Is it possible to control contextual cuing during visual search tasks, or does it guide search automatically despite alternative instruction?

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The work submitted in this report is my own and has not been submitted in substantially the same form towards the award of another degree or other qualifactory work by myself or any other person. I confirm that acknowledgement has been made to assistance given and that all major sources have been appropriately referenced.

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The research documented in this report received ethical approval on: 18/10/2018

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Abstract

The contextual cuing effect (CCE) refers to how visual search is aided by implicitly learned associations between a target object and its surrounding environment, after repeated exposure to it. This study aims to investigate whether this CCE is automatic and cannot be controlled, and continues to guide search despite explicit instruction to search elsewhere. A secondary aim is to examine whether participants are consciously aware of having seen some configurations multiple times. 31 students completed a simple visual search task to elicit the CCE, where their reaction times were recorded to ensure this was the case. In the second phase of the task, an arrow explicitly directed their search to the target, which in repeated trials was either in an expected or unexpected location. This was to determine the effect of explicit instruction on the CCE. There was then an awareness test to see if participants could identify which configurations they had been exposed to in the previous phases. Results showed that participants were unable to control their search to the expected target location, despite explicit instruction directing them to an unexpected location. Results of the awareness test revealed that participants were not aware of which configurations were repeated or random. This suggests the CCE has an implicit and automatic influence that cannot be controlled.

Keywords: contextual cuing, visual search, automatic, awareness.

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Objects in our environment never occur alone but instead exist in a global context with other objects, all of which our visual system uses to provide information to aid our visual search. Generally, objects in a familiar environment can be located more quickly and accurately than those in an unfamiliar environment, because humans implicitly learn the relationships between the context and the target object (Oliva & Torralba, 2007).

Human cognition is composed of two different types of processing, controlled and automatic, according to the dual processing theory (Schneider & Shiffrin, 1977). Most behaviours that require skill are composed of multiple different actions occurring at the same time, for example playing the guitar or driving a car. At first, learning a new skill requires effortful processing and consciously controlled actions. With practice over time, these skills develop to a point where conscious focus is not required, but instead they can be easily carried out automatically (Shiffrin, 1988). For example when first learning to drive a car, each individual action is consciously controlled and processed, like using the pedals, changing gear, or indicating. However after much practice, each step does not need to be consciously considered and controlled, allowing these actions to become automatic.

This shift from a controlled behaviour to an automatic behaviour is related to the redistribution of attention. Attention is a cognitive function which involves excluding irrelevent features of a complex environment and inhibiting their conscious cognitive processing, while identifying relevent features to be processed instead (Vecera & Rizzo, 2004). In terms of the dual processing theory of attention, controlled processing involves consciously guiding attention towards a stimulus, in order to acknowledge and interact with it. This can occur in novel situations, meaning previous knowledge of such is not required.

Automatic processing refers to how attention can be guided to a stimulus in response to a specific, familiar environment or situation, which does not require active initiation or control. Automatic processing is related to long-term memory, as this automatic response must be learned and developed over time (Schneider & Shiffrin, 1977).

Stroop (1935) began looking into the automaticity of human attention processes using his Stroop test, which involves colour words (for example ‘blue’ or ‘yellow’) written in different colours (for example in red or purple ink). He found that people could respond with ease to what the word said, whereas took longer to respond to the colour of the word. Word reading is an automatic process which does not require attention, occuring quickly and effortlessly, and is difficult to inhibit. Colour naming is not as much of an automatic process, and requires controlled processing and attention to perform. Therefore the difficulty in controlling the automaticity of word reading explains why people found it harder to selectively attend to the colour of the word while ignoring the word itself. This demonstrates the role that attention plays in terms of automatic and controlled processes during visual tasks.

It is clear that automatic processes, specifically the automatic direction of attention, plays a large roll in human cognition. If a process is automatic and therefore does not require attention to perform, this implies that it occurs implicitly. It has since been investigated as to whether such automatic responses can not only occur implicitly, but whether automatic responses can be learned in this way too. And if so, whether the information learned is also implicit, or whether it is consciously accessible in awareness. Implicit learning is defined as incidentally gaining knowledge about complex associations, without the expectation of learning anything, and without being consciously aware of the knowledge that has been gained (Seger, 1994). This way of learning allows for attention to focus on only the essential aspects of a situation, with the large amount of non-vital information being acquired outside of awareness, and thus not overloading conscious attention (Shiffrin, 1988). This relates to the idea that human cognition, specifically learning and memory, is composed of an explicit system, which contains information which can be consciously recalled, and an implicit system, which unconsciously and automatically influences behaviour (Squire, 1992).

Tasks demonstrating implicit learning generally ensure participants focus their attention on one aspect of a task, and monitor their behaviour to identify whether they are learning anything about a different aspect of the task that they are not focused on (Seger, 1994). An early study of implicit learning done by Greenspoon (1955) asked participants to list all words that came into their head. The experimenter responded ‘mmm-hmm’ every time the participant said a plural word, which they found increased the number of plural words listed during the 50 minute task. This effect was present even in those who reported being unaware of this reinforcment occurring, despite their plural word listing increasing. This demonstrates how automatic learning can occur implicitly during tasks where attention is focused on a different element.

It was Chun & Jiang (1998) who found that our visual search of the familiar is guided by implicitly learned associations between a target object and the spatial arrangement of the global context, which provides an advantage in terms of locating the target. They called this the contextual cuing effect (CCE). For example, we might learn where to find our mobile phone charger in our bedroom, as we learn it is next to the bedside table, which is next to the bed, which is to the left of the door. The CCE can be demonstrated using a simple visual search task of locating a target object in a display filled with distractor objects. The time it takes to find the target decreases when configurations are repeated, even though many participants claim to be unaware of having noticed any configurations repeating at all. This learning happened incidentally, as participants were not told to learn anything, nor were they aware of having done so. This suggests that automatically learning the context around a target guides our attention and search implicitly, allowing us to locate the target more quickly.

Since the original studies, the CCE has been investigated many times. An aspect which is disagreed upon is whether contextual cuing is genuinely implicit, or whether participants have a more explicit awareness of repeated configurations than originally reported. In CCE tasks, there are ways to test whether participants have been consciously or implicitly learning the configurations. These include asking participants to predict the location of the missing target in repeated configurations, or making recognition judgements about whether they are familiar with a configuration or not. Participants generally perform at chance level, which researchers claim means that they are not aware of having learned about the configurations (Smyth & Shanks, 2008).

Chun & Jiang (2003) followed-up their original studies by testing how implicit contextual cuing actually is, and concluded from the second of their three experiments that knowledge and memory of the learned configurations was not consciously accessible, even when participants were explicitly told to try to remember them. This indicates that contextual cuing in visual search produces implicit knowledge, which has been found in a large number of other studies too (Chun & Jiang, 1998; Park, Quinlan, Thornton, & Reder, 2004; Manns & Squire, 2001).

However, Smyth & Shanks (2008) criticised these studies, claiming previous awareness tests are not sensitive enough to measure whether or not memory and learning in CCE tasks is implicit. They argued that an awareness effect would have to be large in order to be detected in the small number of trials in the awareness tests in previous experiments, and that therefore the awareness tests in many studies are not powerful enough to detect the small amount of explicit awareness that may exist. They claimed that there should be a much greater number of trials to increase sensitivity to an effect. Their first experiment confirmed this, finding that participants displayed explicit awareness of knowledge learned during the study, when tested using a large number of trials in the awareness test.

The awareness test used by Smyth & Shanks (2008) in their first experiment was a generation task, where the target had been removed from the configuration and replaced with a distractor, then presented to participants to guess which quadrant of the display the target previously appeared in. Another method used to measure awareness is the detection task, which asks participants to make a recognition judgement about whether they have seen the configuration before or not. Smyth & Shanks (2008) criticised the generation task because of the range of strategies possible for deciding which distractor was previously a target, while attempting to use knowledge of configurations that participants may not feel they have if it is an implicit effect. Whereas in the detection task, participants search for the target quickly and decide if the configuration is familiar or not. The latter is more similar to the original task of responding to the orientation of the target, and so may be deemed more suitable in studies of this sort.

Smyth & Shanks (2008) concluded that participants are able to access knowledge and memory of the tasks, thus the supposedly implicit contextual cuing experiments might not be as implicit as previously thought. A similar conclusion had been reached in the earlier study by King, Shim, & Jiang (2005), which found that people do have a small amount of explicit awareness and memory of repeated scenes, however they suggested that visual search is facilitated by implicit learning. On the other hand, a study which theoretically and empirically investigated three large samples found strong evidence against the association between the CCE and recognition of learned configurations. The researchers interpreted this as evidence for an implicit learning system responsible for contextual cuing (Colagiuri & Livesey, 2016).

As discussed, there is a large body of evidence debating the awareness of knowledge learned during visual search tasks. Much points towards the CCE in visual search as implicit learning of the context, which is inaccessible to conscious awareness. It is also clear that learned behaviours can occur automatically, without the need for conscious control or to consciously direct attention. This can sometimes occur even when there is an attempt to inhibit or suppress such automatic behavioural responses, as demonstrated by Stroop (1935). It therefore ought to be considered that, if this contextually cued knowledge is implicit and there is no awareness of learning, whether the guidance it provides during visual search tasks is automatic.

Luque, Vadillo, Lopez, Alonso, & Shanks (2017) recently conducted a study to find out whether contextual cuing is controllable in visual search; whether it can be overridden by top-down attentional processes when directed to one area, or whether despite this, the underlying learned associations between the target and the environment still automatically guide search. Their three experiments all involved firstly eliciting the CCE by locating and responding to the orientation of a target 'T' in distractor 'L' shapes and a 'Y' shape. In their third experiment, participants then had to find the previously present 'Y' shape and report whether it was orientated to the left or right, after being told explitily it would appear in one of two locations, some in repeated configurations and some in random configurations. The configurations were either congruent, where the 'T' and 'Y' were the same orientation, or incongruent, where the 'T' and 'Y' were different orientations. They were looking to see whether the congruency of the 'T' and 'Y' targets affected the reaction times for responding to the orientation of the 'Y'. Specifically, whether congruency increased reaction time.

Their hypothesis was that, if the CCE is driven by automatic processes, then a congruency effect should be observed, in which reaction times to the congruent trials were quicker than incongruent trials. This would indicate attention towards the old target location in repeated configurations, despite explicit instruction to look elsewhere,. This would suggest that the CCE in visual search can not be controlled, and instead automatically guides our search and attention. However they found no evidence to suggest that visual search could not be controlled. They claimed that once search is controlled by explicit instruction, there is no automatic influence of the repeated configuration or the CCE on reaction times.

In their study, a possible reason for finding no influence of the CCE is that their phase one and phase two tasks were different. In phase one, participants were searching for a ‘T’, whereas in phase two they were searching for a ‘Y’. It could be that because the context primes our search to a particular object, and in their second task participants were searching for a different object, there may no longer be an influence of the configuration because the goal had changed. This is supported by the earlier findings of Conci, Sun, & Muller (2011), who reported that changes in target location greatly decreased the CCE, suggesting that a change of target identity as well as target location would have a similar influence on the CCE.

The current study aims to provide a further test of the controllability of contextual cuing in visual search, building upon the study and findings of Luque et al (2017). The first phase of this study involved eliciting the CCE. Participants were required to locate a target in a display of distractors in every trial. For half of the trials, the same four configurations were repeated throughout, and the other half were randomly generated configurations. The aim of this first phase was to familiarise participants with the set of four repeated configurations, and ensure their reaction times for such were significantly quicker than for the random configurations, indicating they had developed a sufficient CCE. The second phase involved a similar task of searching for a ‘T’ shape in ‘L’ shapes, but instead there was an arrow before each configuration, showing participants which side of the screen the target would appear on. As well as random trials, half of the repeated ones had the target in the same place as in the first phase (congruent configuration), whereas the other half of the repeated trials had the target in the diagonally opposite position of the display (incongruent configuration). This was to test whether, even with the inclusion of the arrow, participants would still be using some contextual cuing knowledge gained in the previous phase to direct their attention and search.

Here, the search target and goal remained the same throughout the experiment. When the same task is maintained across the different phases of the experiment, it is hypothesised that there will be an automatic effect of contextual cuing for finding the target that cannot be controlled. This is because it is assumed that the reason for the Luque et al (2017) finding, that the CCE is controllable, was due to their experiments involving different search targets in different phases of the experiment. This contrast in task requirement may be interrupting the CCE and thus it does not have an effect on search. Participants in the current study were expected to be quickest at locating the target in congruent trials, followed by random trials. It was expected that they would have the slowest reaction times for incongruent trials, due to the conflicting information from the previously learned, automatic contextual cuing, and the arrow. This would suggest an effect of the conflict between the contextually cued information and the explicit instruction. Specifically, this may indicate the automaticity of contextual cuing information guiding search, despite explicit instruction to search elsewhere.

The final part of the study was an awareness phase, which aimed to identify whether participants could differentiate repeated configurations from random ones. Participants were presented with one configuration at a time, either one of the four repeated configurations, or one of four random configurations, which were all repeated multiple times in this phase. Participants had to respond whether they thought the configuration was random or repeated, to examine whether they were consciously aware of having seen configurations repeating throughout the experiment, or whether they had implicitly learned about the locations of the target without being aware of even having seen them before. It was expected that this test would reveal an implicit knowledge of configurations, because the method used to detect such is similar enough to the original tasks in the first and second phases to elicit an accurate measure of awareness. Importantly, this will contribute further evidence to the debate of how implicit the CCE is, alongside whether awareness of repetitions is associated with quicker reaction times for repeated configurations, compared to those who were less aware of repetitions, which Colagiuri & Livesey (2016) reported was not the case.

Method

Participants

31 participants took part in this study, consisting of 14 males (45%) and 17 females (55%). All were undergraduate students from Lancaster University aged 18-23 (M_{age} = 20.13, SD_{age} = 1.09). There were 26 right handed people (84%) and five left handed people (16%), and all but one participant reported English as their native language.

Participants were recruited using both opportunity sampling, selecting those available at the time by asking them if they would like to take part, and by volunteer sampling using Sona System, the Psychology Research Participation System in the Department of Psychology at Lancaster University. Those registered with Sona System can choose to participate in studies they see advertised there. Participants who were recruited in this way were awarded one course credit for taking part.

Materials

The experiment was carried out using 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. The study was run with a custom made programme controlled by MATLAB using Psychophysics Toolbox extensions (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997).

The programme involved generating configurations of 16 distractor ‘L’ shaped objects at either 0º, 90º, 180º or 270º orientations, with one target ‘T’ shape rotated either 90º to the left or right. The ‘T’ and ‘L’ shapes both were 12mm high by 12mm wide. One of the two lines of the ‘L’ shapes were offset by 1.5mm, so they look more similar to a ‘T’ usual, as can be seen in Figure 1. This makes the task slightly more difficult, and slows down search time. All of the shapes were black on a grey background. The fixation cross before each trial was 6mm high by 6mm wide, also coloured black.

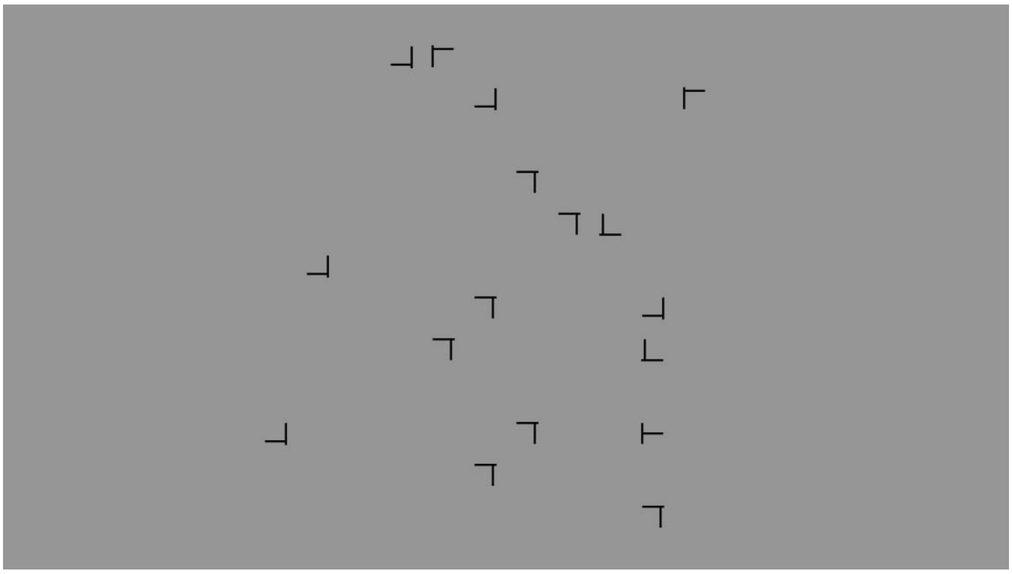

Figure 1. An example configuration.

The first phase consisted of 160 trials, in blocks of eight trials. In each block, there were four configurations which were repeated throughout the experiment, and four configurations which were randomly generated each time, comprised in the same way with one target and 16 distractors. The target could appear in one of 20 locations, as indicated by the yellow squares in Figure 2, and the distractors could appear in any of the white squares. There were four repeated configurations throughout, as Smyth & Shanks (2008) found that there was only a reaction time benefit for two to four configurations, and more had little to no CCE present. See Figure 1 for an example configuration.

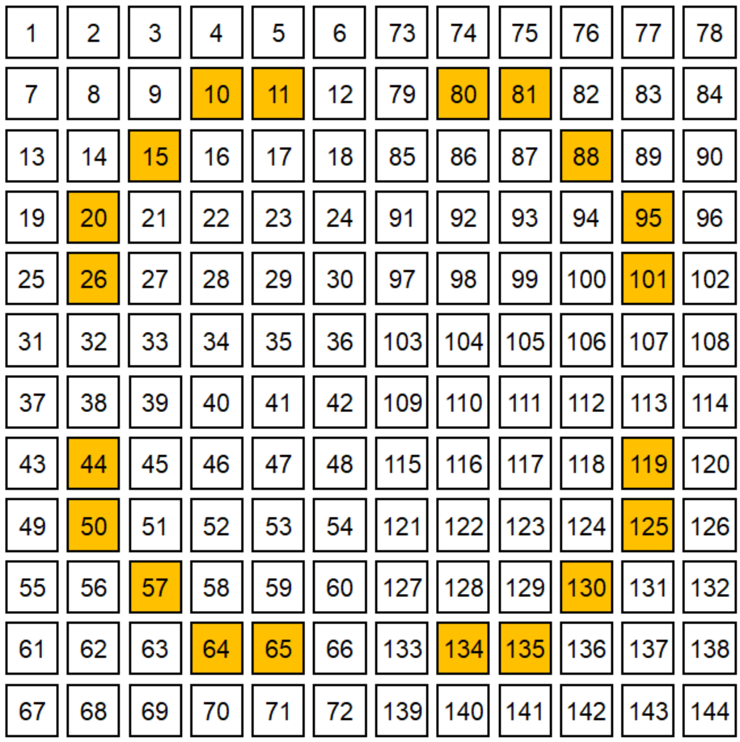

Figure 2. Possible target (in yellow) and distractor (in white) locations.

The second phase was an almost identical format, with 160 trials in blocks of eight, with the four repeated configurations and four randomly generated configurations in each. This phase had the addition of an arrow in the centre of the screen before each trial. The arrow was 6mm wide by 6mm high, and was rotated to point either to the left or right, to indicate which side of the screen the target would appear on. For each repeated trial in the second phase, the programme decided with a 50/50 chance whether the target would be in its usual, congruent position, or whether it would appear in the mirror opposite, incongruent position. For example, if the target on a repeated trial usually appeared in the top left hand corner at position 10, as an incongruent trial it would be flipped to appear in the bottom right at position 135 in Figure 2.

The awareness part of this study consisted of 32 trials in blocks of eight trials. In each block, there were the four repeated configurations from previous phases. The other trials in each block were a set of four new, randomly generated trials which were kept constant throughout this phase. Each of these configurations had the same structure as previous phases, with one target present in one of 20 locations, and 16 distractors. The four random trials were repeated across the blocks in this phase, to see whether participants were aware of having seen the repeated configurations in previous phases, and whether they could differentiate them from the random ones.

Design

This experiment has a within participant design, where all participants took part in all parts of the study. The dependent variable in the first and second phases was reaction time. The independent variables for the first phase were the block number, and the trial type; random or repeated. The independent variables for the second phase were also block number and trial type, which were either congruent, incongruent, or random configurations. For the awareness test phase, the independent variable was the trial type, whether it was a repeated or random configuration, and the dependent variable was accuracy of identifying which it was.

Procedure

At the beginning of the study, participants were given the information sheet and consent form to sign, and the opportunity to ask any questions. Participants were informed that they were taking part in a visual search task. Importantly, no mention was made of some configurations repeating many times throughout the study, as this likely will have affected the results. All data was anonymised.

Participants were given instructions for the first phase of the study, with a screen shot of an example trial to ensure participants completely understood the instruction, as in Figure 1. They were told to find the target and respond quickly and accurately using the keyboard, pressing the ‘c’ key with their left index finger if the target is rotated to the left, and the ‘n’ key with their right index finger if the target is rotated to the right. They were given another opportunity to ask any questions, and then the experimenter began the study when the participant was ready.

A fixation cross appeared in the centre of the screen for half a second before the configuration appeared. This was either one of four repeated configurations, or a randomly generated configuration. Participants had six seconds to locate the target and respond to its orientation correctly, and their response times were recorded. If they took longer than six seconds, a ‘TIMEOUT’ message was displayed for three seconds before resuming the study. If the participant answered incorrectly, an ‘INCORRECT RESPONSE’ message was displayed for three seconds before the study resumed. After this, or after a correct response, there was a one second inter-trial interval, then the fixation cross reappeared before the next configuration appeared. This continued for 160 trials with a 30 second rest break every 60 trials.

After trial 160, another instruction screen was shown explaining the next phase of the study. It explained that after the fixation cross, an arrow pointing to either the left or the right would appear in the centre of the screen, instructing participants on which side the target will appear. This arrow was valid on every trial, always pointing to the side of the target, and was displayed for one second before it disappeared and the configuration appeared. The participants were told to respond in the same way as last time, with the ‘c’ key if the target was rotated to the left, and the ‘n’ key if it was rotated to the right. When the participants were ready, the experimenter started this second phase. Each trial was either a random configuration or a repeated configuration with either a congruent or incongruent target. As previously, ‘INCORRECT RESPONSE’ and ‘TIMEOUT’ messages were displayed for three seconds when necessary. Participant response times were recorded for the 160 trials of this, with a 30 second break every 60 trials, and an inter-trial interval of one second.

Once these had been completed, participants were told that some of the configurations were repeated throughout the study and that they may or may not have noticed this. They were then told that for the next phase, the awareness test, they will view each configuration for five seconds. They would then have ten seconds to respond with the up and down arrows with their index fingers, depending on whether they thought the configuration was a repeated one or random one. If they did not respond within ten seconds, a 'TIMEOUT' message was displayed for three seconds before moving on to the next trial. There was an inter-trial interval of one second, with a fixation cross displayed for half a second, before the next trial appeared. There were 32 trials in this phase, consisting of either a repeated, congruent configuration or one of a set of four random configurations. Reaction time data was not relevant at this stage. Once this was finished, the experiment was complete. The participant was then debriefed, and the study and its aims were fully explained, before offered another opportunity to ask any questions. The whole experiment took approximately 30 minutes per participant.

Ethics Statement

Ethics approval was granted for this study on 18th October 2018 by Lancaster University Psychology Department Ethics Committee.

Results

When examining response time data for the first and second phases, incorrect responses and time-outs were removed from analysis, and mean reaction times for blocks of 32 trials were created. Generally, the results show a trend of reduced reaction times across blocks, especially after the introduction of the arrow which directed search to one side of the display. Specifically, participants became quicker at locating the target in repeated trials than random trials, as can be seen in Figure 3.

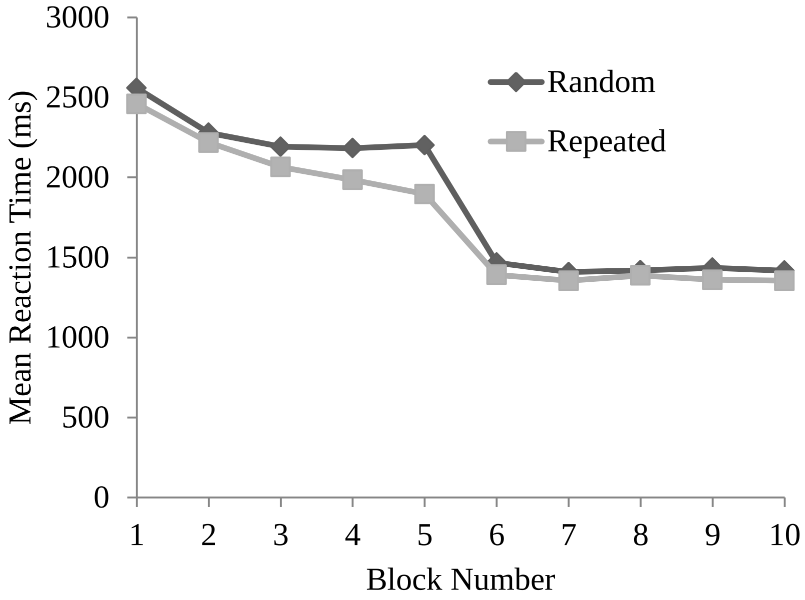

Figure 3. Mean reaction times across blocks for random and repeated configurations in the first and second phases combined.

The first phase of this study was analysed using a 2x5 Within-Subject Factor ANOVA with Configuration Type (two levels: Repeated and Random) and Block Number (five levels: 1-5) as independent variables. There was a significant main effect of block number on reaction time, $F(4,120) = 22.87$, $p<.001$. Participants were quicker at locating the target and responding to its orientation in later blocks compared to earlier blocks. See Figure 3 for the mean reaction times of block number 1-5. There was also a significant main effect of configuration type on reaction time, $F(1,30) = 17.51$, $p<.001$. A paired-samples t-test was conducted to compare the mean reaction times for repeated configurations and random configurations. There was a significant difference in the scores for repeated (M = 2125ms, SD = 403.54) and random configurations (M = 2283ms, SD = 380.98), $t(30) = -4.18$, $p<.001$. Participants showed a CCE: they were generally faster at locating the target and responding to its orientation in repeated configurations compared to random configurations, as demonstrated in Figure 3. There was no significant effect of the interaction between block number and configuration type, $F(4,120) = 2.27$, $p=.05$. These phase 1 results indicate that the CCE was present, as participants could locate the target quicker on repeated configurations than random configurations, and quicker on later trials than earlier trials.

For the first and second phases of this study combined, a 2x10 Within-Subject Factor ANOVA was run, with Configuration Type (two levels: Repeated and Random) and Block Number (ten levels: 1-10) as independent variables. There was a significant main effect of block number on reaction time, $F(9,270) = 107.23$, $p<.001$. Participants generally were quicker at locating the target and responding to its orientation in later blocks compared to earlier blocks. See Figure 3 for the mean reaction times of block number 1-10. There was also a significant main effect of configuration type on reaction time, $F(1,30) = 23.92$, $p<.001$. A paired-samples t-test was conducted to compare the mean reaction times for repeated configurations and random configurations. There was a significant difference in the scores for repeated configurations (M = 1747ms, SD = 329.85) and random configurations (M = 1856ms, SD = 321.75), $t(30) = -4.89$, $p<.001$. Participants were generally quicker at locating the target and responding to its orientation in repeated configurations compared to random configurations, as demonstrated in Figure 3.

The interaction between block number and configuration type was significant, $F(9,270) = 2.26$, $p=.019$. Analysis of the simple main effects showed that there are two causes for the interaction; how configuration type influenced reaction times differently in different blocks, and how block number influenced reaction times differently for different configurations. Block number significantly affected reaction times for both repeated configurations, $F(9,270) = 70.18$, $p<.001$, and random configurations, $F(9,270) = 81.77$, $p<.001$. Reaction times generally decreased across the 10 blocks in both of these cases. The difference between reaction times for repeated and random configurations can be seen in Figure 4. It demonstrates how the differences between reaction times greatly increased during the first phase, when repeated configurations were being learned and responded to more quickly than random ones, and then how the difference decreased during the second phase with the inclusion of the arrow. This shows how the effect of configuration was greater towards the end of the first phase than at the start, as anticipated through learning of the configurations, before the difference becomes smaller in the second phase.

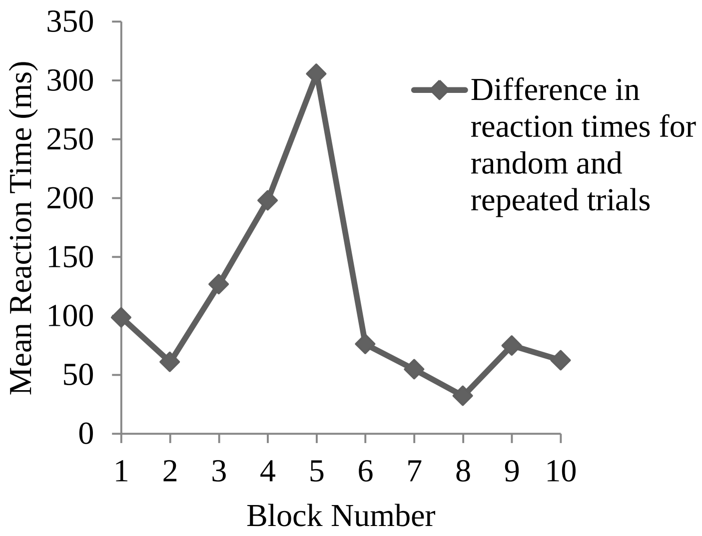

Figure 4. Mean difference between random configuration reaction times and repeated configuration reaction times across blocks in the first and second phases.

As evident from Figure 3, there is a large change in reaction times at the beginning of the second phase, from block five to block six, at the point at which the arrow was introduced. Mean reaction times for configurations in block five was compared to configurations block six using a paired-samples t-test. There was a significant difference in the reaction time for block five (*M* = 1653ms, *SD* = 353.10) and block six (*M* = 1429ms, *SD* = 325.23), $t(30) = 4.92$, $p<.001$. From this, it is clear how the inclusion of the arrow assisted participant search and sped up their reaction time for locating the target.

In the second phase of the experiment, there were three types of configuration: congruent, incongruent, and random. A 3x5 Within-Subject Factor ANOVA was run with

Configuration Type (three levels: Congruent, Incongruent, Random) and Block Number (five levels: 1-5) as independent variables. Here, the analysis was done on the congruent and incongruent trials as separate groups, alongside the random trials, to compare the reaction times for each. There was a significant main effect of configuration type on reaction time, $F(2,60) = 10.28$, $p<.001$, however there was a non-significant main effect of block number on reaction time, $F(4,120) = 0.71$, $p=.588$, and a non-significant interaction between block number and configuration type, $F(8,240) = 0.65$, $p=.734$.

To examine this main effect of configuration type on reaction time, paired-samples t-tests were run to compare the mean reaction times for the congruent, incongruent, and random configurations. There was a significant difference in the reaction times for congruent configurations (M = 1313ms, SD = 318.23) compared to incongruent configurations (M = 1442ms, SD = 378.67), $t(30) = -3.66$, $p=.001$, and also when compared to random configurations (M = 1430ms, SD = 335.13), $t(30) = -4.24$, $p<.001$. Participants were quicker at responding to congruent configurations than incongruent and random configurations. However the paired-samples t-test revealed that the mean reaction times for the incongruent configurations and the random trials did not differ, $t(30) = 0.38$, $p=.707$. See Figure 5.

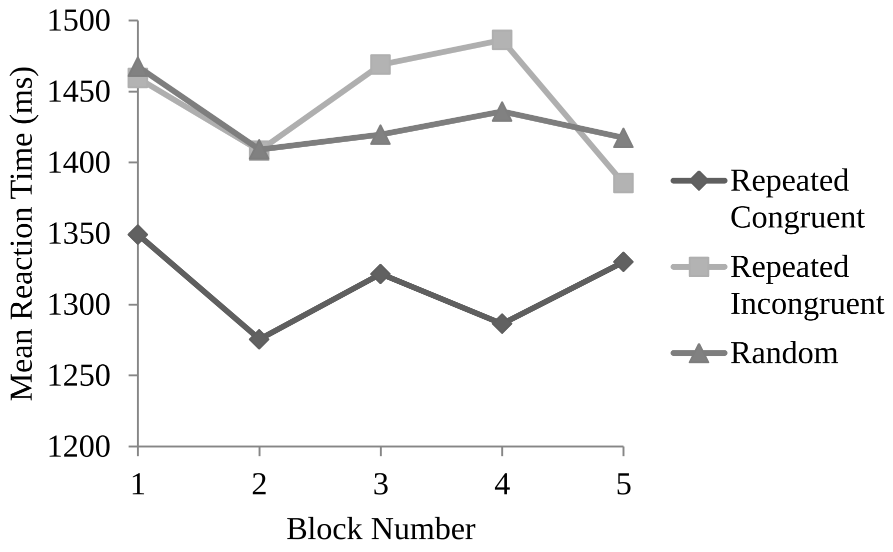

Figure 5. Mean reaction times across blocks for congruent, incongruent, and random configurations in the second phase.

The awareness phase of this task was examining whether participants could accurately differentiate between random configurations and repeated configurations. A paired-samples t-test was conducted to compare participant responses for hits (correctly responding ‘old’) and false alarms (incorrectly responding ‘random’ when it was actually repeated). There was a non-significant difference in the scores for hits (M=0.51, SD=0.17) and false alarms (M=0.49, SD=0.14), $t(30) = 0.74$, p=.467. Analysing the hits and false alarms this way takes into account response bias and allows examination of the ability to discriminate. These results suggest that participants could not accurately tell the difference between random and repeated configurations, and therefore implies that they had implicitly learned the whereabouts of the target in the display of distractors.

An ‘awareness score’ of the number of hits minus the number of false alarms was created for each participant, as was a ‘contextual cuing’ score of reaction times for random configurations minus repeated configurations. A correlation of both of these measures would highlight whether higher scores of awareness are associated with higher scores of contextual cuing, to investigate whether awareness may improve reaction times in locating the target. A Pearson product-moment correlation coefficient was calculated on the relationship between participant awareness scores and participant contextual cuing scores. There was not a significant correlation between the two variables, r_{31}=-.028, p=.883. See Figure 6 for a scatterplot demonstrating this result.

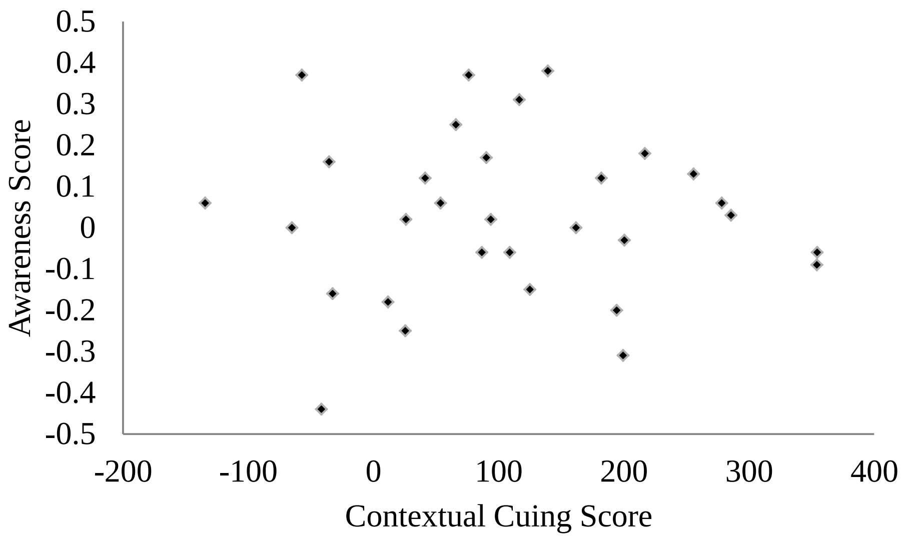

Figure 6. A scatterplot of the correlation between awareness scores (random reaction time minus repeated reaction time) and contextual cuing scores (hits minus false alarms) for each participant.

Discussion

In the first phase of this study, participants had to locate a target in an array of distractors, in random configurations and repeated configurations, to elicit the CCE. In the second phase, participants had to again locate a target in distractors in random configurations, as well as in congruent and incongruent configurations. An arrow appeared before each configuration to indicate which side of the display the target would appear on. Although in some trials the target had switched locations, the task of responding to the orientation of the target remained the same.

In the first phase alone, as well as in the first and second phases combined, participants were quicker at locating the target in repeated configurations than in random configurations. Similarly, they were also quicker at locating the target in later blocks as the study progressed, compared to earlier blocks. The introduction of the arrow in the second phase significantly increased reaction times for finding the target, compared to the first phase.

The reaction times for the congruent, incongruent, and random configurations from the second phase were compared, and analysis revealed that participants were significantly faster at locating the target in congruent configurations than in incongruent and random configurations. There was no significant difference between the reaction times in incongruent and random configurations. As well, there was no significant effect of block number, meaning there was no significant change in reaction time throughout the blocks.

In the awareness phase of this study, participants were presented with the four repeated (congruent) configurations, alongside four new random configurations, and they had to judge whether the configurations were repeated and that they had seen them in the previous phases, or whether they were new, random configurations. Analysis of the awareness test revealed that participants could not significantly differentiate between random and repeated configurations. It was investigated whether there was a correlation between low awareness scores and low CCE scored, however findings suggest no relationship.

When interpreting the results of this study, the increasingly quick reaction times throughout the first phase, specifically for repeated rather than random configurations, demonstrates how the CCE was successfully elicited. The purpose of the inclusion of the arrow in the second phase was to explicitly direct participant search to the half of the display that the target appears on, and to see if their previously learned contextually cued knowledge could automatically override the explicit instruction of the arrow. The findings show that with all configurations, the arrow made reaction times for locating the target quicker. It was the quickest in congruent configurations, whereas incongruent and random configurations were significantly slower, and did not significantly differ from each other.

This finding suggests that the inclusion of the arrow speeds up search in congruent configurations, through halving the area of search and directing attention. This, combined with the learned CCE information from the first phase, makes for a quick reaction time for locating the target. In terms of incongruent configurations, the arrow seems to hinder the search, making it equally as slow as random configurations of which no previous knowledge of target location exists. This could be because although the arrow directs search to the target side of the screen in incongruent conditions, the exposure to the familiar configuration may elicit a CCE, guiding attention and search to the expected location of the target momentarily. This conflict between contextually cued knowledge from the previous phases and the explicit search direction information could be creating a delay in reaction times for locating the target. If this is the case, it suggests that the CCE is not controllable, and is still guiding attention towards where the target previously was, despite the arrow explicitly indicating to search on the other side of the display. This would indicate the hypothesis for this study, that the CCE is automatic and cannot be controlled, can be confirmed.

However the reason for the results could be interpreted differently and conclude that the CCE is in fact controllable. It could be that the incongruent and random configuration reaction times did not significantly differ from each other, and were slower than congruent configurations because the CCE actually had no influence on them. The contextually cued knowledge may have been inhibited and thus controlled so that it did not direct search, and instead participants followed the search instruction in the same way for both the incongruent and random configurations, hence their not significantly different reaction times. If the CCE was interfering with where the participant was searching, their reaction times may have been slower for incongruent configurations than random configurations. However the fact that the random configurations, with no previous or conflicting knowledge of the target location, do not significantly differ in reaction time to the incongruent configurations, suggests that the CCE may not automatically influence search to the expected side. The incongruent and random configurations were slower than congruent configurations, possibly because they did not have both the CCE and arrow to guide their attention to the target. Therefore the CCE may aid search when the target is on the expected, congruent side, but not hinder search when it is on the unexpected, incongruent side.

In order to determine exactly how the explicit instruction of the arrow effects locating the target, eye tracking technology could be used to examine eye movements when searching for the target during incongruent trials. This would indicate how the conflict between the arrow and previously acquired CCE knowledge influences attention and search. It would be able to show whether the arrow is completely overriding any CCE and participants only search for the target on the indicated side, or whether the conflict of information between the arrow and previous CCE knowledge causes participants to search the expected location before the indicated side of the display. If the latter is the case, this would provide stronger evidence for the CCE not being controllable, and that it is used in visual search tasks despite explicit instruction to search elsewhere. If the former is the case, this would instead point towards the CCE being controllable, or at least overridden easily by explicit instruction.

In terms of the awareness phase, results demonstrated that participants could not accurately differentiate between repeated and random configurations that they had never seen before, despite their significantly quicker reaction times for the repeated ones. This suggests that the knowledge of the repeated configurations gained throughout the study was implicit, as participants could not consciously access and report such during this phase, as hypothesised.

However a reason that participants may have not been able to differentiate between repeated and random configurations is because the learned information through the CCE may have broken down due to incongruent trials, as Conci et al (2011) reported can occur. The lack of a target in the expected location may have disrupted the CCE, so when the awareness phase was carried out, participants may have had a much weaker knowledge of the learned configurations after the second phase than they did after the first phase. If this is the case, it is not surprising that participants report no strong awareness of learned configurations. To avoid this CCE degradation, future studies could include another phase of congruent trials after incongruent ones to strengthen the possibly weakened CCE, or they could test awareness before a phase that involves incongruent trials.

Another possible cause of this result is that there are simply not enough trials in the awareness phase to detect the small effect that may exist. Although this study used 32 trials rather than the typical 24, it may still have not been enough. Smyth & Shanks (2008) discussed this and found that upon increasing the number of trials in such awareness phase from 24 to 96, an effect of conscious, explicit knowledge of learned contextually cued knowledge can be seen. In order to examine whether this is the case in this study too, an extended awareness phase should be carried out in future, with a considerably larger number of trials to provide a more sensitive test for detecting a small effect. This would provide further evidence for whether or not the CCE results in implicit knowledge, or whether it is explicitly accessible.

Overall, the results of this study suggest that the hypotheses made have generally been confirmed. Specifically, it was expected that congruent configurations would have the quickest reaction times, followed by random configurations and then incongruent configurations, implying that the CCE is automatic. As well, it was hypothesised that participants would show no explicit awareness of repeated configurations, nor would there be a correlation between high awareness and high CCE. The results showed that this was the case, except random and incongruent trials did not significantly differ in terms of reaction time. From this, it appears that contextual cuing of visual search is an automatic process which can not be controlled, and that the information learned during such tasks is implicit, thus is unaccessible to consciousness. However there ought to be further examination of the processes involved in such, to determine exactly how and why these results occurred, and whether they reflect what processes are truly going on. Similarly, to examine whether a small amount of explicit awareness exisits in contextual cuing, improvements in the number of trials in the awareness test should be made.

In terms of how the results of this study relate to elements of the real world, the finding that information learned through the CCE in visual search tasks is implicit, and cannot be accessed or expressed consciously, provides evidence for Squire's (1992) claims of two separate memory and learning systems. The existence of separate explicit and implicit systems explains the ability that information can be learned in people who may have faulty explicit cognitive processes, as they can still do so using their intact implicit processes.

Eldridge, Masterman, & Knowlton (2002) compared participants with Alzheimer's disease who were suffering from explicit memory deficits, with a control group with intact memory systems. They found no significant differences in performance of implicit memory, although participants with Alzheimer's had no conscious access to what they had learned. The two separate memory systems allows for those with explicit memory and learning deficits to continue to perform daily activities that have been practiced over a long period of time and thus no longer require conscious attention or processing, such as cooking, driving, or playing a musical instrument. Research has found that frequent cognitive activity in older people, such as reading or playing a musical instrument, is associated with reduced risk of developing dementia (Verghese, et al., 2003). This suggests that developing and practicing skills to a point where they can be carried out without conscious processing or attention ought to be encouraged at all ages. This would be not only to attempt to prevent dementia later in life, but also to retain as much independence for as long as possible and continue to enjoy well practiced hobbies if dementia does develop.

As demonstrated from this study, the arrangements of a familiar environment guides attention towards a target. Such environment can become familiar without intentionally learning about it, and the search can happen automatically, without requiring conscious attention to do so. This study has demonstrated that even when the target has changed location in an environment which has remained constant, and there is explicit information directing search to the new location, there is still the implicit CCE guiding attention towards the previous target location automatically.

This implicit effect of carrying out certain behaviours automatically, even in the presence of explicit instruction to do something else, is not just the case in visual search tasks, but occurs in real life too. This has implications for behaviours which are so practiced and automatic that they require a conscious effort to stop or change. An example of this is when trying to change a habit, which is the implicit repetition of a behaviour that has gradually developed through recurrence in a specific context (Wood & Neal, 2007), and thus becomes activated by specific contextual cues, often without consciously realising you are doing it (Neal, Wood, Wu, & Kurlander, 2011). Examples of habits include biting your nails every time you become nervous, or smoking a cigarette to calm down or relax. Findings show that habits are difficult to disrupt and change because of their automatic occurrence, even with frequent reminders to stop them (Neal et al, 2011).

This explains, in terms of real life behaviours, how the explicit instruction of the arrow in this study could be overridden by the learned CCE. Despite alternative instruction, automatic search in the original location still occurred. This has implications for how to best go about stopping habits or other routine behaviours. A further study into the CCE and visual search tasks could investigate if there are any methods that can be undertaken in order to prevent the influence of automatic, learned behaviours overriding explicit instruction. For example, how often an explicit instruction that conflicts the automatic behaviour must be displayed in order for it to be used to guide search instead of the learned CCE. Or similarly, how salient and pronounced an explicit instruction must be to successfully guide search and override the automatic behaviour. This could inform on how best to tackle habits and other unwanted automatic behaviours, to prevent them from occurring. For example, it could ascertain how frequently or explicitly a person might need reminding not to automatically pick up their phone to look at social media while working, smoke a cigarette while they are on a break from work, or bite their finger nails. If this is determined, it could aid the reduction and eventual discontinuation of an undesired habitual behaviour, through attempting to prevent the automatic behaviour from occurring.

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