Using visual interruptions to explore the extent and time course of fixation planning in visual search

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Introduction

• Previous research has demonstrated that during visual search observers plan fixations ahead of the current fixation (Peterson, Beck & Vomela, 2007; see also Gilchrist & Harvey, 2006).

• It remains unclear whether fixation plans involve the encoding of both object locations and object identities, and also how much time is required to build-up a fixation plan.

• In the present study, we examined the role of fixation planning using an interrupted visual search paradigm, where the display was briefly removed during search. The key questions were:

•Did participants 'sit and wait' during the interruption?

•If not, how was search (as indexed by eye movements) influenced by the interruption?

•Were objects fixated during the interruption revisited later?

Method

• 12 undergraduate participants.

• Eye movements recorded using an Eyelink 1000 running at 1000 Hz.

• Search for T-shapes amongst L-shapes, setsize of 12.

• 50% of trials contained a target.

• 640 trials in total, of which 160 (20%) were no-interruption controls.

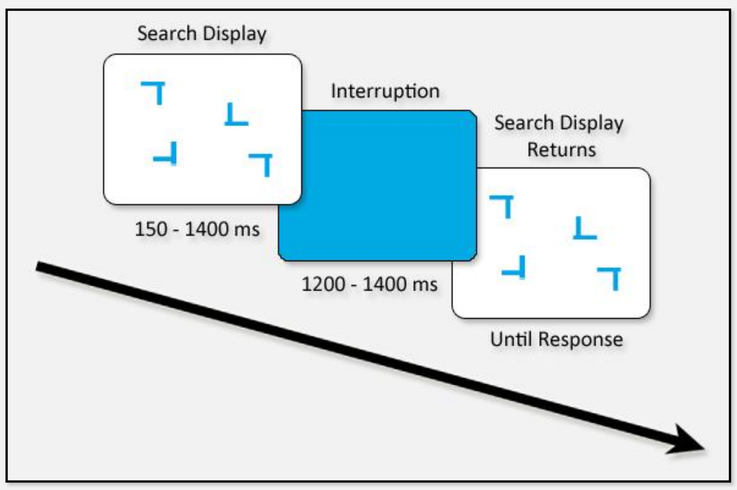

Figure 1. *Trial display sequence for interruption trials.*

Data Processing

• Exclusions: Trials where an incorrect response was given; fixations <60ms; Trials truncated by a response prior to the interruption. Approx. 30% of all trials removed based on these criteria. 4k interruption trials examined after exclusions.

•Data Set: 24k fixations from control trials, 8k from before the interruption, 7k during the interruption, 40k after the interruption.

Did participants 'sit and wait' during the interruption?

• Participants did not 'sit and wait' : Fixations were made to no longer visible objects in the interruption (within 2.5 degrees).

• On only 20% of trials, participants travelled less than 1 degree of visual angle during the interruption (Figure 2, left panel).

• On only 3% of trials, participants fixated no objects during the interruption (Figure 2, right panel).

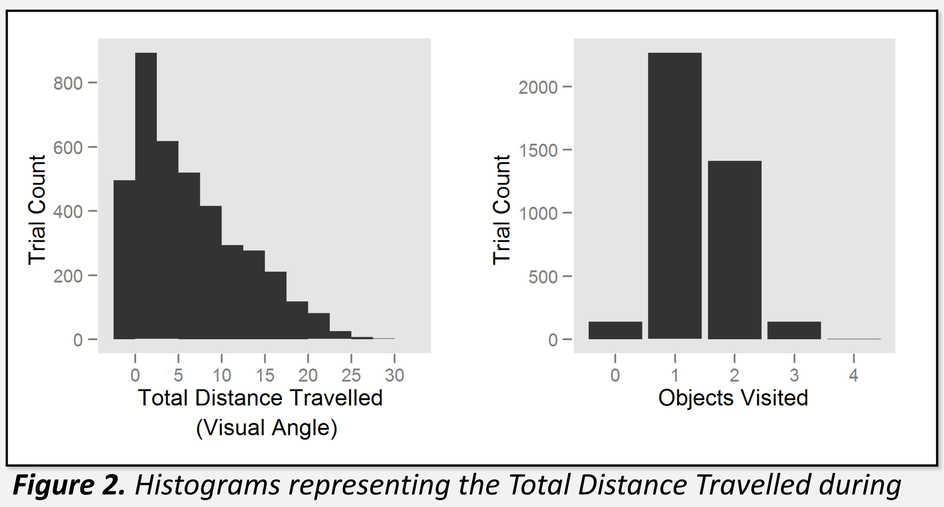

Figure 2. *Histograms representing the Total Distance Travelled during the interruption (left panel) and the number of objects visited during the interruption (right panel).*

How was search influenced by the interruption?

• Compared to control trials, eye movements during the interruption had longer fixation durations, poor targeting accuracy, and lower fixation frequency (see Table 1).

• Also, there was no evidence that the range of pre-interruption duration(s) influenced any of these three measures.

• Fixation plans do not appear to encode sufficient information to allow search to continue 'normally' during an interruption.

Table 1. *Table of means and results for t-tests for fixation frequency (number of fixations per 100ms), fixation duration, and distance to objects (in degrees of visual angle). *p<.001.*

Measure	Controls	Interruption	*t*	*df*
Fixation Frequency	0.43 (0.01)	0.19 (0.01)	21.6*	11
Fixation Duration (ms)	193 (5.7)	337 (23.1)	6.1*	11
Distance to Objects	1.37 (0.05)	1.79 (0.07)	7.8*	11

Were objects fixated during the interruption revisited later?

- For the following analyses ,we aggregated across all pre–interruption durations. We also removed fixations to targets, which were always visited after the interruption ended.
- If fixation plans encode detailed information about object identities, then objects fixated during the interruption should not be revisited later.
- For the objects visited during the interruption, 62% were also visited after the interruption, 5% were also visited before the interruption, and 6% were also visited both before and after the interruption. Only 27% of all the objects fixated during the interruption were not fixated in the other time periods.
- We compared the probability that participants would revisit an object fixated during the interruption with the baseline revisitation rates from control trials (Figure 3). Here we filtered out any objects that were fixated before the interruption.
- Revisitation rates for objects fixated during the interruption were significantly higher than revisitation rates for control trials ($F(1,11)=197$, $p<.0001$).

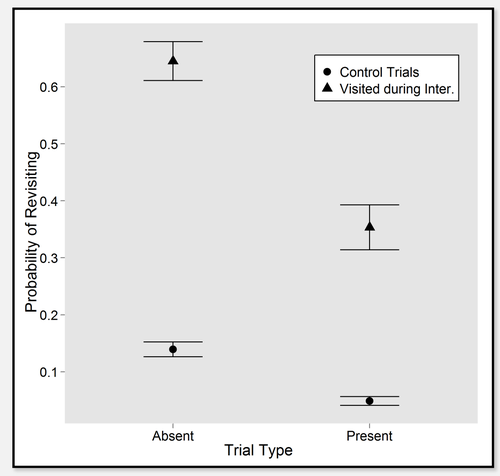

Figure 3. *Probability of revisiting objects visited during the interruption once the interruption ended, compared to revisitation rates for control trials*

Conclusions

• Fixation plans (in terms of location, frequency and duration) appear to not be affected by how long the display was visible prior to an interruption.

• Fixation plans appear not to encode sufficient information regarding object identities to enable search to continue 'normally' when the display is absent.

• Fixation planning may occur, and peripheral information may be used to guide search, but fixation planning appears (from this study) to be limited to about 1-2 objects.

• Fixation planning is limited by the parameters of the sampling system, and the default appears to be to sample on-line, rather than to pre-process object identities prior to fixation.

References

Gilchrist, I. D., & Harvey, M. (2006). Evidence for a systematic component within scan paths in visual search. *Visual Cognition*, 14(4-8), 704-715.

Peterson, M. S., Beck, M. R., & Vomela, M. (2007). Visual search is guided by prospective and retrospective memory. *Perception and Psychophysics,* 69(1), 123-135.

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