Contextual cuing in the presence of an overt instruction

Tom Beesley[1], Louise Earl[1], Hope Butler[1], Inez Sharp[1], Ieva Jaceviciute[1], and & David Luque[2]

[1] Lancaster University

UK

[2] Universidad Autónoma de Madrid

Spain

Author Note

Correspondence concerning this article should be addressed to Tom Beesley, Department of Psychology, Lancaster University, UK, LA1 4YD. E-mail: t.beesley@lancaster.ac.uk

Abstract

abstract here

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Main text here (Tom Beesley et al., 2015)

Experiment 1

Experiment 1 sought to examine whether the learnt attentional behaviour that develops during contextual cuing is expressed when participants are directed with an endogenous instructional cue to search in a particular region of the search space. Participants were first trained with a set of four repeating configurations in phase 1 across 5 epochs of 32 trials each. Then prior to phase 2, participants were told that an arrow would appear before every trial indicating the side of the screen on which the target would be located. This arrow was valid on every trial. In phase 2, the repeating configurations were presented in two forms: "consistent", where the target appeared in the same position as it has appeared for that configuration in phase 1; and "inconsistent", where the target appeared in a position in the opposite quadrant of the screen from where it had appeared in phase 1. Random configurations were also presented in this phase. If the contextual cues within the repeated configurations continue to guide attention in the presence of the instructional cue, then we would expect that response times would be faster on consistent trials compared to random trials. In addition, we would also expect that the contextual cues would guide attention *away* from the (new) target quadrant on inconsistent trials, and so response times should be slower on these trials compared to those on random trials.

Method

Participants

Thirty-one undergraduate students from Lancaster University were recruited (mean age = 20.13, SD = 1.09; 17 identified as male and 14 as female) via the Psychology Research Participation System in the Department of Psychology at Lancaster University, in return for the opportunity to use the recruitment system for their own research in future

years.

Materials

Participants were tested individually in a quiet room with a Dell laptop with a 15.6" screen, a screen resolution of 1920 x 1080, and a full size external keyboard for participants to use to respond to the task. Participants sat approximately 50 cm from the screen. Stimulus presentation was controlled by MATLAB using the Psychophysics Toolbox extensions (Brainard, 1997; Kleiner, Brainard & Pelli, 2007; Pelli, 1997). Responses to the target stimulus were made by pressing the 'c' or 'n' key on a standard keyboard. All experimental materials are available at the github repository for this study.

Distractor stimuli were an 'L' shape (rotated 0°, 90°, 180°, or 270°) while the target stimulus was a 'T' shape (rotated at either 90° or 270°). Stimuli were XX mm (X.X°) square and arranged in a square grid of 144 evenly spaced cells (12 x 12) which was positioned centrally on the screen and was XXX mm (XX°) square. The grid itself was invisible to participants. The fixation cross (displayed centrally before each trial) was XX mm (X.X°) square. The background of the screen was grey (RGB: .6, .6, .6) and the stimuli were presented in black (RGB: 1, 1, 1). There was a small offset in the vertical line of the 'L' distractors, which increased the similarity between the 'L' distractors and the target 'T', making the search task more difficult (Duncan & Humphreys, 1989).

Design

Phase 1 employed a within-subjects design with factors of epoch (1-5) and configuration (repeated and random). All configurations contained 16 distractors, equally divided between the four quadrants of the display, and one target. Four repeated configurations were trained. Four target locations were used, with one from each quadrant assigned to each of the repeated configurations. These same four target positions were used for the the random configurations throughout the task. Each of these four target positions was chosen at random from one of five locations within each quadrant, that were

approximately equidistant from the center of the screen. Distractors could not appear in these target locations.

Phase 2 employed a within-subjects design with factors of epoch (6-10) and configuration (repeated: consistent; repeated: inconsistent; random: consistent; random:inconsistent). On each trial, there was a .5 probability that an "inconsistent" version of the configuration would be presented. This meant that the target was relocated to a diametrically opposed target position such as to maximise the displacement from the trained target position. This could occur for both the repeated and random configurations, hence creating four unique trial types for this phase. While random configurations did not have a "trained", associated, target position, it is necessary to divide the random trials into consistent and inconsistent trial types in this way in order to assess any target frequency effects that may occur, since the inconsistent target locations used in this phase were novel.

Procedure

Participants were tested individually in a quiet testing room. They were given instructions on how to complete the task, including the presentation of an example of a search trial. Participants were shown the two correct responses for the two possible orientations of targets.

Each trial commenced with a fixation cross presented in the center of the screen for 500 ms, which was then replaced immediately by the search configuration. Participants searched for the target stimulus and responded with a left or right response depending on its orientation. Reaction times (RTs) were recorded from the onset of the search configuration. Following a valid response (c or n), the configuration was removed from the screen. The response– stimulus interval (hereafter RSI) was 1,000 ms. If participants made an incorrect response to the target orientation, "ERROR!" appeared in the center of the screen for 3000 ms, prior to the RSI.

Each block of eight trials contained each of the four different repeated

configurations and four random configurations. These eight configurations could appear in any order with the constraint that the position of the target did not repeat across trials or across consecutive blocks.

A rest break of 30 seconds was given every 80 trials. Trials started automatically after these breaks.

After 160 trials, prior to phase 2, participants were given an instruction screen which detailed the arrow that would appear on the screen prior to the configuration. They were able to ask any questions they had at this stage and then proceeded to phase 2. The arrow appeared for 1000ms between the removal of the fixation cross and the presentation of the search configuration. The task was otherwise identical to that used in phase 1.

Results

Our criterion for removing outlier data, at both the participant level and the trial level, was 2.5 standard deviations above or below the mean of the sample. On average, trials ended with a timeout on 1.97% of trials (SD = 2.53). Two participants had an usually high proportion of timeouts and were removed from the analysis. The mean accuracy of participants (not including timeout trials) was 98.10% (SD = 1.65%). One participants that had an unusually low proportion of accurate trials and were also removed. The only participant deemed to be an outlier in terms of mean response time (hereafter RT) was also excluded on the basis of the timeout criterion, noted above.

For the remaining twenty-eight participants we removed trials with a timeout and inaccurate trials, before removing outliers from the RT data. On average, the proportion of outliers removed was 3.03% (SD = 0.79%). zero participants had an unusual proportion of trials removed as outlier RTs.

Within-subject error bars were computed by a process of normalising the RT data for the sample (Cousineau, 2005). Figure 1 shows the RT data across the 10 epochs of the experiment. In phase 1 (epochs 1-5) a contextual cuing effect rapidly emerged. In phase 2,

121 the presence of the guiding arrow had a dramatic effect on the reduction of response times.

122 For all participants, the mean RT across epochs 4 and 5 was higher than the mean RTs

123 across epochs 6 and 7. Despite the clear evidence for the processing of the endogenous cue,

124 the underlying search configuration continued to play a role in the guidance of attention,

125 with faster response times for (consistent) repeated configurations compared to random

126 configurations.
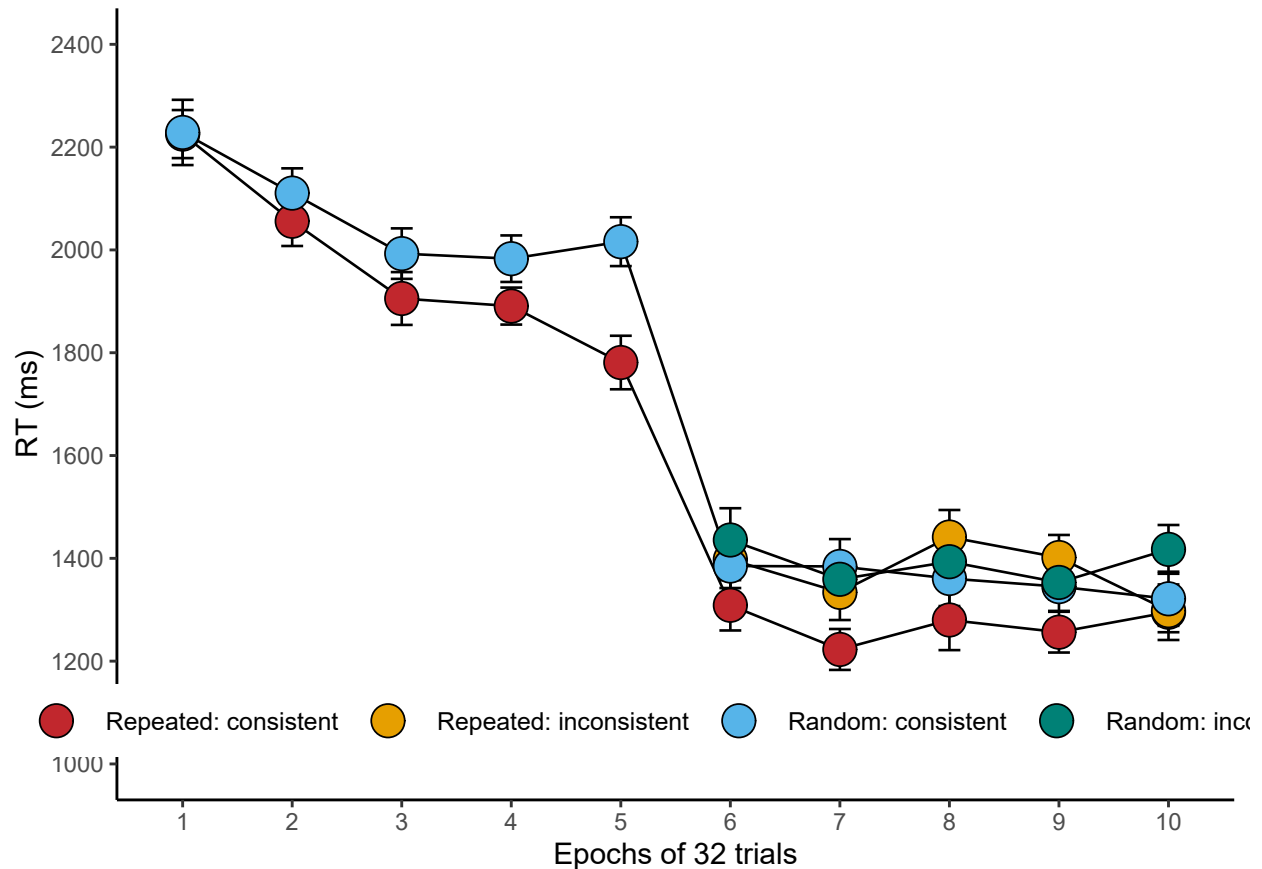
Figure 1

RT data for Experiment 1

127   These data were explored with a Bayesian ANOVA, using the

128 *BayesFactor::anovaBF()* function (for all analyses in this study the priors were set at the

129 default "medium" width). First taking the data from phase 1 (epochs 1-5), the model with

130 the largest Bayes Factor (BF) contained the factors of epoch and configuration (repeated

131 vs. random), $BF_{10} = 2.1 \times 10^{12} \pm 1.01\%$. The addition of the interaction term did not

132 substantially improve the model fit, $BF_{10} = 0.45 \pm 1.51\%$.

133   A Bayesian ANOVA on the data from phase 2 (epochs 6-10) found significant

134 support for the model containing the factor of configuration, $BF_{10} = 9.8 \times 10^1 \pm 8.47\%$.

135 There was evidence to suggest that the addition of the factor of epoch did not substantially

136 improve the model predictions, $BF_{10} = 0.02 \pm 8.55\%$. Comparing the response times from

137 just "repeated: consistent" trials with their respective random trials (random: consistent),

138 revealed support for a difference between these trial types, $BF_{10} = 4.75 \pm 0.76\%$. There

139 was no evidence to support a difference between the "repeated: inconsistent" trials and the

140 respective random trials, $BF_{10} = 0.38 \pm 0.81\%$. There was substantial support for a

141 difference between the repeated consistent and the repeated inconsistent trials, $BF_{10} =$

142 $10.13 \pm 0.77\%$.

143 **Discussion**

144   Experiment 1 sought to examine the consequence of an endogenous cue that

145 prompts top-down control of the search process on contextual cuing. In phase 1 we

146 established a robust contextual cuing effect. Following this, participants received

147 instruction that each trial would be preceded by an arrow stimulus that would signal the

148 side of the screen on which the target would appear. This cue was valid on all trials in

149 phase 2. Consistent with these instructions and the processing of this cue, we observed

150 substantially reduced search times in phase 2 compared to phase 1. The same set of

151 repeated configurations were presented in Phase 2, but for half of the trials, the target was

152 relocated to the diagonally opposed quadrant of the screen. Therefore, on these "repeated

153 inconsistent" trials, the underlying configuration of distractors predicted the target in a

154 location that opposed that of the (valid) endogenous cue. Across this phase we observed

155 significant contextual cuing for the repeated consistent trials, demonstrating that the

156 underlying configuration of distractors continues to guide attention in the presence of the

endogenous cue. However, the repeated inconsistent trials did not lead to an impairment in response times relative to random trials, suggesting that the underlying configuration did not influence search on these trials.

Experiment 2

In Experiment 1 we demonstrated that an established effect of contextual cuing is maintained even when attention is being guided by the presence of a valid endogenous cue. That is, we examined whether the *performance* component of contextual cuing is disrupted by a concurrent controlled attentional behaviour. In Experiment 2 we wanted to explore the *learning* of the contextual cue itself, examining whether the presence of a valid endogenous cue may limit the development of a contextual cuing effect. To do this, we trained each participant on two sets of repeating configurations. One of these sets was always presented in the presence of a valid endognenous cue, while the other set was always presented in the absence of the endogenous cue. The extent to which there is a "cue-competition" effect between the endogneous cue and the contextual cues can be examined by comparing the contextual cuing effect we observe for the two sets of configurations. Given the (expected) difference in RTs we observed in Experiment 1, between the trials with the endogenous cue present and the cue being absent, in a second phase of Experiment 2 we removed the endogenous cue entirely from the task. This second phase therefore allowed us to directly compare the contextual cuing for the two sets of participants when RTs are of the same magnitude.

"Cue-competition" effects have been examined previously in contextual cuing. Endo and Takeda (2004) trained participants with a contextual cuing task composed of distractor location configurations and repeating distractor identities. Their experiments suggested that the stronger configural (spatial) cue out-competed the cue provided by the distractor identities. Similarly, Kunar et al. (2014) found that when colour cues and configural cues both predicted the target location, configural cues were dominant and

tended to overshadow the weaker colour cue. T. Beesley and Shanks (2012) looked at the cue-interaction effects *within* a configuration of distractors. Participants were first trained with half a configuration of repeating distractors that predicted the target (8 out of 16 distractors). In a later stage these distractors were paired with a new half-configuration, such that the whole configuration now predicted the same target location. In contrast to the predictions of the vast majority of models of contingency learning, learning about these new predictive distractors was facilitated, rather than impaired in this second phase (relative to a control condition). Thus, T. Beesley and Shanks (2012) found that cue-competition was not observed within a configuration of equally predictive distractors. Together these studies suggest that the repeated configuration will out-compete non-configural cues for access to the learning mechanism. The dominance of the configuration in these situations may therefore lead to the prediction that the endogenous cue would not "block" the learning of the configuration in this task.

Method

Participants

Thirty-one undergraduate students from Lancaster University were recruited (mean age = 20.13, SD = 1.09; 17 identified as male and 14 as female) via the Psychology Research Participation System in the Department of Psychology at Lancaster University, in return for the opportunity to use the recruitment system for their own research in future years.

Materials

The materials and stimuli were identical to Experiment 1.

Design

Four repeated configurations were created in an identical manner to those used in Experiment 1. For each participant, two of these configurations were used for the

²⁰⁸ "cue-competition" condition, in which the arrow cue was presented before the

²⁰⁹ configuration, while two were used for the "control" condition (no arrow presented). As in

²¹⁰ Experiment 1, the four repeated configurations were paired with unique target positions

²¹¹ from each of the four quadrants. We counterbalanced the use of the target quadrants

²¹² across the factors of configuration type (repeated and random) and cue condition

²¹³ (cue-competition and control). For half of the participants, targets in the top left and

²¹⁴ bottom right were used for the repeated configurations presented with the arrow

²¹⁵ (cue-competition) condition, with targets in the top right and bottom left used for

²¹⁶ repeated configurations in the no-arrow (control) condition. For these participants, random

²¹⁷ configurations presented with the arrow had targets in the top right and bottom left, and

²¹⁸ random configurations without the arrow had targets in the top left and bottom right. For

²¹⁹ the other half of the participants these assignments were revered (repeated-arrow: top-right

²²⁰ and bottom-left; repeated-no arrow: top-left and bottom-right; random-arrow: top-left and

²²¹ bottom-right; random-no arrow: top-right and bottom-left).

Procedure

²²³   The procedure was the same as Experiment 1 with the following differences.

²²⁴ Participants received 320 trials in total. For the first 160 trials, the arrow was presented for

²²⁵ the relevant conditions. For the final 160 trials, the arrow was never presented. Rest breaks

²²⁶ were given every 60 trials.

Results

²²⁸   Our criteria for removing outlier data were identical to Experiment 1. On average,

²²⁹ trials ended with a timeout on 2.13% of trials (SD = 1.83). Zero participants had an

²³⁰ usually high proportion of timeouts. The mean accuracy of participants (not including

²³¹ timeout trials) was 95.85% (SD = 6.10%). One participant had an unusually low

²³² proportion of accurate trials and were also removed. Zero participants were deemed to be

²³³ an outlier in terms of mean RT.

234 For the remaining thirty-three participants we removed trials with a timeout and

235 inaccurate trials, before removing outliers from the RT data. On average, the proportion of

236 outliers removed was 2.81% (SD = 1.04%). One participant had an unusual proportion of

237 trials removed as outlier RTs and were not included in the final analysis.
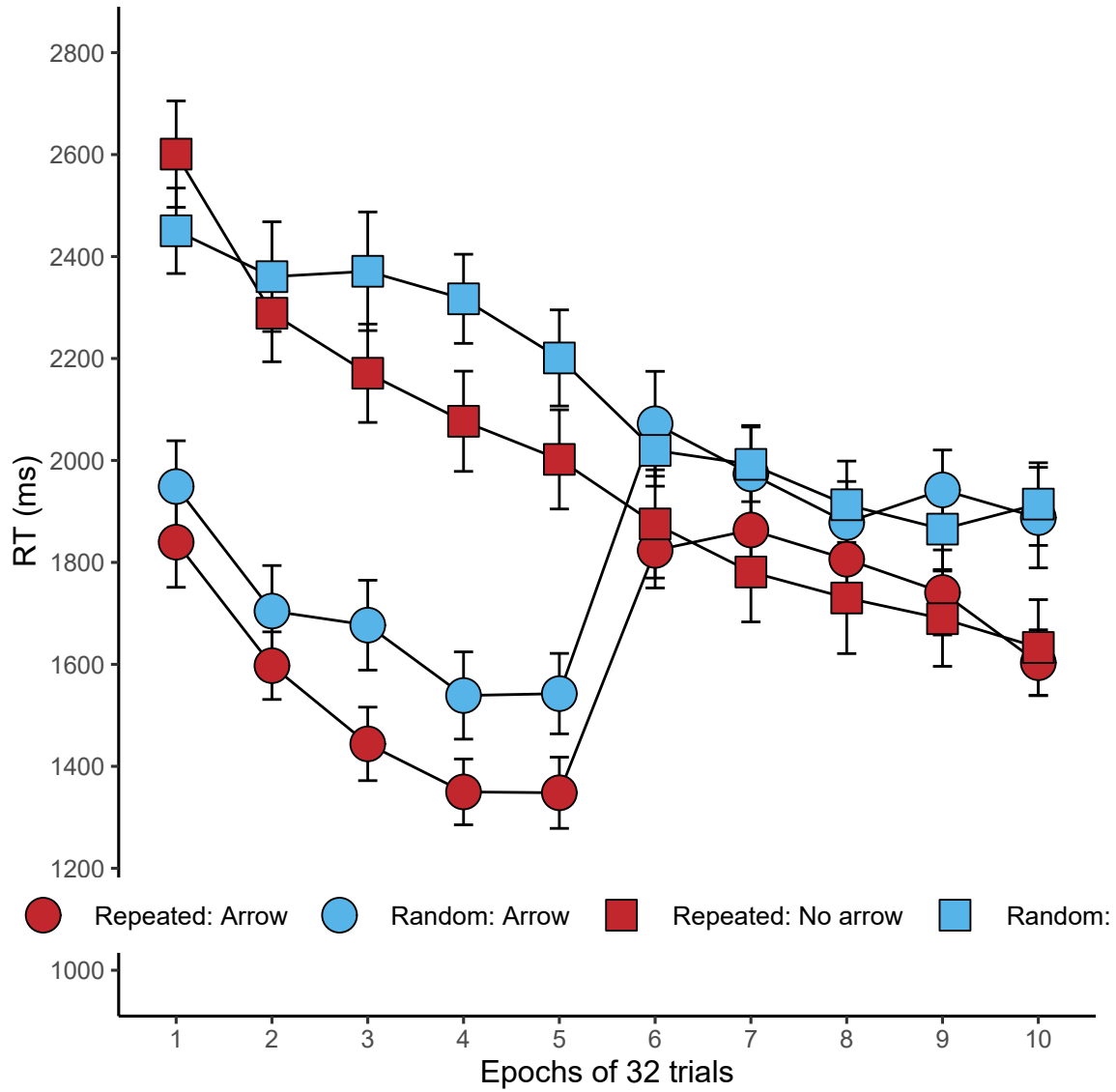
Figure 2

RT data for Experiment 2

238 Figure 2 shows the RT data across the 10 epochs of the experiment. Contextual

239 cuing emerged rapidly in both the arrow and no-arrow conditions, with little suggestion

that the CC effect was different in the two cuing conditions. The Phase 1 data were explored with a Bayesian ANOVA, which revealed that the the model with the largest Bayes Factor (BF) contained the factors of epoch, configuration (repeated vs. random), and endogenous cue (arrow present vs. arrow absent), with no interaction terms, $\text{BF}_{10} = 7.3\text{x}10^{100} \pm 2.76\%$. The next best fitting model contained all three factors and the interaction of epoch and configuration, $\text{BF}_{10} = 5.1\text{x}10^{100} \pm 4.36\%$, and this model was not a substantially worse fit to the data, $\text{BF}_{10} = 0.71 \pm 5.17\%$. All other models were substantially worse fits than the best fitting model, largest $\text{BF}_{10} = 0.26 \pm 5.14\%$. Importantly, the interaction term between the factors of endongenous cue and configuration did not improve the fit of the model, with support for the absence of this interaction, $\text{BF}_{10} = 0.19 \pm 3.88\%$.

When the endogenous cue was removed in the second half of the experiment, RTs were equivalent across the two conditions. An effect of configuration was seen for both cuing conditions, with little discernible difference between the size of the cuing effects. We conducted a Bayesian ANOVA with factors of epoch, configuration and endogenous cue condition (arrow vs. no-arrow). The best fitting model was that with just the factors of epoch and configuration with no interaction between the factors, $\text{BF}_{10} = 1.1\text{x}10^{15} \pm 11.18\%$. There was substantial support for this model over the next best fitting model, $\text{BF}_{10} = 9.83 \pm 11.54\%$. To examine the interaction of the configuration and endongenous cue factors, we compared the model containing those two factors to the model containing the two factors plus the interaction of configuration and endogenous cue, which revealed support for the absence of an interaction, $\text{BF}_{10} = 0.12 \pm 2.71\%$.

To provide further support for the absence of the interaction between the factors of configuration type and endogenous cue, the data from across the experiment (epochs 1-10) were analysed with a Bayesian ANOVA with only the factors of configuration and endogenous cue. The best fitting model was that with the two factors and no interaction, $\text{BF}_{10} = 3.6\text{x}10^{51} \pm 1.91\%$. The addition of the interaction term did not strengthen the

267 model, with considerable support evident for the absence of the interaction, $BF_{10} = 0.09 \pm$

268 2.44%.

Discussion

270   Experiment 2 sought to examine whether the presence of a valid endogenous cue

271 would impair the acquisition of a contextual cuing effect. In the first phase, two sets of

272 configurations were trained, one of which was always presented in the presence of the

273 endogenous cue, and one set which was presented without the cue. Overall there was

274 considerable evidence that the cue was processed and acted upon, as response times to the

275 target were much faster on cued trials. However, there was no evidence to suggest that this

276 impaired the acquisition of the configurations on those trials. Similarly, when the

277 endogenous cue was never presented in the final phase of the experiment, the level of

278 contextual cuing was also equivalent between the two sets of configurations. The Bayesian

279 analyses found support for the equivalence of these CC effects.

280   The lack of competition effects seen in Experiment 2 are at odds with some findings

281 in the CC literature (i.e., (Endo & Takeda, 2004; Kunar et al., 2014)), where competition

282 has been seen by more dominant or salient features of the displays. Instead, the findings

283 point towards a more automatic nature to contextual cuing, whereby associations form

284 ubiquitously, so long as they receive the focus of attention at some point within the search

285 process (e.g., T. Beesley and Shanks (2012)).

286   Taken together with the findings of Experiment 1, these data suggest that attention

287 can be initially cued in an endogenous manner, before the underlying search configurations

288 refines this attentional process to facilitate search for the target in repeated configurations.

289 Given that there was equivalent learning of the configurations in the two conditions (cued

290 and uncued) it would suggest that the contextual cuing effect in these tasks is driven

291 largely by the contextual information that is encountered once endogenous cuing has taken

292 place. Experiment 3 explored this hypothesis.

²⁹³ **Experiment 3**

²⁹⁴ Existing data from studies of contextual cuing has pointed towards a localised

²⁹⁵ learning effect for repeated configurations, with those distractors closest to the target being

²⁹⁶ preferentially weighted in the learning process over those located further from the target.

²⁹⁷ For example, Olson and Chun (2002) trained participants with three sets of repeating

²⁹⁸ configurations that differed in terms of which distractors repeated across trials. For one

²⁹⁹ set, the entire global context (all of the distractors) repeated, while for the other two sets

³⁰⁰ only the short-range (those close to the target) or the long-range distractors (those far from

³⁰¹ the target) repeated across trials. They found no difference between the CC effect in the

³⁰² short-range and global configurations, while the CC effect was not significant for the

³⁰³ long-range context. Similar results have been shown by (**brady2005?**) which led to the

³⁰⁴ development of the spatial constraints model of contextual cuing.

³⁰⁵ It is important to note how the bias towards local learning may interact with the

³⁰⁶ attentional scanning process during contextual cuing. The analysis of eye-movements

³⁰⁷ during contextual cuing tasks (Tom Beesley et al., 2018; Tseng & Li, 2004) has revealed a

³⁰⁸ characteristic scanning pattern comprising two phases: search initially occurs in a

³⁰⁹ seemingly random manner, as the eyes move between distractors in the central region of

³¹⁰ the distractor field, before then moving in a more directed manner towards the target

³¹¹ position. Contextual cuing appears to result from a cessation of the first (random) search

³¹² phase at an earlier time point in the entire search process, such that processing of repeated

³¹³ distractors will, on average, result in fewer fixations. With respect to the current study, in

³¹⁴ Experiments 1 and 2 we have initially directed attention towards the side of the screen that

³¹⁵ contains the target on cued trials. This will bring about an early cessation of the first

³¹⁶ phase of the search process. From here, however, it seems that eye-movements are still

³¹⁷ facilitated by the repetition of the context.

³¹⁸ To test this characterisation of the interaction between the endogenous cue and the

repeated context, we exposed participants to a the same procedure as used in phase 1 of Experiment 1, which establishes a contextual cuing effect prior to the use of the endogenous cue. In a second phase we then presented the endogenous cue on every trial (as in Experiment 1), but we manipulated the presence of the repeated distractors within the configurations. For each repeated configuration we created two variations: in the "local" configurations, only the distractors in the quadrant containing the target match those from the full repeated configuration, while the distractors in the other three quadrants were randomly arranged on each trial; in the "global" configurations, the distractors closest to the target were randomised, while the distractors in the other three quadrants were the same as those in the full repeated configuration. During this phase we also presented fully repeated configurations and fully randomised configurations. Comparison of the response times across these four trial types will allow us to determine the contribution of local and global distractors to the CC effect in this task.

Method

Participants

Forty-two undergraduate students from Lancaster University were recruited (mean age = 18.64, SD = 2.84; 28 identified as male and 12 as female) via the Psychology Research Participation System in the Department of Psychology at Lancaster University, in return for the opportunity to use the recruitment system for their own research in future years.

Materials

The materials and stimuli were identical to Experiment 1.

Design

The design of phase 1 was identical to Experiment 1, with four repeated configurations created and presented with random configurations during this phase. For

³⁴⁴ Phase 2, each of the four configurations was manipulated to create two alternative

³⁴⁵ conditions. In the "Repeated global" condition, the four distractors in the target quadrant

³⁴⁶ were randomly arranged on each trial, while the 12 distractors in the other three quadrants

³⁴⁷ were presented in the same positions as had been trained in Phase 1. Thus, slower response

³⁴⁸ times for this condition (compared to the fully repeated configurations) would indicate the

³⁴⁹ extent to which participants CC was governed by the distractors closest to the target. For

³⁵⁰ the "Repeated local" condition, the four distractors in the target quadrant were presented

³⁵¹ in the same positions as had been trained in Phase 1, while the 12 distractors in the other

³⁵² three quadrants were randomly arranged on each trial. Thus, slower response times for this

³⁵³ condition (compared to the fully repeated configurations) would indicate the extent to

³⁵⁴ which CC was governed by the distractors further from the target.

³⁵⁵ *Procedure*

³⁵⁶ The procedure was identical to Experiment 1. Participants received 160 trials

³⁵⁷ without the endogenous cue and then 160 trials with the endogenous cue. Rest breaks

³⁵⁸ occurred every 80 trials.

³⁵⁹ **Results**

³⁶⁰ Our criteria for removing outlier data were identical to Experiment 1. On average,

³⁶¹ trials ended with a timeout on 2.81% of trials (SD = 2.25). Two participants had an

³⁶² usually high proportion of timeouts. The mean accuracy of participants (not including

³⁶³ timeout trials) was 96.09% (SD = 8.57%). Two participants that had an unusually low

³⁶⁴ proportion of accurate trials and were also removed. Zero participants were deemed to be

³⁶⁵ an outlier in terms of mean RT.

³⁶⁶ For the remaining thirty-eight participants we removed trials with a timeout and

³⁶⁷ inaccurate trials, before removing outliers from the RT data. On average, the proportion of

³⁶⁸ outliers removed was 3.17% (SD = 0.71%). zero participants had an unusual proportion of

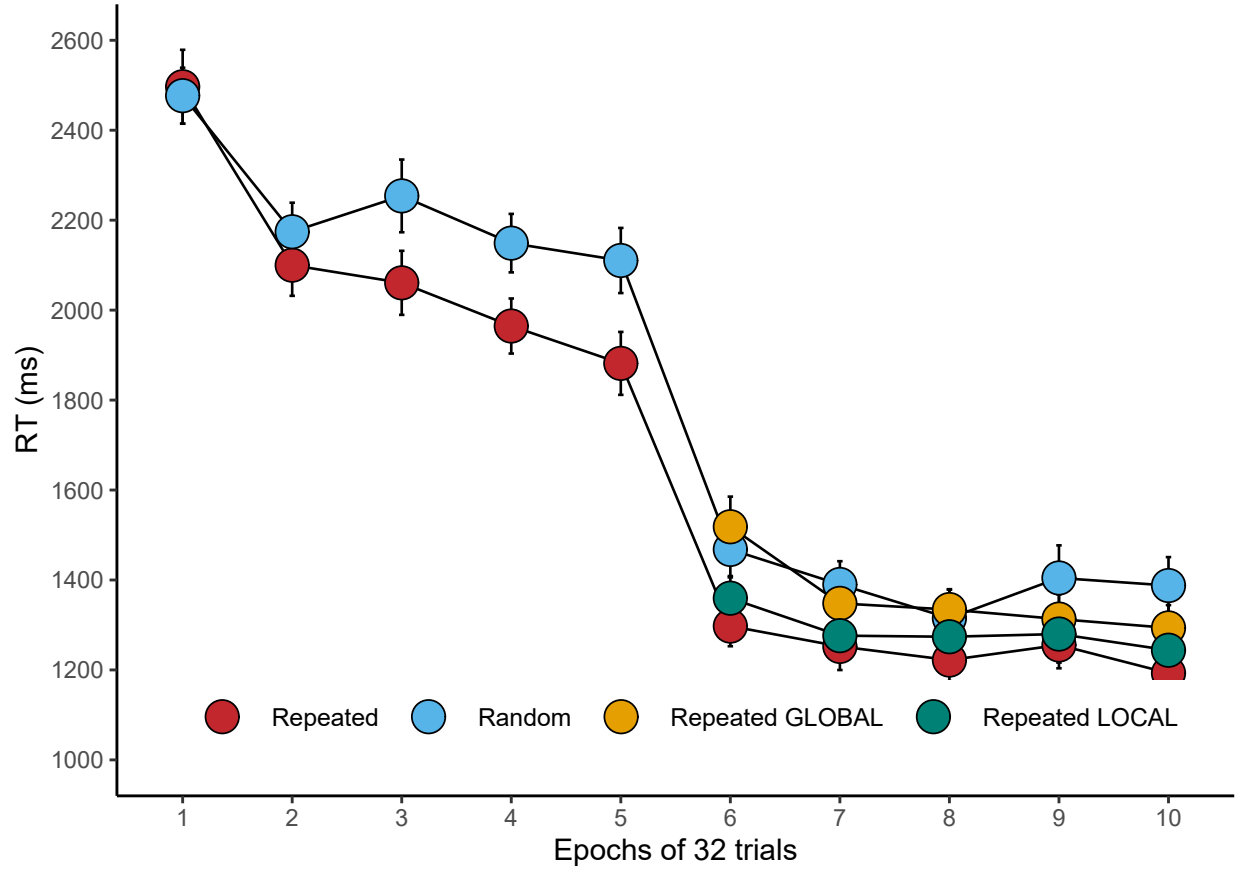³⁶⁹ trials removed as outlier RTs and were not included in the final analysis [EAF4S].

Figure 3

(ref:Exp3-RT-figure)

₃₇₀   Figure 3 shows the RT data across the 10 epochs of Experiment 3. As in Experiment

₃₇₁ 1, contextual cuing was readily established in Phase 1. These data were subjected to a

₃₇₂ Bayesian ANOVA which revealed that the best fitting model was that with the factors of

₃₇₃ configuration (repeated vs. random) and epoch, and an interaction between those factors,

₃₇₄ $BF_{10} = 5.4x10^{24} \pm 2.11\%$. However, the model without the interaction provided a strong

₃₇₅ fit to the data, $BF_{10} = 5x10^{24} \pm 1.3\%$, and a comparison between the two models did not

₃₇₆ find significant evidence in support of the interaction term, $BF = 0.92 \pm 2.48\%$. The best

₃₇₇ fitting model was substantially supported over the remaining models, smallest $BF =$

₃₇₈ $3954.62 \pm 2.18\%$, providing considerable support for the factors of epoch and configuration.

₃₇₉   The response times decreased significantly with the presentation of the valid

380 endogenous cue in Phase 2. Response times to the fully repeated configurations were

381 somewhat comparable to those when just the local repeated distractors were present.

382 Response times for the globally repeated distractors appeared to be slower and comparable

383 to the fully random configurations. The Phase 2 data were subjected to a Bayesian ANOVA

384 which found that the best fitting model contained the factors of configuration and epoch

385 but no interaction between the factors, $BF_{10} = 1.5\text{x}10^{14} \pm 1.98\%$. This model provided a

386 superior fit to the data compared to the next best fitting model that included the two

387 factors and the interaction term, $BF = 128.69 \pm 2.13\%$, providing strong support for the

388 contribution of the two factors and the absence of an interaction between the two factors.

389   To explore the differences in response times across the four trial types, the data were

390 averaged across the 5 epochs, and Bayesian ttests were run for all pairwise comparisions

391 using BayesFactor::ttestBF with the default Cauchy prior. The response times to repeated

392 and repeated-local configurations were both faster than those to random configurations,

393 smallest $BF_{10} = 10313.81 \pm 0\%$. In contrast, there was no evidence that the response times

394 to repeated-global configurations were different from those to random configurations, BF_{10}

395 $= 0.39 \pm 0.04\%$. Response times to repeated configurations were faster than those to

396 repeated-local configurations, $BF_{10} = 4.67 \pm 0\%$. Response times to repeated-local

397 configurations were faster than those to repeated-global configurations, $BF_{10} = 31.88 \pm 0\%$.

References

Beesley, Tom, Hanafi, G., Vadillo, M. A., Shanks, David. R., & Livesey, E. J. (2018). Overt attention in contextual cuing of visual search is driven by the attentional set, but not by the predictiveness of distractors. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*(5), 707–721. https://doi.org/10.1037/xlm0000467

Beesley, T., & Shanks, D. R. (2012). Investigating cue competition in contextual cuing of visual search. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(3), 709–725. https://doi.org/10.1037/a0024885

Beesley, Tom, Vadillo, M. A., Pearson, D., & Shanks, D. R. (2015). Pre-exposure of repeated search configurations facilitates subsequent contextual cuing of visual search. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(2), 348–362. https://doi.org/10.1037/xlm0000033

Cousineau, D. (2005). Confidence intervals in within-subject designs: A simpler solution to Loftus and Masson's method. *Tutorials in Quantitative Methods for Psychology*, *1*(1), 42–45. https://doi.org/10.20982/tqmp.01.1.p042

Endo, N., & Takeda, Y. (2004). Selective learning of spatial configuration and object identity in visual search. *Perception & Psychophysics*, *66*(2), 293–302. https://doi.org/10.3758/BF03194880

Kunar, M. A., John, R., & Sweetman, H. (2014). A configural dominant account of contextual cueing: Configural cues are stronger than colour cues. *Quarterly Journal of Experimental Psychology (2006)*, *67*(7), 1366–1382. https://doi.org/10.1080/17470218.2013.863373

Olson, I. R., & Chun, M. M. (2002). Perceptual constraints on implicit learning of spatial context. *Visual Cognition*, *9*(3), 273–302. https://doi.org/10.1080/13506280042000162

Tseng, Y.-C., & Li, C.-S. R. (2004). Oculomotor correlates of context-guided learning in visual search. *Perception & Psychophysics*, *66*(8), 1363–1378. https://doi.org/10.3758/BF03195004