Eye-movements in Repeated Visual Search

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Abstract

Visual search may be facilitated through implicit learning of spatial configurations (Chun & Jiang, 1998), or knowledge of the identities of search items (Mruczek & Sheinberg, 2005). In two experiments, we tracked eye-movements during repeated visual search to examine which aspects of viewing behavior changed, facilitating performance as observers gained experience with the displays. Participants searched for new targets (in unpredictable locations) embedded among repeated distractors. A surprise recognition memory test was administered to probe incidental retention of target and distractor identities. Across experiments, the consistency of spatial information was degraded to tease apart the contributions of spatial and visual memory to search performance. We examined the numbers of views and average dwell times committed per trial to determine if people become better locators or more efficient identifiers. Moreover, we contrasted three hypotheses that attempt to explain facilitation of search RTs; results favor a view wherein response selection thresholds are lowered through the learning of object identities and spatial configurations.

Motivating questions

Previous research has shown that searching through a repeated scene is speeded by:

❖ (1) implicit learning of predictive spatial configurations (Chun & Jiang, 1998), (2) knowledge of search item identities (Mruczek & Sheinberg, 2005), and (3) the conjunction of spatial and object memory (Hout & Goldinger, 2009).

What changes take place within the visual system that allow us to search more efficiently?

❖ Do we view items less frequently as we become better locators? Or, is identification of items speeded as we learn their identities?

Method

❖ Participants searched for a new target(s) embedded among a set of repeated distractor objects. Stimuli were gray-scaled photographs of singular objects.

❖ On half the trials, the target was present; on half the target was absent. Three blocks of search were conducted among 12, 16, or 20 objects. Different distractors were used for each block. Ninety-six total trials.

❖ Three levels of WM Load were manipulated between-subjects. People searched for 1, 2, or 3 potential targets (low, medium, high WM Load, respectively).

❖ Search was concluded when a single target was identified, or the array was searched exhaustively.

❖ Following search, a surprise 2AFC recognition memory test was given for the distractors and targets encountered during search (using category-matched foils).

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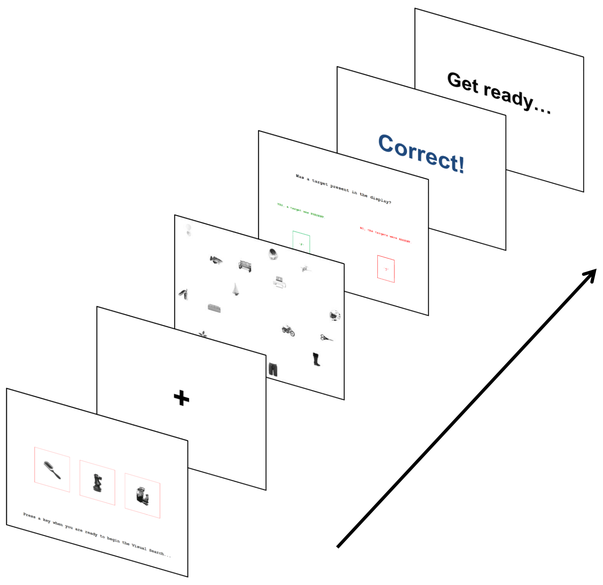


Progression of a visual search trial

Experiment 1

❖ Spatial layout (placement of distractor objects on the screen) was constant throughout a block of trials.

❖ Search could be enhanced through both spatial learning, and memory for distractor identities.

Experiment 2

❖ Spatial layout was randomized on each trial. Only distractor identities remained constant.

❖ Search could be enhanced only through object memory.

3 Hypotheses to Explain Facilitation of Search RTs

Attentional Engagement

❖ As objects are learned, search is facilitated through efficient identification and dismissal of non-target items; see Mruczek & Sheinberg, 2005.

❖ Predictions: significant facilitation in Experiments 1 and 2, with shorter average dwell times as a function of experience with the display.

Short-term Memory Enhancement

❖ As spatial layouts are learned, search is facilitated through an increased ability to avoid unnecessary revisitations; see Beck et al., 2006.

❖ Predictions: significant facilitation in Experiment 1 only, driven by a decrease in the number of views committed on each trial.

Response Selection

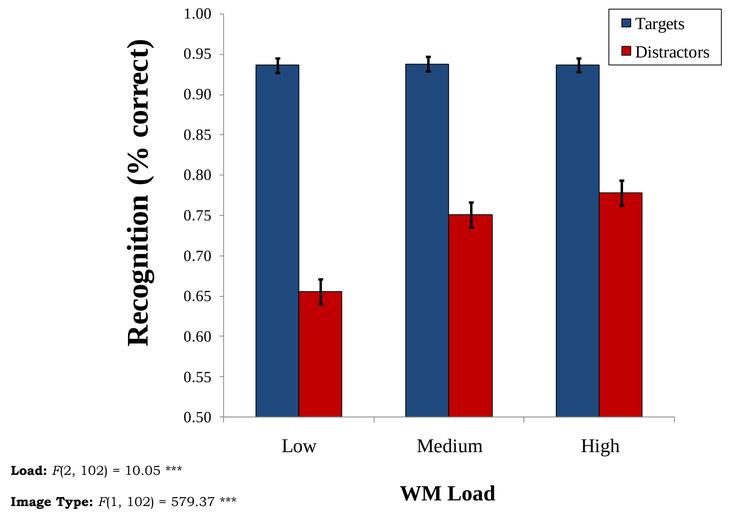
❖ As either spatial layouts or object identities are learned, response thresholds are lowered, allowing for faster search decisions; see Kunar et al., 2007.

❖ Predictions: significant facilitation in Experiments 1 and 2, driven by a decrease in views as a function of experience.

Results

❖ Although participants had no reason to encode the distractors, they generated incidental memory for their identities above chance performance.

❖ We found an effect of **Load** ($F > 10$)***, with better memory among higher load groups. There was an effect of **Image Type** ($F > 500$)***, with better memory for targets, relative to distractors, and a **Load x Image Type** interaction ($F > 18$)***.



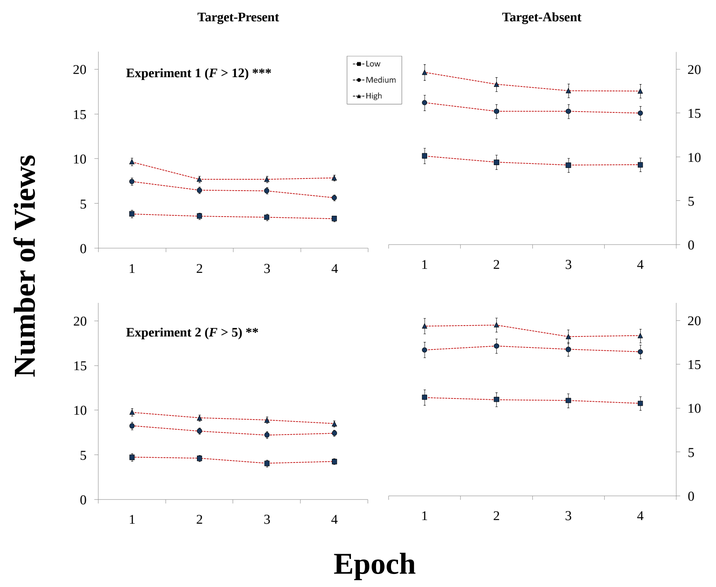
Load: $F(2, 102) = 10.05$ ***

Image Type: $F(1, 102) = 579.37$ ***

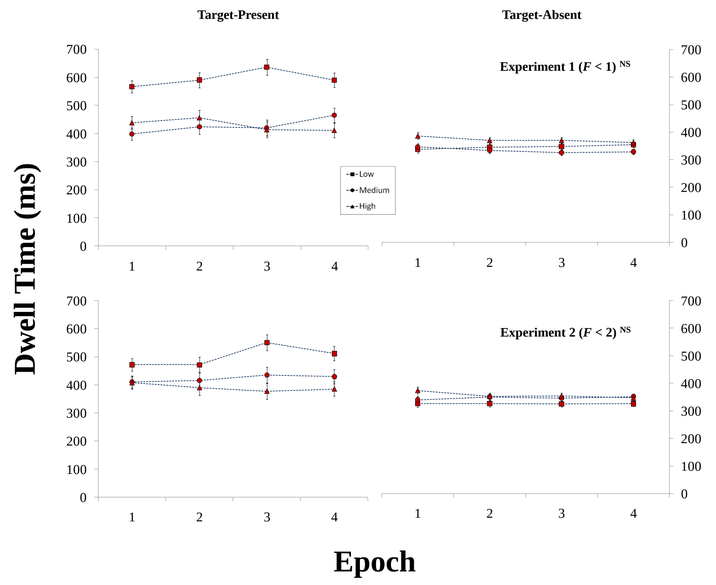
Load x Image Type: $F(2, 102) = 18.15$ ***

❖ In both experiments, we found significant facilitation of search RTs, with faster search over a block of trials (both Fs > 5).

❖ Critically, this effect was driven by a decrease in the number of views needed to complete search (both Fs > 5).



❖ However, we found no change in average dwell times across trials (both Fs < 2).



Discussion

❖ The results favor the **Response Selection** hypothesis, a view wherein the amount of information required to reach a search decision is reduced through both object and spatial learning.

❖ This hypothesis correctly predicted facilitation of search RTs (even in the absence of consistent spatial information), and that such an effect is driven by participants committing fewer views per trial.

❖ The identification and dismissal of non-targets does not seem to be affected by prior knowledge of item identities.

❖ Across trials, targets effectively stand out from the distractors to a greater extent, and exhaustive search is shortened by a sense of certainty that all locations have been searched, and that none of the inspected items were the target.

References

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