Working Memory Load Increase Predicts Visual Search Efficiency

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Introduction

- The size of the observer's pupil varies with factors such as ambient luminance, arousal, cognitive effort, and working memory load.
- Previous studies found that pupil size statistically increased over the course of the search, and they attributed this finding to accumulating working memory load. However, other factors, e.g.,arousal and effort, likely affected pupil size as well and added noise to the data and some uncertainty to the conclusions.
- **In the present study, we interspersed a simple search task with intermittent blank screens showing only a central fixation marker, thought to induce a low, stable level of arousal and cognitive effort to minimize the influence of these variables on the estimation of working memory load.**

Method

- SR Research EyeLink-2K
- 32 items (31 distractors, 1 target)
- Target: Vertical , Horizontal

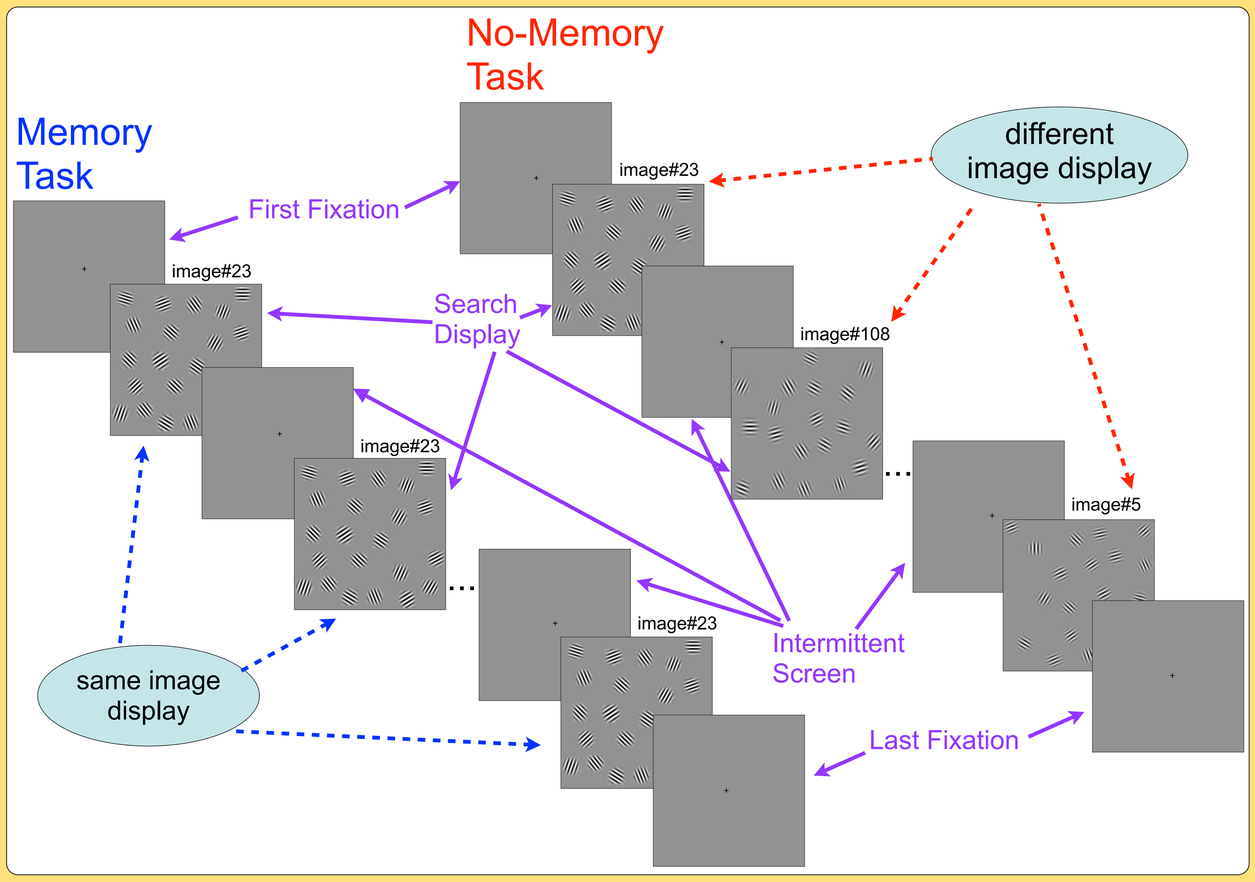
Time Duration:

1 Sec 3 Sec

- 10 Trials per block
- 10 Search displays per trial
- 13 Subjects

4 Memory blocks = 40 Search displays

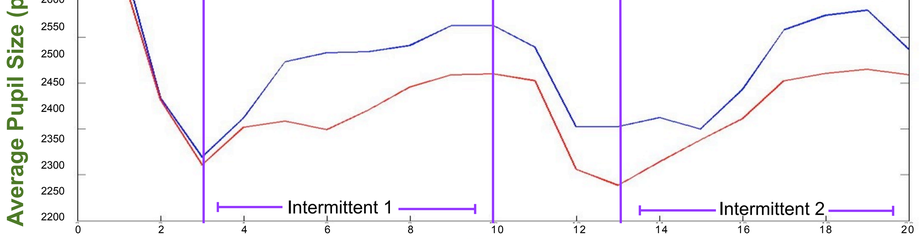
4 No-Memory blocks = 400 Search displays



- One important paradigm for such application is visual search, whose utilization of working memory has been the subject of long-standing debates.
- The method is adapted from the study by Porter Troscianko, and Gilchrist (QJEP 2007). In contrast to their study, our experiment estimated working memory load by measuring pupil size during the presentation of intermittent fixation screens.
- To test our hypotheses that **(1)** increasing working memory load during search can best be measured by comparing pupil size between successive fixation screens and **(2)** loading working memory is an integral part of performing the search task sufficiently, we included two controls: **First**, we introduced a no-memory task in which after each fixation screen, a different search display was shown. **Second**, we computed the difference in pupil size in successive search displays as a measure of working memory load increase.

Results: Average Pupil Size

- Differences in mean pupil size between successive fixation screens mainly reflect changes in working memory load that occurred during the search interval between the screens in the memory blocks.
- The results are indicating that during the memory blocks, the greater pupil size increase in the intermittent blank screens tended to be followed by shorter search time. Furthermore, the difference in mean pupil size between the first two search display presentations did not predict RT in both memory and no-memory blocks.



Results: Correlation Between Pupil Size Difference and RT

Tests of Within-Subjects Effects	
Effect of Task:	F(1;12) = 4.05, P = 0.067
Effect of Phase(Image, Intermittent):	F(1;12) = 5.08, P = 0.044
Effect of Task*Phase(Image, Intermittent):	F(1;12) = 8.4, P = 0.013

- A within-subject analysis showed that the pupil size difference between the first two fixation screens in the memory blocks was a significant predictor of RT in the same trial, with an inverse correlation of approximately r = -0.23. There were clearly weaker correlations for the no-memory blocks and for pupil measurement during search phases.

Conclusions

The result supported our hypotheses:

- Working memory load increases during search.
- This load increase is a major factor determining search efficiency.
- Intermittent fixation screens greatly enhance pupil-based memory load estimation, even providing trial-by-trial insight into the utilization of working memory

References

- Porter, G., Troscianko, T. & Gilchrist, I.,D. (2007). Effort during visual search and counting: Insights from pupillometry, The Quarterly Journal of Experimental Psychology, 60:2, 211 - 229
- Bijleveld, E., Custers, R., Aarts, H. (2009). The unconscious eye opener: pupil dilation reveals strategic recruitment of resources upon presentation of subliminal reward cues. Psychol Sci.20(11):1313-5

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