TOP DOWN EXPECTATIONS GOVERN ATTENTIONAL ALLOCATION TOWARDS DISTRACTOR LOCATIONS

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Abstract

Failures of selective attention may be explained by the attentional white bear (AWB) hypothesis (Tsal & Makovski, 2006) maintaining that prior knowledge of distractor location causes attentional allocation to it. The AWB is demonstrated by embedding infrequent trials of two simultaneous dots among flanker trials. The dot at the expected distractor location is perceived as appearing before the dot at the expected empty location, indicating attentional allocation to expected distractor locations. A major requirement of the AWB hypothesis is that it occurs in a top down manner due to expectations. We devised a variation of the original AWB experiment which enabled us to differentiate between the top down and bottom up contributions. The results show that top down expectancies, which are a critical part of the AWB characterization, occur independently of bottom up contributions.

When viewing a presentation of multiple stimuli, attention can be allocated only to a portion of these stimuli. Some are chosen as targets to be attended and processed, while others are not. However, selective attention to the target is not always perfect. Sometimes irrelevant non-target stimuli are also processed. This occurs even when these stimuli are distractors and attending to them will be unbeneficial to the main task. Such a failure in selective attention is demonstrated in the flanker task (Eriksen & Eriksen, 1974), where participants are asked to attend to the target letter at the center of the display and ignore two identical flanking distractor letters. The flanking letters could be mapped out to a response that is either congruent with or incongruent with the target's response. Typically, a response compatibility effect with the identity of the distractors is found, showing longer response times (RTs) when the target and distractor's responses are incongruent and shorter RTs when they are congruent, indicating that the distractors have been processed.

Tsal and Makovski (2006) pointed out an inherent discrepancy in the flanker task, as well as in other basic tasks of selective attention. In the flanker task the distractor and target locations are known in advance and the task's instructions calls for participants to attend to the target and ignore the distractors. These instructions discern the target and distractor locations and differentiate them from other empty or non-mentioned locations. It could be that the very referral to display items' locations induces perceptual activation that begins with an attentional allocation to the spatial region in which they are expected to appear. This activation is in line with the instructions to attend to the target, but is incompatible with the request to ignore the distractors. Thus, it is possible that the instructions in the flanker task initiate an active attendance towards both the target and distractor locations, which enhances the processing of the target but hampers the ability to ignore the distractors.

Tsal and Makovski (2006) suggested the attentional white bear (AWB) hypothesis, which maintains that the mere expectation of a stimulus actively draws attention to its expected location. They asked their participants to partake in a flanker task in which the distractors were placed diagonally at either the top left and bottom right or top right and bottom left positions from the target. The location of the distractors varied between blocks,

but remained fixed throughout the block. On a minority of the trials two dots appeared instead of a flanker display (i.e., a pre stimulus probe) (see Figure 1). The two-dot trials were randomly intermixed within the flanker trials and participants were not informed which trial type is going to appear. One of the dots occupied the location a distractor always appeared at in the flanker display, and the other dot occupied a location which was always empty in the flanker display. Since the flanker trials were much more frequent than the two-dot trials, it can be maintained that one dot appeared at an expected distractor's location and the other dot appeared at an expected empty location. Participants were asked to judge which of the dots appeared first. Stelmach and Herdman (1991) have shown that the perceived temporal order of two simultaneous dots is affected by attention: when two dots appeared at the same time but attention is allocated to only one of them, the attended dot is perceived as appearing before the unattended one. Tsal and Makovski (2006) inferred that the location of the dot which participants were to judge as appearing first was the more attended location. Their results showed that the dot at the expected distractor location was perceived to appear prior to the dot at the expected empty location, leading to the conclusion that attention was allocated to the expected distractor location, prior to the onset of the distractor stimulus. These temporal judgment differences indicating attention to expected distractor location are a manifestation of the AWB effect.

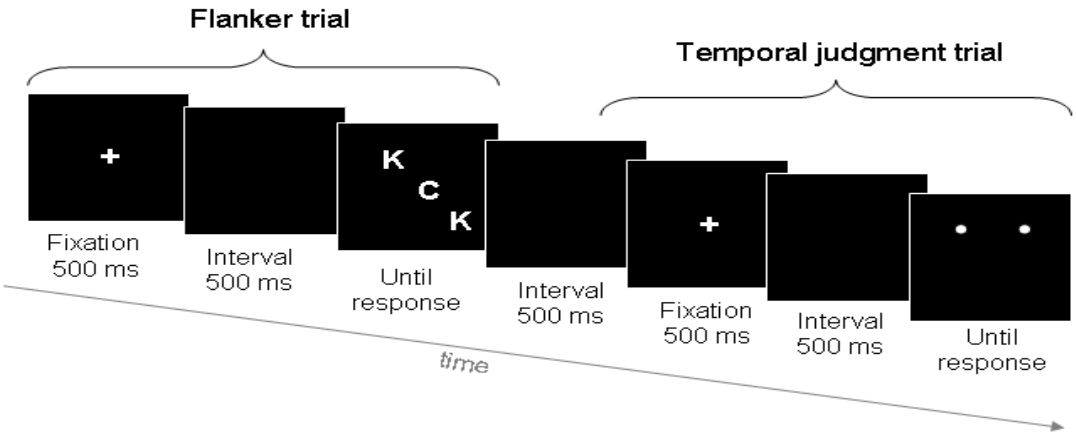

Figure 1: An example of a Top left position flanker trial followed by a two-dot temporal judgment trial.

Tsal and Makovski (2006) assume that since the AWB effect occurs *prior* to display presentation, attention is drawn to the expected distractor's location in a top-down manner, based on participants' expectations and knowledge about the upcoming location. However, because the distractor locations in their experiment were fixed and remained constant throughout the block, an alternative possibility may be that attention is drawn to the distractor location due to priming of that location by the stimulus in the previous trial. In order to rule out this priming explanation, a similar experiment was conducted with blocks in which the distractor positions varied randomly. As the participants could not anticipate the upcoming distractor's location in the experiment with the random trials, a perceived temporal difference between the two dots was not expected. Indeed, the results showed no difference in the temporal judgment of the two dots, indicating there was no priming of the location occupied by a distractor in the previous trial, supporting the claim that the effect is due to top down expectations (see Figure 2).

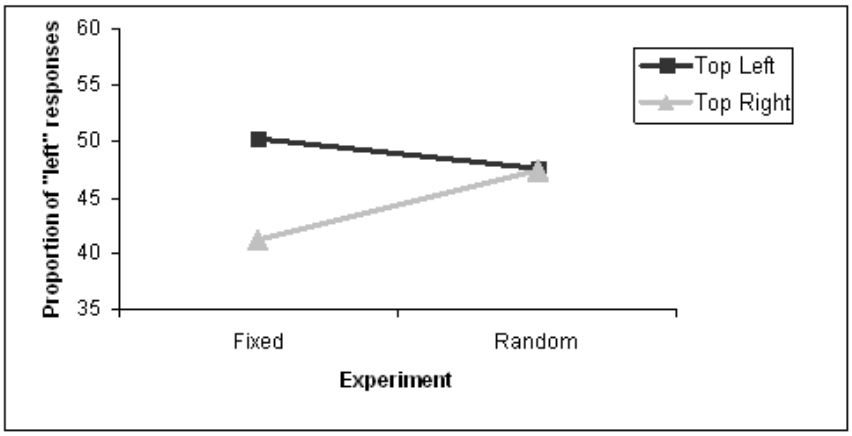

Figure 2: Mean proportions of "left" responses (perceiving the left dot before the right dot) when the distractor was expected in the Top left versus the Top right locations (Fixed locations experiment), or had just appeared in the Top left versus the Top right locations (Random locations experiment).

The AWB effect disappeared when top down information was eliminated because distractor location varied randomly, indicating the effect is based on expectations. Yet, there are alternative ways of interrupting these results. One alternative explanation may be that when distractors varied randomly between two locations, both locations have been rendered top down relevant, causing them both to be deliberately attended and camouflaging a genuine AWB effect. Another possibility is that when distractor locations were random, both locations received substantial amounts of bottom up priming over the course of trials. This priming may have built up enough to make them both equally and highly attended, resulting in no temporal judgment differences.

In order to clearly dissociate between top down and bottom up processes, we created an experiment that allows us to distinguish between their relative contributions to the AWB. We designed a flanker task that includes eight possible distractor locations around the permanent target location in the middle of the display. Distractors always formed a line with the target, resulting in two possible diagonal lines (distractors at the Top Left-Bottom Right locations and distractors at the Top Right-Bottom Left locations), a vertical line (distractors at the Top-Bottom locations), and a horizontal line (distractors at the Left-Right locations). The distractor locations changed between trials in a consecutive clock-wise manner. For example, if trial N was Top Left-Bottom Right diagonal, trial N+1 was Top-Bottom, trial N+2 was Top Right-Bottom Left, trial N+3 was Right-Left, and trial N+4 was Top Left-Bottom Right again. This design meant that participants could anticipate where the next trial's flankers will appear, but flanker positions were never repeated in consecutive trials.

The two-dot trials appeared randomly within the block, always at the Top Left and Top Right positions. A two-dot trial can be considered as a measure of top down or bottom up processes based on the type of distractor location trial it had followed (see Figure 3). A two-dot trial following a Left-Right distractor locations trial can be considered to measure a pure top down expectancy for a distractor in the Top Left position. This is because participants expect the upcoming trial to be a flanker with distractors in the Top Left- Bottom Right locations, and there was no bottom up activation of either the Top Left or Top Right locations from the previous trial. A two-dot trial following a Top-Bottom locations distractor trial can

be considered to measure a pure top down expectancy for a distractor in the Top Right position. This is because participants expect the upcoming distractor to appear at Top Right-Bottom Left positions, and those locations have not been primed in the previous trial. Along the same logic, the two-dot trials following the Top Left-Bottom Right flanker can be seen as a pure measure of bottom up activation of the Top Left position, because the Top Left location has just been primed but participants expect the distractors to now appear at the Top and Bottom positions. And the two-dot trials following the Top Right-Bottom Left diagonal measure the pure bottom up activation of the Top Right position, because the distractor has just appeared at that location but is not expected there in the upcoming trial. The temporal judgment differences in the two-dot trials following the horizontal and vertical distractor positions can be used to measure the top down contributions to the AWB effect, while the temporal judgment differences in the two-dot trials following the two types of diagonal flankers can serve as a measure of how much bottom up activation contribute to the AWB effect. Therefore, this design enables to differentiate and measure the separate contributions of the top down and bottom up processes to the overall AWB effect.

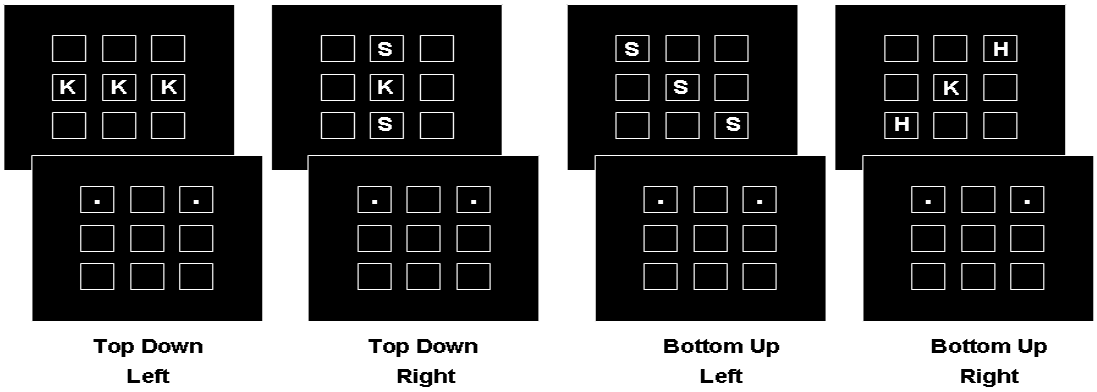

Figure 3: An example of the four possible classifications of two-dot trials based on the distractor location in the previous trial.

Method

Participants were presented with five similar 150-trial blocks. Each block consisted of 120 diagonal flanker displays and 30 two-dot displays. At the start of each block 9 boxes in a 3 X 3 array appeared and remained on screen throughout the block. Each box subtended 1.14 deg in height and width. The center-to-center distance between each box was 1.72 deg of a visual angle. Each letter in the flanker display was white and subtended 0.33 deg in height and 0.24 deg in width. The stimuli letters and dots appeared in the middle of the boxes. The target appeared inside the center box, while in each trial distractors appeared in two of the eight external boxes. Participants were instructed to respond as fast and as accurately as possible to the central target while ignoring the two identical diagonal distractors. They pressed the "L" key with their right index finger when the target was either an H or a K and the "A" key with their left index finger when the target was either a C or an S. Half of the distractors were congruent with the target, i.e., belonged to the same response category (e.g., half H distractors and half K distractors for an H target) and half were incongruent, i.e., belonged to the opposite response category (e.g., half S distractors and half C distractors for the H target). The four possible target letters were equally frequent and randomly intermixed. For each target letter the four distractor types were randomly intermixed. The center-to-center distance

between the target and distractor in the top, bottom, left and right boxes was 1.72 deg of visual angle. The center-to-center distance between the target and distractor in the top left, top right, bottom left and bottom right boxes was 2.44 deg of visual angle. When the two dots appeared, they were located at the top left and top right boxes. Each dot in the two-dot display was white and subtended .095 deg in diameter. The distance between the two dots was 3.36 deg of a visual angle. Participants were required to indicate which of the dots appeared first by pressing the "K" key with their right index finger for the right dot and the "S" key with their left index finger for the left dot. Only accuracy was emphasized in this task.

There were four possible distractor location sets: Top Left-Bottom Right, Top-Bottom, Top Right-Bottom Left, and Right-Left. The distractor locations changed between trials in a consecutive clock-wise manner. Two-dot trials appeared randomly within the block. The flanker trial following a two-dot trial was the same diagonal that had been expected to follow the flanker trial that preceded the two-dot trial. This has been explicitly told to the participants during practice period.

Each session began with 16 practice temporal judgment trials in which one dot appeared before the other, followed by 20 introductory practice trials with a similar design and sequence as the experimental trials. An auditory feedback was given on accuracy for the flanker task during the practice trials.

Results and Discussion

Flanker task

Mean accuracy rates for the Congruent and Incongruent displays were 98% and 97% respectively. A paired samples t test between accuracy rates revealed a significant difference ($t(15)=2.66$, $p=0.02$).

Incorrect responses and responses deviating by more than two standard deviations from the mean were removed from the RT analyses. Mean response times (and standard deviation) for the Congruent and Incongruent trials were 672 (133) msec and 690 (125) msec respectively. A paired samples t test revealed the difference to be significant ($t(15)=2.52$, $p=0.023$).

Temporal judgment

Given potential individual biases in responding to either right or left visual stimuli, instead of comparing "left" and "right" responses for a given display type, we compared the same response type as a function of display type. We compared perceiving the left dot as appearing first when the distractor was expected in the Top Left position relative to when the Top Left position was expected to be empty (i.e., the distractor was expected in the Top Right position) as a measure of top down contribution. We compared perceiving the left dot as appearing first when the distractor had just appeared in the Top Left position relative to when the Top Left position has been empty (i.e., the distractor had just appeared in the Top Right position) as a measure of bottom up contributions. We present only the "left" responses since the proportions of the "right" responses are complementary and therefore provide redundant information.

A Trial Type (Top Down vs. Bottom Up) X Distractor Location (Top Left vs. Top Right) repeated measures ANOVA was performed on the proportions of "left" responses (see Figure 4). A significant effect of Distractor Location was found ($F(1,15)=21.09$, $p<0.001$), due to more "left" responses when a distractor was anticipated or appeared in the Top Left position than in the Top Right position. An approaching significant difference was found

between the proportion of "left" responses in the different Trial Types ($F(1,15)=3.94$, $p=0.066$). There was no interaction ($F(1,15)=0.4$, $p=0.54$).

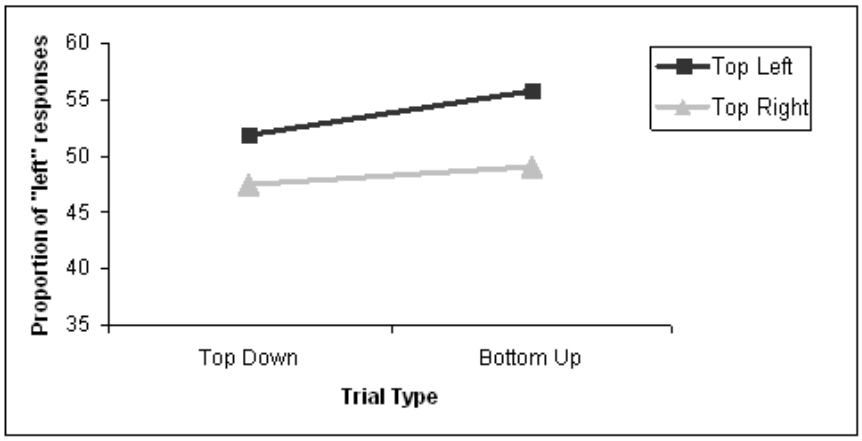

Figure 4: Mean proportions of "left" responses (perceiving the left dot before the right dot) in the Top down and Bottom up Trial Types.

The significant Distractor Location and lack of interaction suggests that both top down and bottom up processes contribute (in equal amounts) to the AWB effect, as it is measured in this study. Most importantly, these results show there are pure top down contributions, which are a critical part of the theoretical AWB definition. The bottom up contribution is a residue activation deriving from the operational manipulation of the effect.

Conclusion

A major feature of the AWB is that it occurs because participants have been given information about the upcoming distractor location and know where to expect it. This means the AWB effect arises due to expectations, in a top down manner. However, the method devised to demonstrate the AWB effect (Tsal & Makovski, 2006) permits both top down and bottom up contributions for the measured attentional allocation. In the current study we managed to differentiate between the two, and show that there are pure top down expectancy elements which are the critical part of the AWB characterization, in addition to bottom up contributions which derive from the operational examination of the effect.

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