Metacognitive contributions to visual search termination

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**Introduction**

While a significant amount of research investigates the mechanisms behind target detection, less work has been conducted on what brings us to abandon a search and conclude that a target is absent. The present experiment is the second of a series of experiments investigating the contribution of metacognitive knowledge to search termination when a target is absent.

To understand visual search behaviour, the classic experimental paradigm involves the study of response time (time taken to report the presence/absence of a target) as a function of set size (the number of items in the search display; see Wolfe, 1998 for a review). Depending on the type of stimuli and target’s salience, search efficiency varies with set size and as a result so does the slope of the function relating set size to response time. Several cognitive models of visual search such as the Guided Search Model 4.0 (GS4) and the Competitive Guided Search Model (CGS) generate computational simulations that successfully reproduce empirical RT x set size slopes (Wolfe & Gray, 2007; Moran et al., 2013).

However, when it comes to understanding the mechanisms underlying search termination on target-absent (TA) trials, cognitive models of visual search reflect a poor understanding of the mechanisms underlying this process. For example, Chun and Wolfe’s (1996) model of search termination is based on an assumption: the decision to terminate a search on TA trials relies on experience with the task. In the CGS model, the probability of quitting a search increases each time an item is rejected as a distractor. The value of this increase is a free parameter “under strategic control of the observer”, but the origins of that strategy is left unspecified. This series of experiments investigates the extent to which search termination on TA trials relies on metacognitive expectations of search time, prior to experience with the task. The questions at the heart of this line of research are:

What proportion, if any, of metacognitive expectations about search time do participants have prior to the task?

How is this knowledge shaped or extended by experience with the task?

To investigate this, experiment 1 (Mazor & Fleming, 2020) uses colour search, where the target item can be identified solely by its colour. Colour is one of a class of properties that give rise to “visual pop-out”, whereby the target item is so salient that it pops immediately to awareness, without need for endogenous control (e.g. red item among blue items), leading to very efficient search independently of set size. Empirical *RT x set size* slopes for pop-out search tasks are flat, near zero ms/item, for both TA and TP trials (Wolfe, 1998). In Experiment 1, Mazor & Fleming controlled the order of experimental trials, such that the experiment started with four TA trials for all participants. By starting with TA trials, participant’s ability to teminate the search based on experience with target-present trials is eliminated, thereby isolating the effect of metacognitive knowledge. Results are clear evidence for a colour pop-out effect on TA trials, prior to experience with target-present (TP) trials, suggesting that participants used metacognitive expectations about pop-out search time to terminate their search.

The present experiment will attempt to extend the findings of experiment 1 to shape pop-out search, as well as attempt to specify the nature of the metacognitive knowledge involved in shape search termination (implicit or explicit).

**Method**

This study was approved by the Research Ethics Committee of University College London (study ID number 1260/003).

**Participants**

Participants will be native English speakers recruited via Prolific. They will be compensated £0.51. A power analysis on G\*Power for a small effect size of 0.20 (Cohen, 1992) with a statistical power of 95% indicated that data should be collected until obtention of 320 included participants for each hypothesis.

**Pre-registered exclusion criteria**

Participants making over one error in the main part of the experiment will be excluded. Subjects with RTs below 250ms or above 5000ms in over 25% of trials will be excluded. Participants who give blank answers to questions 1 and/or 2 will be excluded.

**Procedure and Design**

Participants will give informed consent before participation. We will give instructions on the visual search task: state whether a target item is present or absent (pressing “J” or “F” respectively), being as accurate and as fast as possible. Participants will complete practice trials (See Figure 1) followed by 12 trials (structure of each trial in Figure 2) forming the main part of the experiment (see Figure 3).

Diagram

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*Figure 1.* To familiarize with the task, participants will complete practice trials in blocks of 6, until they produce correct responses for at least 5 out of 6 trials. In practice trials, set size is fixed to 3 and participants search for a rotated T among rotated Ls (from Mazor & Fleming, 2020)

Graphical user interface, application

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*Figure 2.* Each trial begins with a screen showing the target stimulus. Next, the search display is presented until a response is given. The feedback screen is displayed for 1000ms after correct responses and 4000ms after errors, to boost accuracy (figure from Mazor & Fleming, 2020).

Diagram

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*Figure 3.* The main part of the experiment consists of 12 trials. Unbeknown to participants, blocks 1 and 3 (trials 1-4 and 9-12) are target-absent and block 2 (trials 5-8) are target-present. Participants search for a red circle (target item) among red squares (shape search) or among red triangles and blue circles (conjunction search). The number of items in the search display (set size) is 4 or 8. The following 2x2 design is applied: Type of search (shape, conjunction) X Set size (4,8). Item position is randomised. Trial order within each block is randomised.

After completing the main part of the experiment, participants will be asked the following multiple-choice question (Q1): "In a recent experiment, we found that participants take 500 ms on average to find a triangle among 5 ellipses. How long (on average) did it take them to find the triangle among 10 ellipses?". They will be given a range of possible answers to choose from (e.g. 460ms, 500ms, 540ms, etc.), before proceeding to question 2. Q2: “Have you had any experience with this type of experiment in the past (i.e. searching for a target of a certain shape among items of a different shape)?”. If they answer “Yes” to Q2, this follow-up question will appear on the next screen: “When did you encounter a similar experiment? What did you have to do?”.

**Analysis**

Trials with response times below 250ms or above 1000ms, as well as error trials, will be excluded from the analysis. Throughout the analysis, we will consider that slopes significantly lower than 10ms/item indicate a pop-out effect. Slopes will be computed using simple linear regression, controlling for serial trial order.

To test for the presence of a pop-out effect in each block: within-subjects t-tests will determine whether there is a significant difference between conjunction and shape slopes, and whether the shape slope is significantly below 10ms/item.

We will repeat this analysis for the subgroup that replied “No” to Q2 (participants reporting no experience with a similar task in the past). Finding a pop-out effect on block 1 for this group will enable us to rule out the contribution of past experience as the main influence on our results.

To test for a learning effect between blocks 1 and 3, as a result of experience with TP trials in block 2, a within-subjects t-test will compare the shape slope in block 1 with the shape slope in block 3.

To specify the nature of participants’ metacognitive knowledge (implicit or explicit), their answers to Q1 will be added as a covariate to the model.

**Anticipated results and implications**

A picture containing timeline

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*Figure 4.* Typical search times for conjunction versus shape trials. TP: target-present, TA: target-absent.

*Figure 5.* Obtaining the above results will indicate that the chosen stimuli induces a shape pop-out effect on TP trials and thus validate our methods.

If we validate our methods (see Figure 5), we can conceive of three patterns of results:

*Figure 6.* This pattern of results was found for color search in experiment 1. These findings would indicate that search termination on TA trials is based on metacognitive expectations of a shape pop-out effect, and not experience with the task, since shape slope is flat from block 1, and no learning effect is found between blocks 1 and 3.

If we find this same pattern of results for the subgroup who answered “No” to Q2, we will be able to infer that metacognitive knowledge alone contributes to search termination. If not, we cannot rule out the contribution of past experience to search termination.

*Figure 7.* This pattern of data would suggest that contributions to search termination are partly metacognitive and partly experiential, revealing a learning effect as a result of experience with TP trials.

*Figure 8.* Alternatively, we could find that search termination is based on experience alone.

References

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