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Familiarity and categorization processes in memory search

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A fundamental distinction in tasks of memory search is whether items receive varied mappings (targets and distractors switch roles across trials) or consistent mappings (targets and distractors never switch roles). The type of mapping often produces markedly different performance patterns, but formal memory-based models that account quantitatively for detailed aspects of the results have not yet been developed and evaluated. Experiments were conducted to test a modern exemplar-retrieval model on its ability to account for memory-search performance involving a wide range of memory-set sizes in both varied-mapping (VM) and consistent-mapping (CM) probe-recognition tasks. The model formalized the idea that both familiarity-based and categorization-based processes operate. The model was required to fit detailed response-time (RT) distributions of individual, highly practiced subjects. A key manipulation involved the repetition of negative probes across trials. This manipulation produced a dramatic dissociation: False-alarm rates increased and correct-rejection RTs got longer in VM, but not in CM. The qualitative pattern of results and modeling analyses provided evidence for a strong form of categorization-based processing in CM, in which observers made use of the membership of negative probes in the "new" category to make old–new recognition decisions.

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1. Introduction

Memory-search tasks (Sternberg, 1966) are among the major vehicles used for studying how different types of practice influence controlled and automatic processes in human cognition (Shiffrin & Schneider, 1977). In such tasks, subjects are presented with a list of to-be-remembered items (the "memory set") and are then probed with a test item. The subjects' aim is to respond as quickly as possible, while minimizing errors, whether the probe was a member of the memory set. Old probes are termed "targets" whereas new probes are termed "distractors".

In their studies that examined hybrid forms of memory/visual search, Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977) varied the types of practice in which subjects engaged. Under varied-mapping (VM) conditions, items that served as targets on some trials would serve as distractors on other trials, and vice versa. By contrast, under consistent-mapping (CM) conditions, targets and distractors never switched roles across trials. Shiffrin and Schneider observed dramatic differences in performance across the VM and CM conditions. For VM, response times (RTs) lengthened considerably with list length ("memory set size") and this pattern remained even after extensive practice. By contrast, for CM, following sufficient practice, RTs were nearly invariant with memory set size. The general interpretation was that performance in VM tasks required effortful, controlled information processing, regardless of the amount of practice; whereas practice in CM tasks allowed for the development of automatic information processing.

Shiffrin and Schneider (1977) developed a conceptual framework for understanding the nature of these forms of controlled and automatic processing and provided support for that framework with an extensive set of experimental results involving diverse manipulations across tasks. We will review portions of that conceptual framework in the present article. A limitation of that original work, however, is that a formal quantitative model for accounting for the detailed performance patterns of the individual subjects was not provided. Townsend and Ashby (1983) reviewed and analyzed a wide variety of formal models that have been applied to the domain of memory search, but did not consider formal accounts of the differences between VM and CM performance. Strayer and Kramer (1994) used diffusion modeling (Ratcliff, 1978) to characterize differences in performance across VM and CM memory-search conditions. For example, under conditions in which VM and CM tasks were tested in separate blocks, they found that both drift rates (i.e., rates of evidence accumulation) and response-threshold settings differed across tasks. However, their aim was not to develop a deeper process-level model of the underlying memory and cognitive processes that give rise to different rates of evidence accumulation across VM and CM conditions. One main goal of the present work was to begin to fill these gaps and aim for the development of a unified, memory-based quantitative model of performance in VM and CM memory-search tasks.

Some progress towards that goal was recently made in a study reported by Nosofsky, Cox, Cao, and Shiffrin (2014). In that study, a modern formal model of probe recognition was used to account for performance in VM and CM memory-search tasks in cases involving a wide range of list lengths (memory set sizes of 1, 2, 4, 8 and 16). The formal model was an extended version of the *exemplar-based random-walk* (EBRW) model of categorization (Nosofsky & Palmeri, 1997) and old–new recognition (Nosofsky, Little, Donkin, & Fific, 2011). This model predicts both accuracy and RTs, thereby extending prior exemplar models of both categorization (e.g. Hintzman, 1986; Medin & Schaffer, 1978; Nosofsky, 1986) and recognition memory (e.g. Gillund & Shiffrin, 1984; Hintzman, 1988; Kahana & Sekuler, 2002; Nosofsky, 1991; Shiffrin & Steyvers, 1997) that predicted accuracy alone. Indeed, the model joins other modern approaches that aim to unravel the nature of memory through detailed modeling of the time course of old–new recognition decision making (e.g., Rae, Heathcote, Donkin, Averall, & Brown, in press; Starns, Ratcliff, & McKoon, 2012). We describe the EBRW model in formal detail later in this article. The basic idea is that each item of a study list is stored as a separate exemplar in memory. Presentation of a test probe leads to the probabilistic retrieval of these old exemplars. The probability of retrieval is greatest for old exemplars that are highly similar to the test probe and that have high "memory strengths". In cases in which presentation of the test probe leads to the efficient retrieval of the old exemplars, information accumulates rapidly towards an "old" response threshold and the observer makes fast "old"