

Hemispheric Differences in Contextual Cuing

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Abstract

Contextual cuing refers to the effect of implicit learning on the deployment of attention in visual search task and is based on learning the relation between relative positions of distractors and the target position. This study investigates hemispheric differences in the covert attentional mechanisms involved in contextual cuing. We investigated reaction time and accuracy differences in contextual cuing with repetitions to the visual field either ipsilateral or contralateral to that of the first presentation. Both reaction time and accuracy data revealed contextual cuing effects in the ipsilateral visual field. However, only the accuracy data revealed contextual cuing in the contralateral visual field as well. Accuracy data also revealed more facilitation for contralateral than ipsilateral repetitions in the LVF-RH, which might indicate a RH bias for covert attention shifts. As the visual search tasks were only presented for 200 ms and not until participants detected the target, reaction time does not accurately reflect the time taken to perform the visual search task. Future research should investigate other valid measures for contextual cuing. Future studies could also explore whether the hemispheric differences in contextual cuing effects reflect hemispheric bias for covert attentional shifts or other mechanisms such as processing low spatial frequency information or implicit learning.

Hemispheric Differences in Contextual Cuing

We are constantly presented with a flood of visual information that we must sift through to identify what is relevant and attend to it. Memory representations play a role in selecting the information to attend to. Both implicit and explicit memories can affect what we attend to and what we ignore. One of the ways in which implicit memories affect attention can be examined using the contextual cuing paradigm.

Chun and Jiang (1998) proposed the contextual cuing paradigm to explore the way implicit memories of the global properties of an image guide the deployment of attention towards it. They measured the reaction time for detecting targets in new presentations and repeated presentations (repetitions) and found that participants responded faster to the repetitions. They proposed that the facilitation of response time reflects facilitation of attentional deployment due to implicit learning of the spatial configuration of items, especially the relation between distractor locations and the target location. They also found that this implicit learning took place in parallel across the entire visual field. This explained how attention is allocated when there are a multitude of items competing for attention. While this model made clear an association between implicit learning mechanisms and deployment of attention, it was still unclear what exactly was learned during the contextual cuing paradigm.

Jiang and Wagner (2004) explored the question of what was learned during contextual cuing by presenting participants with two kinds of repetitions. In recombined repetitions, half the distractors were from one learned configuration

and half the distractors were from another learned configuration. In rescaled repetitions, the configurations were either larger or smaller in overall size and the overall configuration was shifted. As contextual cuing was observed for both kinds of repetitions, the researchers proposed that contextual cuing relies on learning of global spatial configurations and on making individual target-distractor associations.

Jiang and Song (2005) further investigated the implicit learning mechanisms in play during contextual cuing by having participants perform visual search tasks and change detection tasks within the contextual cuing paradigm. They found that in the visual search task, participants associated each distractor location with the target position. In the change detection task, on the other hand, participants learned the visual array as a global layout of items. Jiang and Song proposed that the individual associations in the first task were due to the serial nature of a conjunction search such as the visual search task. In the change detection task, participants were presented with each display for only 400ms and hence could only process the global context of the stimuli.

Endo and Takeda (2005) further explored the process of learning the global configuration of items in contextual cuing by conducting the same paradigm with two kinds of changes to the global context in the repetitions. In the first type of repetition, the top and bottom halves of the each visual array were interchanged. In the second type of repetition, the overall array was displaced. Contextual cuing effects were not observed when relative positions were changed in the first type but were still found when only absolute positions were changed in the second type. The

researchers concluded that when participants specifically process the global context of a visual array in the contextual cuing paradigm, they learn to associate the relative positions of the distractors with the target location.

To further explore how brief presentations times interact with learning the global context of visual arrays, van Asselen and Catelo-Branco (2009) presented visual search tasks to participants for 500 ms while participants fixated on a cross at the center of the visual array. By presenting the visual search task to the participants' near-peripheral, or perifoveal, vision, they found that covert attention shifts facilitate contextual cuing when the stimuli are presented in the peripheral vision. They proposed that peripheral visual areas are better suited to integrate visual information and process the global context rather than individual items.

In this study, I examined whether the contextual cuing paradigm reflected hemispheric differences in the processing of visual stimuli. Based on past research, I presented the visual search arrays briefly in either the right or the left visual field with two kinds of repetitions. Ipsilateral repetitions were when the repetition was in the same visual field as the initial presentation. Contralateral repetitions were when the repetitions were presented in the visual field opposite to that of the initial presentation. Past research has shown that distractor sets that are salient in either shape or color distract attention from the target (Conci & von Muhlenen, 2009). To avoid distraction from salient distractors, the distractors were presented in an arc around the fixation cue. By comparing ipsilateral and contralateral repetitions in each visual field, I hoped to identify whether implicit learning and covert attentional shifts occurred before or after the two hemispheres interacted in the visual system. I

also hoped to identify hemispheric differences in the mechanisms of implicit learning, global processing, and spatial attention that are involved in contextual cuing.

Method

Participants were seated arm's length from the computer and were presented a visual search task for the target 'T' among the distractors 'L'. Half the trials contained the target and the other half only consisted only of distractors. Half the configurations were presented in the left visual field (LVF) and half in the right visual field (RVF). Each visual search array consisted of 5 items of which one was a target on half the trials. The items were presented in 5 out of 9 possible locations in each visual field that were along the circumference of a circle 7cm in radius around the center of the screen. Each configuration was presented for 200 ms followed by blank screen until the participant's response. Participants were instructed to maintain eye fixation on the fixation point in the center of the screen and press the 'p' key with their right index finger if they saw a 'T' in the configuration and press the 'q' key with their left index finger if they did not see a 'T' in the configuration. Participants were told to respond as quickly as possible without compromising the accuracy of their performance. Once they had completed the search task, participants were fully debriefed about the purpose of the study.

Results

Reaction time was significantly faster for ipsilateral repetitions than novel presentations overall, $F(2,52)=24.97, p<.001$. Participants responded significantly faster for presentations in the RVF ($M=.59, SD=.10$) than those in the LVF ($M=.63,$

$SD=.11$), $F(1,26)=32.24$, $p<.001$. As shown in Figure 1, in the RVF, ipsilateral repetitions ($M=.55$, $SD=.10$) were faster than contralateral repetitions ($M=.61$, $SD=.11$), which were faster than novel presentations ($M=.63$, $SD=.11$). In the LVF, ipsilateral repetitions ($M=.60$, $SD=.11$) were faster than contralateral repetitions ($M=.64$, $SD=.12$) and novel presentations ($M=.66$, $SD=.10$), which did not differ significantly from each other. Statistical tests for each comparison are reported in Table 1.

The RVF presentations had significantly higher accuracy rates ($M=.86$, $SD=.15$) than those in the LVF ($M=.86$, $SD=.14$), $F(1,26)=32.24$, $p<.001$. There was a main effect of type of presentation, $F(1,26)=11.97$, $p=.002$. As shown in Figure 2, for the RVF, ipsilateral repetitions ($M=.92$, $SD=.14$) had higher accuracy rates than contralateral repetitions ($M=.86$, $SD=.17$), which had higher accuracy rates than novel presentations ($M=.81$, $SD=.13$). For the LVF, ipsilateral ($M=.89$, $SD=.14$) and contralateral repetitions ($M=.89$, $SD=.15$) had higher accuracy rates than novel presentations ($M=.79$, $SD=.14$) but did not differ significantly from each other. Statistical tests for each comparison are reported in Table 2.

Discussion

This study supported past findings of contextual cuing as reaction times were shorter and accuracy rates were higher for ipsilateral repetitions than for novel presentations. As the stimuli were presented to each visual field while the participant fixated on the center of the screen, this study further supports that contextual cuing, and hence the implicit learning of global context, can take place in peripheral vision.

It is also important to note that contralateral repetitions were mirror images of the novel presentations, not exact repetitions. Therefore, contralateral repetitions implied a change in the absolute position of targets in relation to the target location. Our accuracy data revealed contextual cuing even for the contralateral condition, thereby supporting Endo & Takeda's (2005) conclusion that contextual cuing involves learning the relative positions of the context, not the absolute positions of the distractors in relation to the target.

The data also supported an overall facilitation for responses to stimuli in the RVF in that reaction times were shorter and accuracy rates were higher for the RVF than the LVF. There are two possible reasons for this. The stimuli consisted of letters, which are traditionally believed to be processed by the left hemisphere (LH), and could have led to a RVF-LH bias for responses to the linguistic stimuli. Another point to note is that all the participants were accustomed to reading English, which is read from left to right. Therefore, they may be more proficient at shifting attention to the right than to the left as they frequently do this while reading English.

As can be seen in Figure 1, reaction time data reflects contextual cuing for ipsilateral repetitions in both visual fields but only in the RVF for contralateral repetitions. However, it is possible that reaction time is not an appropriate measure for the current study. While Jiang & Song (2005) conducted a visual search task with longer presentation times and a change detection task with shorter presentation times, our study combined the two to present a visual search task with presentation times of 200 ms. In order to prevent shifts in eye gaze while the stimuli was still

visible. Past research has discussed that difference in the presentation time can lead to differences in what is learned (Jiang & Song, 2005). We will rely on the measure used in their study for brief presentation times and focus on accuracy as a measure of learning in short presentation times.

Accuracy data revealed contextual cuing for both visual fields and both types of repetitions. This is reflected in higher accuracy rates for ipsilateral and contralateral repetitions in both visual fields as compared to novel presentations. This may imply that deployment of covert spatial attention does not take place till later stages in the visual system after the two hemispheres have interacted to create a whole percept of both visual fields. This would explain why Chun and Jiang (1998) found implicit learning taking place in parallel across the visual field rather than within each hemi-field.

It is also interesting to note that there were no significant differences between accuracy rates for ipsilateral and contralateral repetitions for the LVF. Contextual cuing relies on implicit learning of global context. If, regardless of the side of novel presentation, the LVF repetition shows higher accuracy rates, this may suggest that either implicit learning or global processing is preferentially accomplished in the right hemisphere, which processes LVF information. This may support theories that the right hemisphere is preferentially suited for low-spatial frequency processing and hence better suited to process the global context of visual arrays.

On the other hand, this data may also suggest a right-hemisphere bias for implicit learning or covert attentional shifts. Roser et al. (2011) conducted a series of studies on a split-brain patient to find that the right hemisphere was

preferentially suited for visual statistical learning, such as that necessary to learn repetitions in visual arrays. At the same time, past research has also found that peripheral presentations support covert shifts of attention based on contextual information. Further research would be required to identify whether the accuracy data reflects RH preference for global processing, attentional shifts, or implicit learning.

This study reflects hemispheric differences in the mechanisms involved in contextual cuing. This methodology in this study resulted in reaction time not being an accurate measure of contextual cuing. Future research should explore different measures for contextual cuing other than accuracy, such as eye fixation duration. This study could also be extended to identify whether the LVF-RH bias reflects RH dominance for global processing or for implicit learning.

References

- Asselen, M., & Castelo-Branco, M. (2009). The role of peripheral vision in implicit contextual cuing. *Attention, Perception, & Psychophysics*, *71* (1), 76-81.
- Conci, M., & Muhlenen, A. (2009). Region segmentation and contextual cuing in visual search. *Attention, Perception, & Psychophysics*, *71*(7), 1514-1524.
- Chun, M. M., & Jiang, Y. (1998). Contextual cueing: implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology*, *36*, 28-71.
- Endo, N., & Takeda, Y. (2005). Use of spatial context is restricted by relative position in implicit learning. *Psychonomic Bulletin & Review* *12* (5), 880-885.
- Jiang, Y., & Song, J. (2005). Spatial context learning in visual search and change detection. *Perception & Psychophysics*, *67* (7), 1128-1139.
- Jiang, Y., & Wagner, L. C. (2004). What is learned in spatial contextual cuing-configuration or individual locations? *Perception & Psychophysics*, *66* (3), 454-463.
- Roser, M. E., Fiser, J., Aslin, R. N., & Gazzaniga, M. S. (2011). Right hemisphere dominance in visual statistical learning. *Journal of Cognitive Neuroscience*, *23*(5), 1088-1099.

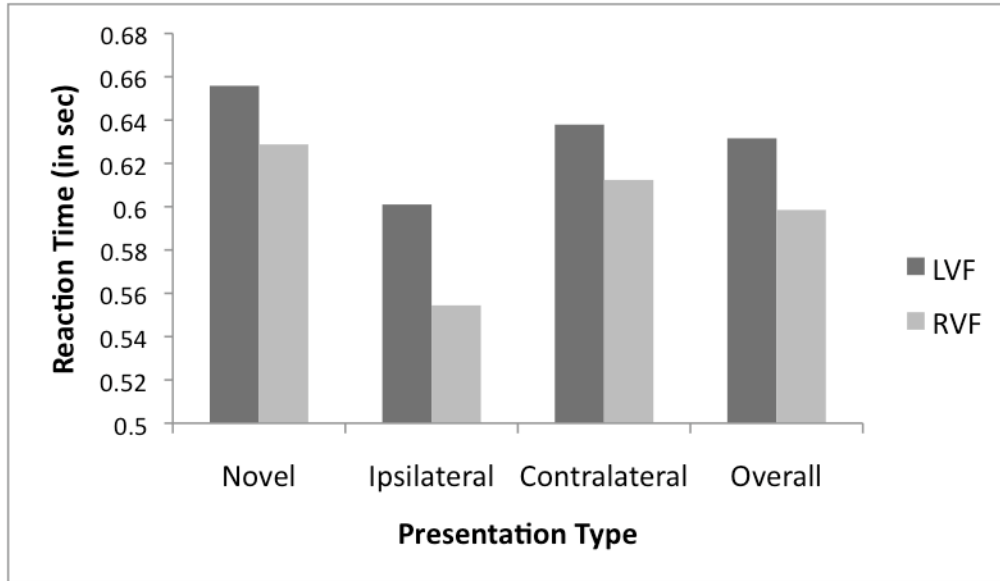


Figure 1. Reaction time for responses to each type of presentation.

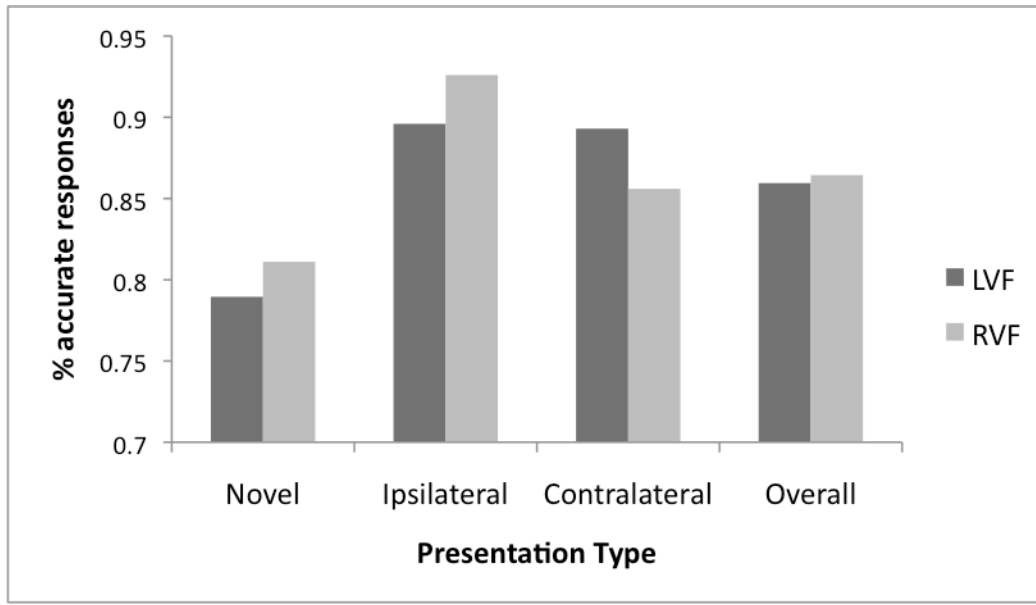


Figure 2. Accuracy rates of responses to each type of presentation.

Comparison	t-statement
RVF ipsilateral repetition vs. RVF contralateral repetition	$t=4.29, p<.001$
RVF ipsilateral repetition vs. RVF novel presentation	$t=6.49, p<.001$
RVF contralateral repetition vs. RVF novel presentation	$t=2.09, p=.046$
LVF ipsilateral repetition vs. LVF contralateral repetition	$t=2.23, p=.035$
LVF ipsilateral repetition vs. LVF novel presentation	$t=4.84, p<.001$
LVF contralateral repetition vs. LVF novel presentation	$t=1.53, p=.138$

Table 1. Statistical comparisons of reaction times between presentation types.

Comparison	t-statement
RVF ipsilateral repetition vs. RVF contralateral repetition	$t=3.05, p=.005$
RVF ipsilateral repetition vs. RVF novel presentation	$t=5.96, p<.001$
RVF contralateral repetition vs. RVF novel presentation	$t=4.13, p<.001$
LVF ipsilateral repetition vs. LVF contralateral repetition	$t=.166, p=.869$
LVF ipsilateral repetition vs. LVF novel presentation	$t=6.62, p<.001$
LVF contralateral repetition vs. LVF novel presentation	$t=2.72, p=.011$

Table 2. Statistical comparisons of accuracy between presentation types.