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Eyetracking and selective attention in category learning[☆]

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Abstract

An eyetracking version of the classic Shepard, Hovland, and Jenkins (1961) experiment was conducted. Forty years of research has assumed that category learning often involves learning to selectively attend to only those stimulus dimensions useful for classification. We confirmed that participants learned to allocate their attention optimally. We also found that learners tend to fixate all stimulus dimensions early in learning. This result obtained despite evidence that participants were also testing one-dimensional rules during this period. Finally, the restriction of eye movements to only relevant dimensions tended to occur only after errors were largely (or completely) eliminated. We interpret these findings as consistent with multiple-systems theories of learning which maximize information input in order to maximize the number of learning modules involved, and which focus solely on relevant information only after one module has solved the learning problem.

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1. Introduction

Selective attention has played a prominent role in theories of categorization ever since Roger Shepard's influential work (Shepard, Hovland & Jenkins, 1961) demonstrated that a simple stimulus generalization account of category learning is untenable. The stimulus generalization account took category learning to be a process of simple associations between stimuli and category labels. This account predicted that it should be easy for participants to associate stimuli that shared many features with one category label, and difficult to associate such stimuli with different labels. Unexpectedly, one important determiner of difficulty was the number of stimulus dimensions needed for correct classification. It has been generally accepted that this pattern of results is best understood in terms of learners optimally allocating their selective attention to those dimensions diagnostic of category membership (Medin & Schaffer, 1978; Nosofsky, 1984; Shepard et al., 1961).

Currently, selective attention is an integral component of all major categorization theories. For example, in both exemplar models (Hampton, 1995; Medin & Schaffer, 1978; Nosofsky, 1986) and prototype models (Nosofsky, 1992; Smith & Minda, 1998), selective attention is formalized in terms of the influence, or weight, that different stimulus dimensions have on a classification decision. Rule-based models also implicitly assume the operation of selective attention to those stimulus dimensions referred to by the current hypothesis (i.e., rule) being tested (Smith, Patalano, & Jonides, 1998).

Moreover, in more recent years, these theories have been extended to include the mechanisms by which selective attention changes with learning. One prominent example is Kruschke's (1992) ALCOVE, a connectionist exemplar model that changes attention weights as a function of error feedback. Another is Nosofsky, Palmeri, and McKinley's (1994) rule-plus-exception (RULEX) model, which first performs hypothesis (rule) testing on single dimensions, then on multi-dimensional rules and exceptions to those rules if needed.

Despite its prominence in modern categorization theory, however, evidence for the operation of selective attention has always amounted to demonstrations that dimensions vary in their influence on explicit categorization judgments (or same-different judgments, Goldstone, 1994), but not on the operation of selective attention per se (Lamberts, 1998). Accordingly, this study had two main goals. The first was to determine if eyetracking data would support the claim that learners allocate their attention to optimize classification performance. To this end, we replicated the Shepard et al. (1961) category learning experiment with an eyetracker. Specifically, we asked whether Shepard et al.'s claims regarding learners' reallocation of attention to only those stimulus dimensions relevant to producing correct classification decisions would be directly corroborated by eyetracking data.

To our knowledge, the current work is the first to apply eyetracking to the domain of categorization research. At the outset then, one concern that must be addressed is the interpretation of eye movements as a surrogate measure of attention during category learning. It is of course well known that attention can dissociate from eye gaze under certain circumstances (Posner, 1980). However, in many cases changes in

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