Repeated Visual Search: the Contributions of Object Identity, Spatial Information, and Working Memory Load.

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Abstract

Although visual search is most efficiently performed by ignoring distracting non-targets, people may incidentally learn the identities and locations of such "background" objects. Indeed, over repeated presentations, such learning may enhance search efficiency. In the current investigation, we examined the relative contributions of spatial information and object identity to implicit learning of visual search arrays. Participants repeatedly searched for new target objects embedded among repeated distractors. The results indicated that people become faster at search over time, even when placed under working memory load, and that participants under high load retain more visual information about distractors, relative to those under low WM load.

Memory In Visual Search

- Both retrospective memory (e.g., fewer re-visits) and prospective memory (e.g., strategic scanpath planning) may help guide attention during visual search (Peterson, Beck, & Vomela, 2007).
- Familiarity with targets and distractors leads to more efficient search (Mruzcek & Sheinberg, 2005).
- Korner and Gilchrist (2007) found faster search times upon the second presentation of search arrays, and a "fixation recency effect." The more recently a letter was fixated in trial N, the faster it was located if it became the target on trial N+1.

Incidental Retention of Visual Information

- Long-term visual representations are incidentally generated during scene perception (Castelhano & Henderson, 2005).
- Incidental memory for search objects is related to viewing behavior. Objects related to search targets receive more viewing, relative to unrelated distractors, leading to superior encoding of details (Williams, Henderson, & Zacks, 2005).

Working Memory

- Despite differences in accuracy, search slopes between low- and high-WM capacity participants are equivalent across different visual search tasks (Kane et al., 2006).
- An "executive" WM load creates differences in search slopes across single and dual-task conditions. Simple maintenance of information in WM does not (Han & Kim, 2004).

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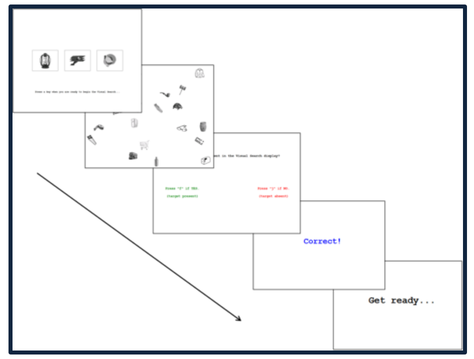
The Current Study



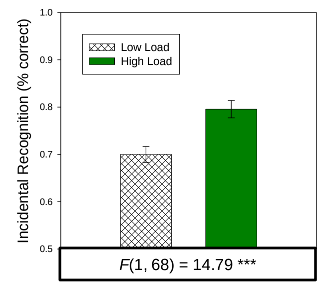
- Participants searched for a new target embedded among a set of repeated distractor objects. Stimuli were images of real-world objects.
- On half the trials, the target was present; on half the target was absent. Forty trials per block.
- Two blocks were completed, each with different sets of distractor objects.
- The Low WM load group searched for single targets; High WM load searched for three targets, any (or none) of which was present in the search array.
- Following search, a 2AFC recognition memory test was given for distractors encountered during search (using category-matched foils).

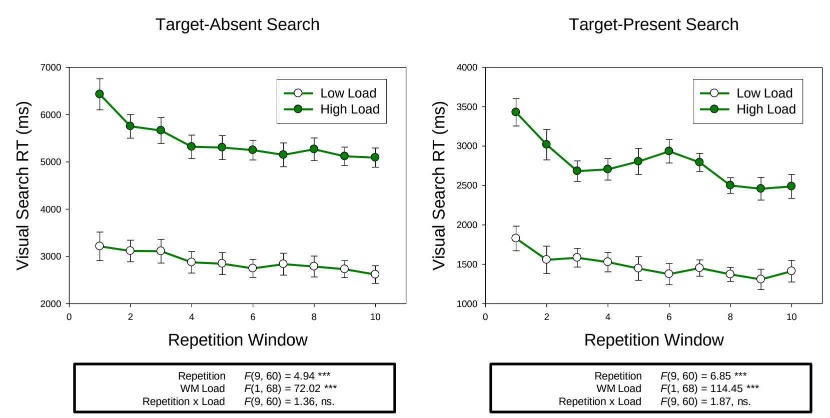
Experiment 1 – Constant Spatial Information

- Overall spatial layout (placement of distractor objects on the screen) remained constant throughout a block of trials.
- Object-to-location mapping was also constant per block: Each distractor remained in the same location throughout each block of trials.

Experiment 1 – Results

- High-load searched slower, relative to low-load.
- Both groups improved in search efficiency across repeated trials.
- The high-load group incidentally retained more visual information from search, outperforming low-load on the recognition test by 10%.



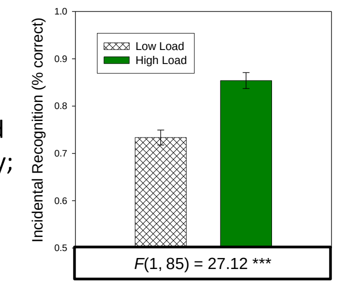


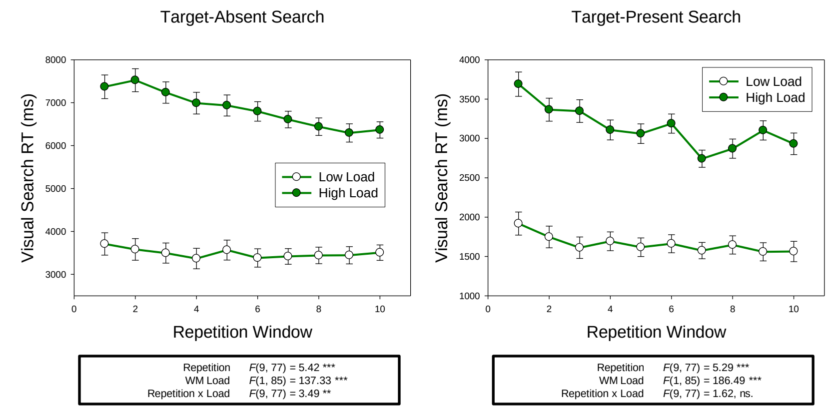
Experiment 2 – Random Object-to-Location Mapping

- Overall spatial layout remained constant over a block of trials.
- However, object-to-location mapping was randomized. That is, on each trial, distractor objects were randomly located among the set of fixed spatial locations.
- Thus, distractor identities and spatial layout remained constant, but were decoupled from one another.

Experiment 2 – Results

- High load again performed search slower, relative to Low load.
- Overall, search was slower than Experiment 1, indicating that the decoupling of identity from location created a more difficult search task.
- Both groups nevertheless improved in search efficiency across trials.
- The high-load group again outperformed the low-load group on recognition memory; now by 12%.



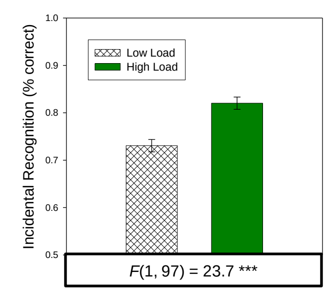


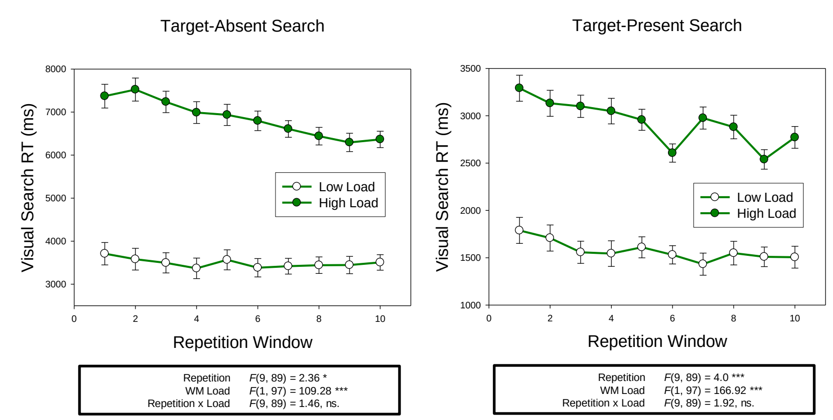
Experiment 3 – Random Object Placement

- Distractors were randomly located on each trial, with 5 objects per quadrant.
- No valid spatial information could be used to guide search; only distractor identities remained constant.

Experiment 3 – Results

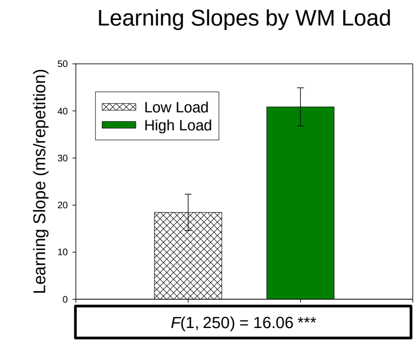
- Even without helpful spatial information, participants in both load conditions improved search efficiency.
- Once more, the high-load group outperformed low-load (by 9%) in recognition memory.

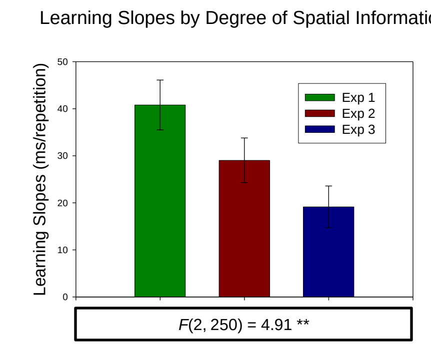




Learning Slopes Across WM Load and Spatial Information

- Comparisons of learning slopes (i.e., the improvement in visual search RTs per trial) revealed faster learning for the high-load group, relative to low-load.
- The high-load group better acquired information from each presentation of the search arrays , achieving steeper learning gradients.
- Across experiments, learning slopes were steeper when more valid spatial information was available (Experiment 1), relative to a lesser degree (Experiment 2) or the absence of spatial information (Experiment 3).
- Although valid spatial information improves learning for visual search, people can also learn from object identity, without spatial consistency.





General Conclusions

- The present investigation provides clear evidence for the roles of object identity and spatial information in the facilitation of repeated visual search.
- Despite being placed under a difficult executive WM load, the high-load group was able to learn the search arrays just as well (or better) than the low-load group.
- Consistent with Williams et al. (2005), visual details of distractor objects were incidentally encoded during visual search.
- Although the high-load group had more trouble completing search (they were slower, with more errors), they retained more visual information for the distractors, relative to the low-load group.
- Mediation analyses (not presented) demonstrate that visual search time mediated the effect of WM load on recognition memory; though not in all cases (Experiment 2).
- WM load created slower search processes. The increased viewing time for distractors was partially responsible for the subsequent increase in recognition (comparing WM groups).
- Ongoing investigations involve eye-tracking, allowing more precise measures of visual behavior (e.g., number of fixations per object, fixation durations, strategic scanpaths).

References

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