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A synchronization account of false recognition

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ABSTRACT

We describe a computational model to explain a variety of results in both standard and false recognition. A key attribute of the model is that it uses plausible semantic representations for words, built through exposure to a linguistic corpus. A study list is encoded in the model as a gist trace, similar to the proposal of fuzzy trace theory (Brainerd & Reyna, 2002), but based on realistically structured semantic representations of the component words. The model uses a decision process based on the principles of neural synchronization and information accumulation. The decision process operates by synchronizing a probe with the gist trace of a study context, allowing information to be accumulated about whether the word did or did not occur on the study list, and the efficiency of synchronization determines recognition. We demonstrate that the model is capable of accounting for standard recognition results that are challenging for classic global memory models, and can also explain a wide variety of false recognition effects and make item-specific predictions for critical lures. The model demonstrates that both standard and false recognition results may be explained within a single formal framework by integrating realistic representation assumptions with a simple processing mechanism.

1. Introduction

False recognition is one of the most empirically studied psychological phenomena in recent times, however, very little formal modeling has been conducted to explore the mechanisms that produce it. The dominant experimental paradigm to study false recognition in the laboratory is the

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Deese/Roediger–McDermott (DRM) task (Deese, 1959; Roediger & McDermott, 1995). In a DRM task, lists of words that are associated with a specific critical word are presented to subjects, and on subsequent memory tests the non-presented critical lures are falsely recognized and recalled at approximately the same level as studied items (Roediger & McDermott, 1995). For example, given *nurse*, *hospital*, *sick*, *cure*, etc. to remember, subjects are likely to produce a false alarm to the critical lure *doctor*.

False recognition is a very reliable effect (McDermott & Roediger, 1998). Many factors influence false alarms to semantic associates, including the number of studied items (Robinson & Roediger, 1997), the associative structure of study lists (Gallo & Roediger, 2002), level of processing (Thapar & McDermott, 2001), and instructional content (Brainerd, Wright, Reyna, & Mojardin, 2001), to identify just a few. Research using the DRM paradigm has demonstrated convincingly that humans use semantic information both to store and to retrieve memories, and that semantic confusions can lead to profound memory errors. Nevertheless, the exact mechanisms that underlie false recognition have evaded a formal explanation. Instead, researchers have focused more on conceptual frameworks of cognition, such as spreading activation (Anderson & Bower, 1972), fuzzy-trace theory (Brainerd & Reyna, 2002), and source monitoring (Johnson, Hashtroudi, & Lindsay, 1993).

Spreading activation theorists (e.g., Anderson & Bower, 1972) propose that the critical word becomes activated during study through the repeated exposure to semantically associated words. The increased activation in memory produces a higher probability of accepting the critical lure on a subsequent recognition test, and leads to the high levels of false recognition. In this sense, false recognition is explained by spreading activation in a fashion very similar to other types of semantic priming.

A related theory that has been very influential is the source monitoring framework (Johnson et al., 1993). Source monitoring theory proposes that the repeated exposure to related items increases the probability that the critical word is generated during the study phase. The increased probability may reflect spreading activation, or some other type of generation mechanism. At test, this generation during study leads to confusion about the source of the memory for the critical item (i.e. whether it was studied or not), which in turn leads to an increased false alarm rate for that item.

A competing theory to source monitoring is fuzzy trace theory (FTT; Brainerd & Reyna, 2002). FTT proposes that there are two types of memory traces stored for events: verbatim and gist traces. Verbatim traces are the surface forms of the items that are being studied, while gist traces contain the concepts (meanings, relations, and patterns) that are associated with the studied items. To explain false recognition in the DRM paradigm, FTT assumes that the semantic relatedness of studied items induces participants to rely on semantic information. False recognition reflects the high similarity of the critical lure to a gist trace that was formed through study of its associates.

Currently FTT and source monitoring are the two most influential theories of false recognition, and are commonly seen as competitor models. A complete review of these two approaches is beyond the scope of this article (but see Reyna & Lloyd, 1997, and Lindsay & Johnson, 2000, for a description of the strengths and weaknesses of both approaches). The formal model we propose has more in common with FTT, but we suggest in Section 5 how to build mechanisms of source monitoring into the same framework.

All three theories have evaded formal computational modeling. The main reason is that all three require a realistically structured lexical semantic representation for false recognition to be modeled. In spreading activation theories, a quantifiable associative connection needs to be made between word nodes within a semantic network to allow activation to spread to a critical item. The source monitoring framework requires a semantic representation for the critical word and its associates to allow the critical lure to be generated during study. FTT also requires semantic representations for words to allow gist traces to be created and confused with the representation of the critical lure.

The lack of a plausible semantic representation is problematic not only for these conceptual theories of false recognition, but also for standard computational recognition memory models. Most recognition models do not use a realistic semantic representation, but instead assume that lexical semantic structure can be approximated with random representations—each word's semantic representation is modeled as a randomly generated vector, created with a particular similarity structure. For instance, REM uses gamma vectors (Shiffrin & Steyvers, 1997), TODAM uses dense Gaussian vectors (Murdock 1982, 1993), BCDMEM uses sparse binary vectors (Dennis & Humphreys, 2001), and