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# Explicit awareness supports conditional visual search in the retrieval guidance paradigm ☆

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ABSTRACT

In four experiments we explored whether participants would be able to use probabilistic prompts to simplify perceptually demanding visual search in a task we call the retrieval guidance paradigm. On each trial a memory prompt appeared prior to (and during) the search task and the diagnosticity of the prompt(s) was manipulated to provide complete, partial, or non-diagnostic information regarding the target's color on each trial (Experiments 1–3). In Experiment 1 we found that the more diagnostic prompts was associated with faster visual search performance. However, similar visual search behavior was observed in Experiment 2 when the diagnosticity of the prompts was eliminated, suggesting that participants in Experiment 1 were merely relying on base rate information to guide search and were not utilizing the prompts. In Experiment 3 participants were informed of the relationship between the prompts and the color of the target and this was associated with faster search performance relative to Experiment 1, suggesting that the participants were using the prompts to guide search. Additionally, in Experiment 3 a knowledge test was implemented and performance in this task was associated with qualitative differences in search behavior such that participants that were able to name the color(s) most associated with the prompts were faster to find the target than participants who were unable to do so. However, in Experiments 1–3 diagnosticity of the memory prompt was manipulated via base rate information, making it possible that participants were merely relying on base rate information to inform search in Experiment 3. In Experiment 4 we manipulated diagnosticity of the prompts without manipulating base rate information and found a similar pattern of results as Experiment 3. Together, the results emphasize the importance of base rate and diagnosticity information in visual search behavior. In the General discussion section we explore how a recent computational model of hypothesis generation (HyGene; Thomas, Dougherty, Sprenger, & Harbison, 2008), linking attention with long-term and working memory, accounts for the present results and provides a useful framework of cued recall visual search.



## 1. Introduction

We examined whether participants would be able to use experience in order to reduce the perceptual demands of a probabilistic visual search task. More specifically, we ask whether participants would be able to use memory prompts to retrieve features associated with that prompt in the past in service of visual search. We argue that much of our day to day visual search relies on such long-term memory (LTM) retrieval to define an attentional set to support search. To investigate the processes unfolding in such circumstances we developed a novel visual search paradigm in which participants are provided with prompts that probabilistically predict a target feature (its color) in a forthcoming search array. We refer to this procedure as the retrieval guidance paradigm as retrieval of likely target colors given a prompt will drastically improve search.

This paradigms' usefulness lies partly in the ecologically relevant variables it affords control over. Importantly, it allows us to assess people's sensitivity to the probabilistic relationships between prompts and targets through 1) the global base rate of a target (raw frequency of occurrence) and 2) an individual prompts' diagnosticity (i.e., predictiveness). Both characteristics influence the posterior probability of any target given any prompt and the memory retrieval based on observed prompts. Related research examining how people use associations to support visual search has largely focused on the contextual cueing paradigm. The general trend in these experiments is that targets within repeated scenes having the same target to distracter spatial configurations are found faster than non-repeated scenes (Chun & Jiang, 1998, 1999). We are likewise interested in how cues (what we term memory prompts) can be used to retrieve important target characteristics in service of visual search. Given the similarity between our empirical paradigms, it would be a reasonable expectation that results from both procedures would implicate similar cognitive

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processes. As will be demonstrated below, however, our data suggest different underlying cognitive mechanisms regarding the ability of search to be enhanced via predictive memory prompts.

Our experimental paradigm diverges from the standard contextual cueing paradigm in several ways. As will be discussed in the General discussion section, our paradigm more readily affords the investigation of interactions between LTM, working memory (WM), and attention. We and other researchers believe that elucidating these mechanisms will foster deeper understandings of how attention is deployed in various contexts (Woodman & Chun, 2006). In the experiments presented below we manipulated both target base rates and prompt diagnosticities by pairing memory prompts (preceding the onset of a search array) with critical target features (i.e., colors). Thus, the memory prompt provided complete, partial, or non-diagnostic information regarding the color of the target in the upcoming search array (note that in Experiment 4, there is not a non-diagnostic condition). These manipulations distinguish our procedure from the standard contextual cueing paradigm in that both base rate and diagnosticity information are manipulated within the same experiment for all participants (i.e., it is a within subjects factor). Another difference between our paradigm and contextual cueing paradigm is the discriminability of the memory prompts. In the contextual cueing procedure the prompt for retrieval is often the visual search array itself and the visual arrays can be quite similar to one another. In our experiments, however, the memory prompts for retrieval differed in that the memory prompts were separate from the search arrays and were highly discriminable (see Fig. 1 for two example memory prompts). Additionally, there has also been some work to show that the effects found in contextual cueing may not be due to attentional guidance, but rather differences in response thresholds (Kunar, Flusberg, Horowitz, & Wolfe, 2007). This suggests that contextual cueing may not be an adequate paradigm to study interactions between LTM, WM, and attention in visual search.

To foreshadow the results, in Experiment 1 we find that participants are faster to find a target associated with a more diagnostic prompt. However, Experiment 2 revealed similar performance when the diagnosticity of the prompt was eliminated, suggesting that the participants in Experiment 1 were only utilizing base rate information and were not using the memory prompts to inform their search. In Experiment 3 participants were made explicitly aware of the possible connection between the memory prompts and the color(s) of the targets resulting in substantial improvements in performance. Additionally, in Experiment 3 we found that those who were able to name the correct target color(s) associated with the prompt were faster than those participants who were unable to do so. Finally, in Experiment 4 we manipulate the diagnosticity of the memory prompts without manipulating base rate information (as Experiments 1–3 had done). We find a similar pattern of results such that visual search RTs decrease as a function of increased diagnosticity.

## 2. Experiment 1

Experiment 1 was conducted to assess the degree to which participants would use prompt information to simplify a difficult visual search task. Participants were asked to indicate the orientation of a "T" (rotated 90° clockwise or 90° counterclockwise), while ignoring modified "L"s. Each visual array contained 14 different items (13 distracters and 1 target), with each item being unique in color. Prior to the onset of the search array, a memory prompt was presented that provided complete, partial, or non-diagnostic information regarding the target's color (see Fig. 1 for a schematic trial). After the visual search task, participants performed a recognition task where they were asked to determine whether the target in the search array was valid (i.e., the target was that color during the experiment given the memory prompt) or invalid.

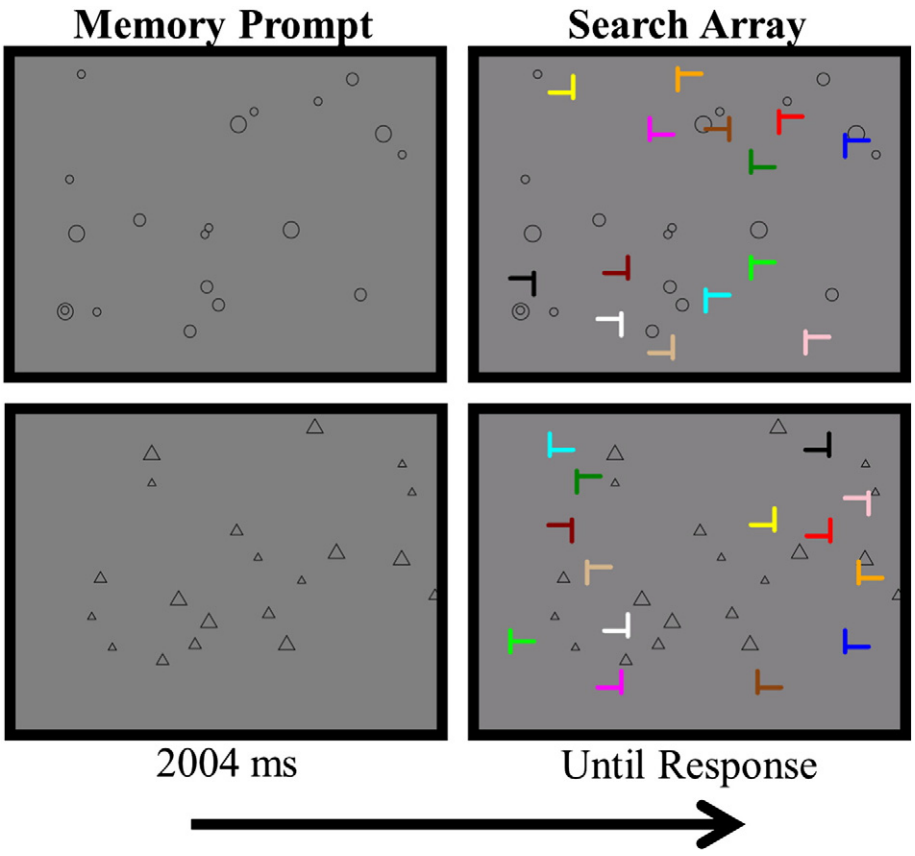


**Fig. 1.** Schematic illustration of the main components of two trials for Experiments 1, 3, & 4.