieval conditions compared to the right hemisphere's familiarity-based monitoring. This will result in more lure errors in the right compared to the left hemisphere – the pattern seen in most prior research (Bellamy & Shillcock, 2007; Ben-Artzi et al., 2009; Ito, 2001; Westerberg & Marsolek, 2003).

Finally, if hemispheric asymmetries for memory errors reflect a combination of activation and monitoring processes, the data will show differences in error patterns between hemispheres in the fast retrieval condition, and the size or direction of that difference will change in the slow retrieval condition. The strongest evidence that both activation and monitoring contribute to hemispheric differences in false recognition would take the form of hemispheric differences that exist in the fast retrieval condition reversing in