The effect of target size and salience in visual search within naturalistic scenes under degraded vision

Adam Clayden, Robert B. Fisher & Antje Nuthmann
s1475487@sms.ed.ac.uk
http://www.ppls.ed.ac.uk/people/adam-clayden

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THE UNIVERSITY of EDINBURGH

Introduction

- We have previously found that foveal vision is not necessary for localising context free targets (Clayden, Fisher & Nuthmann, 2015) and context driven objects (Nuthmann, 2014).
- On the other hand, peripheral vision has been shown to be essential in obtaining an efficient search performance (Loschky & McConkie, 2002).
- In Exp. 1, we specifically targeted foveal vision where observers searched for the letter 'T' with and without a foveal blindspot. We also manipulated the salience and size of the target.
- Going beyond the initial manipulation of foveal vision, Exp. 2 increased the size of the blindspot to compare a degradation of foveal/parafoveal vision (2.5° Blindspot) with a degradation of parafoveal/peripheral vision (2.5° Spotlight). This manipulation of the visual field was combined with varying the saliency of the target.

Methods

Stimuli: 120 greyscale images of real-world scenes (25° × 19°) in which a target letter was embedded.
Apparatus: SR Research EyeLink 1000/2K Desktop mount, 21-inch CRT monitor at 140 Hz.
Design: **Exp. 1:** Two target sizes were crossed with the presence vs absence of foveal vision and low vs high locations of visual salience. **Exp. 2:** Small target size crossed with low vs high salience target locations, but with 3 viewing conditions (normal, 2.5° blindspot, 2.5° spotlight).
Target size (letter width): Exp. 1: 0.41° (S), 1.08° (L). Exp. 2: 0.41°
Foveal vision: A gaze-contingent moving mask was used to simulate the absence of foveal vision. The grey mask was circular with a radius of 1° (exp. 1) and 2.5° (exp. 2) with its perimeter smoothed.
Spotlight: Exp. 2 also added a 'spotlight' counterpart, rendering content within the gaze-contingent window to be visible, and everything outside the window to be absent (see Fig. 2).
Instruction: In both experiments, observers were instructed to press a button once they found the letter "T".
Target location: location for which there was either a *lower or upper quartile* change in local contrast when inserting the letter.
Algorithmic approach to target insertion:

$$\text{CriteriaMap}(r,c) = \sum_{\text{letter, size}} \left| \text{ContrastDifferenceMap}_{\text{letter}}^{[size]}(r,c) - t_{\text{letter, size}} \right|$$

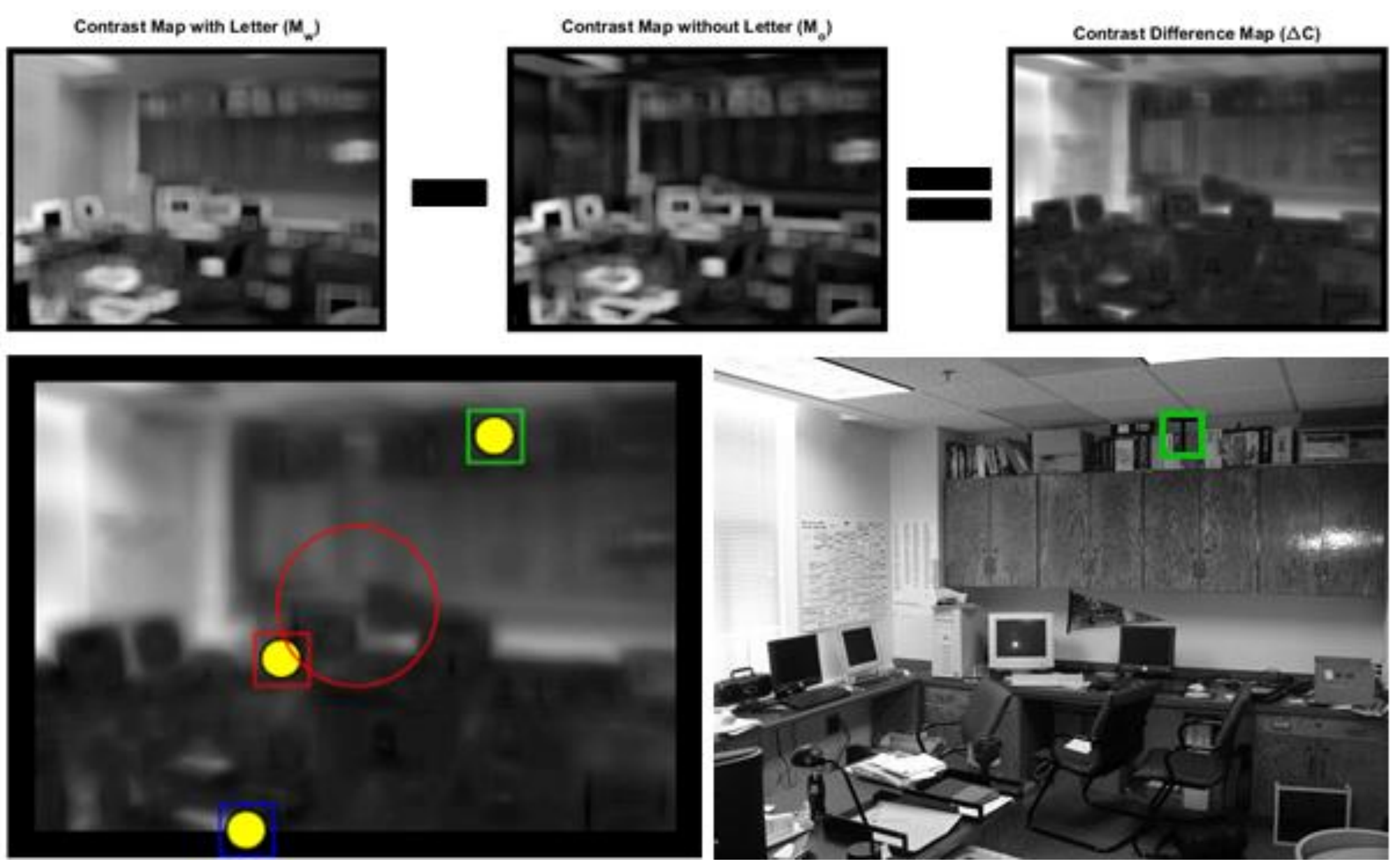
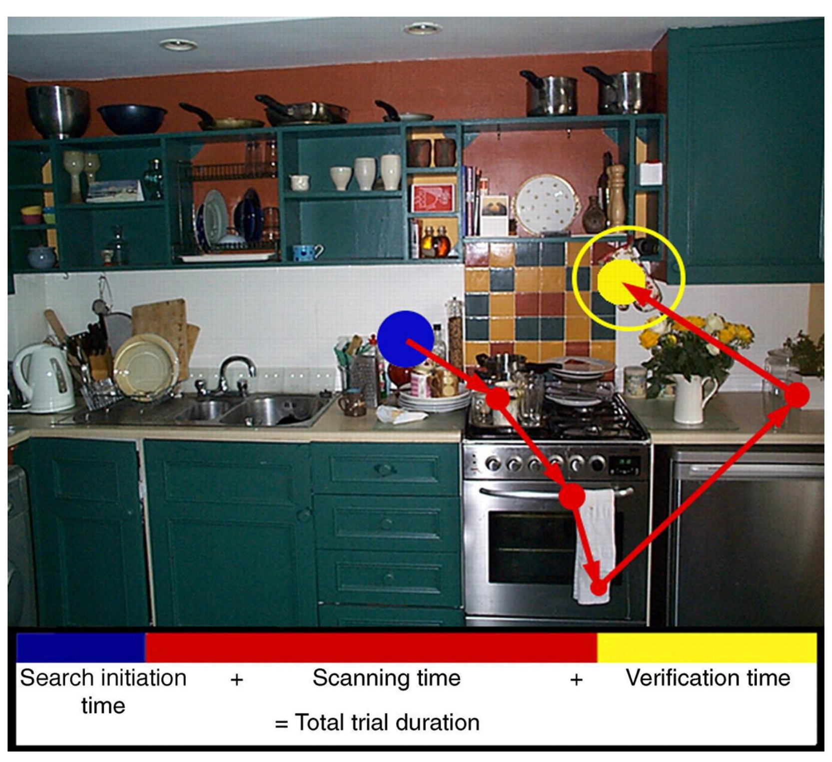


Figure 1. Algorithm depicting the initial creation of the contrast difference map. Followed by criteria checking (central exclusion in red and edge exclusion in blue) before finally selecting a position (green box) for the target.

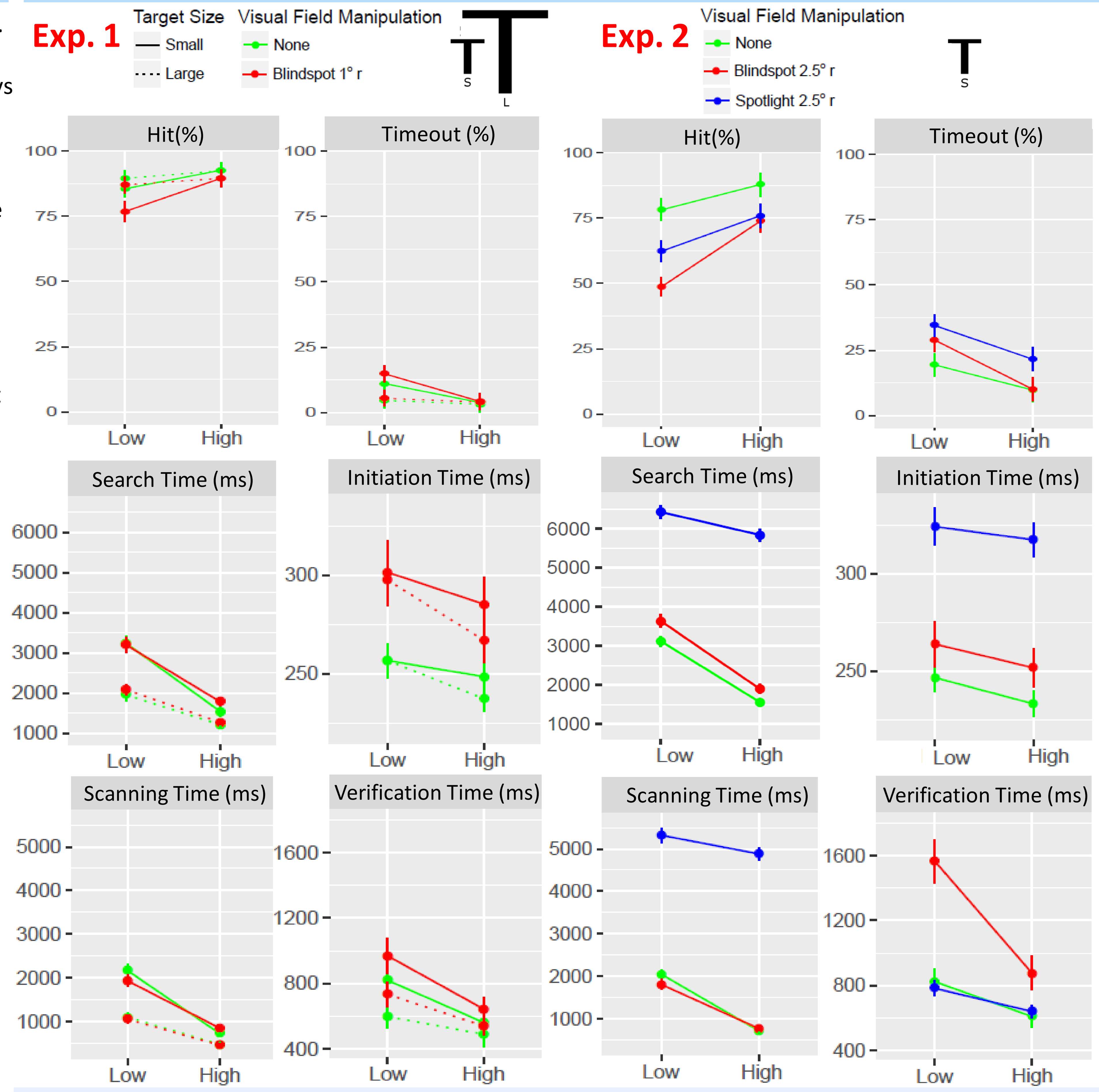
Figure 2. Foveal blindspot, 2.5° blindspot, 2.5° spotlight



Initiation Time: Initial saccade latency. Scene onset to initiation of first saccade.
Scanning Time: From the first eye movement until gaze lands within target interest area (actual time searching for the target).
Verification Time: The gaze duration on the target. Time taken from first gaze into interest area until the button was pressed.

Figure 3. Gaze-based decomposition of search time (Malcolm & Henderson, 2009)

Results



Key findings and discussion

Experiment One:
- **Main Effects: 1)** Increased target size reduced search time, scanning time, and verification time. **2)** Increased salience reduced search time, initiation time, scanning time, and verification time.
- For each dependant measure, size and salience interacted such that as salience decreases, target size becomes more important.

Discussion
- For all conditions, there was no effect of having a blindspot on the ability to localise/verify the target, regardless of target size and salience. This is in general agreement with previous work in which we manipulated the size of the target whilst keeping the salience of the location constant (Clayden, Fisher & Nuthmann, 2015).

Experiment Two:

Blindspot vs baseline
- **Main effects: 1)** Searching with a larger blindspot increases search time and verification time; **2)** Low salience was associated with prolonged search time as a whole and at all three epochs.
- **Interaction between** blindspot and salience on verification time.

Spotlight vs baseline
- **Main Effects: 1)** Searching through a spotlight increases search time and scanning time (Loschky & McConkie, 2002, Nuthmann, 2014); **2)** Decreasing salience results in an increase to search time as a whole and at all three epochs.
- All conditions interacted except for initiation and verification time.

Discussion
- Searching with a larger blindspot led to a specific cost in verification time, which was particularly large for targets of low salience. By contrast, no such effect was observed for search with a foveal blindspot in Exp. 1.
- Salience is less relevant when searching with a moving spotlight due to peripheral processing not being available in this condition. These results highlight the importance of peripheral vision.

Take-home message:
- Foveal vision is less important for localising targets than previously thought.
- Increasing the size of a lowly salient target decreases the time taken to locate it. This is evidence that the size of a target can compensate for the fact that it is lowly salient.

References

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