

Stronger interference from distractors in the right hemifield during visual search

Christophe Carlei & Dirk Kerzel

To cite this article: Christophe Carlei & Dirk Kerzel (2018) Stronger interference from distractors in the right hemifield during visual search, *Laterality: Asymmetries of Body, Brain and Cognition*, 23:2, 152-165, DOI: [10.1080/1357650X.2017.1327539](https://doi.org/10.1080/1357650X.2017.1327539)

To link to this article: <https://doi.org/10.1080/1357650X.2017.1327539>



Published online: 13 May 2017.



Submit your article to this journal [↗](#)



Article views: 44



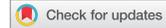
View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)



Stronger interference from distractors in the right hemifield during visual search

Christophe Carlei and Dirk Kerzel

Faculté de Psychologie et des Sciences de l'Éducation, Université de Genève, Geneva, Switzerland

ABSTRACT

The orientation-bias hypothesis states that there is a bias to attend to the right visual hemifield (RVF) when there is spatial competition between stimuli in the left and right hemifield [Pollmann, S. (1996). A pop-out induced extinction-like phenomenon in neurologically intact subjects. *Neuropsychologia*, 34(5), 413–425. doi:10.1016/0028-3932(95)00125-5]. In support of this hypothesis, stronger interference was reported for RVF distractors with contralateral targets. In contrast, previous studies using rapid serial visual presentation (RSVP) found stronger interference from distractors in the left visual hemifield (LVF). We used the additional singleton paradigm to test whether this discrepancy was due to the different distractor features that were employed (colour vs. orientation). Interference from the colour distractor with contralateral targets was larger in the RVF than in the LVF. However, the asymmetrical interference disappeared when observers had to search for an inconspicuous colour target instead of the inconspicuous shape target. We suggest that the LVF orienting-bias is limited to situations where search is driven by bottom-up saliency (singleton search) instead of top-down search goals (feature search). In contrast, analysis of the literature suggests the opposite for the LVF bias in RSVP tasks. Thus, the attentional asymmetry may depend on whether the task involves temporal or spatial competition, and whether search is based on bottom-up or top-down signals.

ARTICLE HISTORY Received 21 November 2016; Accepted 1 May 2017

KEYWORDS Hemispheric asymmetries; laterality; additional singleton paradigm; visual search

Introduction

The neural basis of attention is not symmetric between the two hemispheres. For instance, it is a well-documented finding that hemineglect is more frequent after right-hemisphere lesions than after left-hemisphere lesions (Vallar, 1998). The interpretation was that the right hemisphere controls attention in both the ipsi- and contralateral visual field, whereas the left hemisphere only controls attention in the contralateral hemifield. Thus, lesions of the left hemisphere

CONTACT Christophe Carlei  christophe.carlei@unige.ch

© 2017 Informa UK Limited, trading as Taylor & Francis Group

do not impair attention in the contralateral, right visual field (RVF) because the right hemisphere may compensate the loss (Heilman & Van Den Abell, 1979; Posner & Cohen, 1984). In contrast, lesions of the right hemisphere leave the contralateral, left visual field (LVF) with reduced attentional capacities because the left hemisphere cannot compensate. Further evidence for a functional dominance of the right hemisphere in attentional reorienting comes from imaging studies (Shulman & Corbetta, 2012).

LVF bias in rapid serial visual presentation

Per se, the asymmetric control of attention does not make strong predictions regarding attentional capacities of the left and right hemispheres in healthy participants because of the strong interconnectivity of the two hemispheres. However, it may be that the stimuli in the LVF are favoured when there is competition between stimuli presented simultaneously in the LVF and RVF. LVF stimuli may have more direct access to the right ventral network in charge of reorienting attention (Shulman & Corbetta, 2012) because their initial representation is in the right hemisphere, whereas stimuli presented in the RVF have to pass from the left to the right hemisphere.

Some recent studies using rapid serial visual presentation (RSVP) and exogenous cueing provide support for an LVF dominance in attentional tasks with healthy participants. When two RSVP streams were presented simultaneously in the LVF and RVF, inconspicuous targets were less frequently missed in the LVF than in the RVF, supporting better attentional capacities in the LVF (Asanowicz, Smigasiewicz, & Verleger, 2013; Śmigasiewicz, Westphal, & Verleger, 2017). This hypothesis was further supported by a cueing manipulation. When a salient exogenous cue was presented close to the RSVP stream that did not contain the inconspicuous target (invalid cue), the cue was more disruptive when it was presented in the LVF compared to the RVF (Śmigasiewicz, Asanowicz, Westphal, & Verleger, 2014).

In related studies, distractors in the periphery that matched the colour of the target in a central RSVP stream caused a stronger decrement in performance when they appeared in the LVF compared to the RVF (Du & Abrams, 2010). However, the asymmetrical interference was attenuated when target-matching distractors were not perceptually distinct (Burnham, Rozell, Kasper, Bianco, & Delliturri, 2011). In sum, invalid onset cues or target-matching distractors in the LVF capture attention to a larger degree when the experimental task involves the rapid succession of stimuli in RSVP paradigms.

RVF orienting-bias

In contrast, research using simultaneous search displays found the opposite asymmetry. Pollmann (1996, 2000) measured interference from an

irrelevant-but-salient orientation singleton (the tilted letter T) while observers searched for an inverted letter T. The search displays were briefly shown and masked. Reaction times (RTs) were longer when the distractor was present than when it was absent, but the important result was that a distractor contralateral to the target had a larger effect when it was presented in the RVF compared to the LVF. Based on a theory by Kinsbourne (1993), Pollmann suggested that there was a dominance of the orienting-bias for the left hemisphere, resulting in stronger attentional capture by salient stimuli presented in the RVF when there is competition with a target stimulus in the opposite hemifield.

In Pollmann's (1996, 2000) work, the main hypothesis was that the stronger orienting-bias to the RVF results in attentional capture by salient distractors in the RVF so that targets on the opposite side are difficult to find. In contrast, the orienting-bias to the LVF was supposed to be smaller so that salient distractors in the LVF do not "dislocate" (Pollmann, 1996, p. 414) attention away from the target as much and result in smaller interference. Importantly, the orienting-bias is not at odds with experiments using the RSVP technique because the orienting hypothesis is limited to situations where there is spatial competition between stimuli in opposite hemifields. In contrast, the target in RSVP experiments is sometimes presented in the centre (Burnham et al., 2011; Du & Abrams, 2010) or on the vertical midline (Śmigasiewicz et al., 2017), which is outside the scope of the orienting-bias hypothesis.

Present study

It is curious that there are two opposite biases for attentional selectivity. The LVF bias in RSVP studies (Asanowicz et al., 2013; Burnham et al., 2011; Du & Abrams, 2010) is contrary to the RVF orienting-bias in visual search tasks (Pollmann, 1996, 2000). The most obvious difference between the two lines of research is that there is strong temporal competition in RSVP studies because the main task of the participants is to find the target in a series of stimuli shown in rapid succession at the same location. In some studies, there was only temporal, but no spatial uncertainty about target presentation because only a single RSVP stream was shown at central fixation (Burnham et al., 2011; Du & Abrams, 2010). In other studies, there was both temporal and spatial uncertainty because the target could appear in one of two or three RSVP streams (Śmigasiewicz et al., 2014, 2017). In contrast, there was no temporal, but only spatial uncertainty in Pollmann's work, because a single set of stimuli was simultaneously shown and participants had to indicate the location (Pollmann, 1996) or presence (Pollmann, 2000) of the target. Thus, asymmetries in interference between distractors presented in the LVF or RVF may depend on whether selection is mostly temporal or mostly spatial.

However, less interesting differences between the two lines of research may explain the opposite hemispheric asymmetries. In studies using a central RSVP stream, the asymmetry concerned the impact of distractors matching the colour or the target (Burnham et al., 2011; Du & Abrams, 2010). In studies using more than one RSVP stream, the asymmetry concerned the impact of cues that suddenly appeared in the vicinity of the RSVP streams in the LVF or RVF (Śmigasiewicz et al., 2014, 2017). In contrast, the distractor in Pollmann's work was a letter with a different orientation (Pollmann, 1996, 2000). Thus, the different distractor features may explain the discrepant results.

To provide converging evidence that the main difference between the LVF bias in RSVP tasks and the RVF orienting-bias in visual search are due to the different temporal and spatial task demands, we used colour distractors in the widely used additional singleton paradigm developed by Theeuwes (1991, 1992) and examined effects of visual hemifield. Participants were asked to search for a shape singleton and on 50% of the trials, a salient-but-irrelevant colour singleton was shown (see Figure 1). A typical finding in the additional singleton paradigm is that RTs are longer when a distractor is present than when it is absent. In contrast to RSVP tasks, the stimuli in the additional singleton paradigm are shown all at once and the target is never at central fixation.

Experiment 1: different-dimension distractors

Observers in Experiment 1 were asked to indicate the orientation of a line inside the element with a unique shape. On 50% of the trials, one element had a colour that was different from the remaining elements. The target and distractor positions were random and all combinations of target and distractor placement were equally probable. Because our stimulus array had no positions on the vertical midline, target and distractor were either ipsilateral or

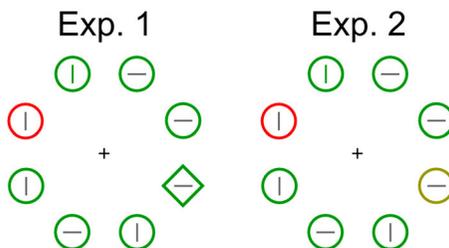


Figure 1. Illustration of experimental stimuli in Experiments 1 and 2 (drawn to scale). The target was a shape singleton in Experiment 1 and the yellow element in Experiment 2. The distractor (here: the red element) was more salient than the target in both experiments, but the target–distractor similarity was greater in Experiment 2. To view this figure in colour, please see the online version of this journal.

contralateral. Only the latter condition is relevant for the evaluation of the orientation-bias hypothesis.

Methods

Participants

Thirty right-handed undergraduate psychology students at the University of Geneva participated in this experiment (19–26 years). Only 3 out of 30 participants were male, which reflects the larger proportion of female students in psychology. As hemispheric asymmetries are more prevalent in males than females (Grabowska, Herman, Nowicka, Szatkowska, & Szelag, 1994), we think that our sample provides a conservative test for effects of hemifield asymmetries. However, we admit that future research should take gender differences into account. All participants reported normal or corrected-to-normal visual acuity and participated for class credit. All procedures were approved by the ethics committee of the “Faculté de Psychologie et des Sciences de l’Education” at the University of Geneva and were in accordance with the 1964 Declaration of Helsinki. Before the experiment, participants gave their written informed consent. One participant was excluded because of an extremely large distractor effect of 189 ms in one condition, whereas the mean for the remaining participants was 15 ms.

Stimuli and apparatus

The experiment was conducted in a dimly-lit room. Participants were seated at a distance of 45 cm from a CRT screen with their heads stabilized by a chin rest. Participants’ eye movements were monitored by the experimenter from outside the experimental booth with the help of the image of the eye provided by an EyeLink 1000 eye-tracker (SR-Research, Ontario, Canada). Eye movements were not recorded or analysed, but the experimenter reminded the participants to maintain fixation when necessary. Displays were composed of eight geometrical shapes at an eccentricity of 4.2°. Circles had a diameter of 1.8° and diamonds had a diameter of 2.0°. A vertical or horizontal bar of 0.9° length was shown at the centre of each shape and drawn in grey. One of the eight stimuli had a shape different from the nontarget shapes (shape singleton). On 50% of the trials, one of the stimuli had a colour different from the remaining stimuli. This stimulus is a colour singleton and served as distractor. All stimuli had a luminance of 18.5 cd/m².

Procedure

The task of the participant was to report the orientation of the line inside the shape singleton by pressing one of two keys on a standard keyboard. Participants were asked to respond as fast as possible. Error feedback was shown after incorrect responses and late trials (RTs > 2 s). Before the experiment,

participants completed 48 trials in which they were trained to perform the task while maintaining eye fixation at the centre of the screen. The target/distractor colours were swapped between the first and second session, but remained fixed within a session. The colour in the first block, the target/nontarget shapes (diamond target with circle nontargets or circle target with diamond nontargets) and the mapping of line orientation to key was counter-balanced across participants. Participants worked through 1,344 trials (672 per session).

Results and discussion

There were 0.2% late trials and 5% choice errors. We removed trials with RTs exceeding the cell mean by more than 2.5 standard deviations, which resulted in the removal of 2.1% of the trials.

We compared RTs with LVF and RVF targets on distractor-absent trials. As shown in the top left panel of [Figure 2](#), RTs were 21 ms shorter with RVF than LVF targets (634 vs. 655 ms), $t(28) = 4.57$, $p < .001$.

Next, we corrected RTs in distractor-present trials for RT differences between LVF and RVF targets. To this end, we subtracted RTs in the distractor-absent conditions from RTs in the distractor-present conditions with matching target hemifield. The resulting means are referred to as distractor effect. Mean distractor effects are plotted in the lower left panel of [Figure 2](#). We conducted a 2 (distractor hemifield: left, right) \times 2 (relative target hemifield: ipsilateral, contralateral) repeated-measures ANOVA. We found the distractor effect to be larger with ipsilateral than contralateral targets (20 vs. 10 ms), $F(1, 28) = 8.21$, $p = .008$, $\eta_p^2 = .227$. Importantly, the interaction of distractor and target hemifield reached significance, $F(1, 28) = 19.16$, $p < .001$, $\eta_p^2 = .406$. Consistent with Pollmann's work, the distractor effect for contralateral targets was 17 ms larger with RVF than LVF distractors (19 vs. 2 ms), $t(28) = 2.97$, $p = .006$. Additionally, we found the opposite difference for ipsilateral targets. The distractor effect for ipsilateral targets was 11 ms larger for LVF than RVF distractors (25 vs. 14 ms), $t(28) = 2.69$, $p = .012$.

We ran the same analyses as above on the percentage of choice errors. On distractor-absent trials, fewer choice errors occurred with targets in the RVF than in the LVF (4.2% vs. 5.4%), $t(28) = 2.89$, $p = .007$. No other effects reached significance, $F_s < 1.5$, $p_s > .315$, ruling out speed-accuracy trade-off.

Discussion

The results are consistent with Pollmann's (1996, 2000) RVF orienting-bias hypothesis. When there was competition between stimuli in the left and right hemifield (i.e., with contralateral stimuli), interference was stronger with RVF than LVF distractors, suggesting that attention is preferentially directed to the

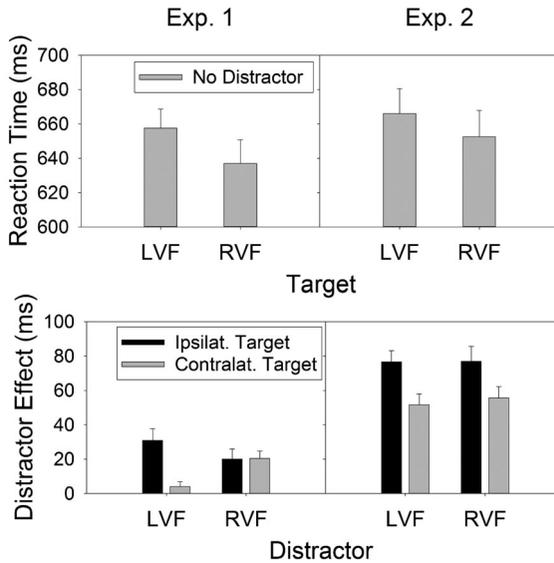


Figure 2. Results from Experiments 1 and 2 are shown on the left and right, respectively. The upper panels show RTs as a function of the visual field of the target on distractor-absent trials, whereas the lower panels show the distractor effect as a function of the visual field of the target. The distractor effect corresponds to RTs with distractor minus RTs without distractor, matched for target hemifield.

Note: LVF, left visual field and RVF, right visual field.

RVF. Thus, there is converging evidence from the additional singleton paradigm for stronger distraction by RVF than LVF distractors under conditions of spatial competition. Further, it is unlikely that the choice of the distractor feature explains the difference between RSVP and visual search tasks because the same distractor feature (colour) was shown to result in an LVF advantage in the RSVP literature but produced a RVF advantage in the present investigation.

Further, we observed that the distractor effect was larger for LVF than RVF for ipsilateral stimuli. While the orienting hypothesis does not make specific predictions about ipsilateral targets, the results could be explained by the larger difficulty to resolve competition inside a hemifield when attention was initially directed to the wrong hemifield. If attention is initially directed to the RVF as the orienting-bias hypothesis suggests, then target and distractor are in the focus of attention with ipsilateral stimuli in the RVF, whereas attention has to be redirected to the opposite hemifield with ipsilateral stimuli in the LVF. This may explain the larger distractor effect with ipsilateral stimuli in the LVF compared to the RVF. Finally, the shorter RTs for RVF than LVF targets on distractor-absent trials further buttress the notion that attention was initially directed to the RVF, even if the orienting-bias hypothesis does not specifically address this situation unless one assumes that the

nontarget elements, which were always present contralateral to the target, also resulted in competition with the target.

There are a number of technical issues that need to be addressed before we turn to Experiment 2. Our main comparison was between distractor hemifields with contralateral targets, but we also report comparisons between ipsilateral and contralateral conditions. This comparison is complicated because it confounds relative hemifield and the distance between target and distractor. In our displays, target–distractor distances ranged between 1 (adjacent) and 4 (diametrically opposed), but the range of distances was limited to 3 with ipsilateral stimuli (see [Figure 1](#)). In general, the mean target–distractor distance was 1.67 for ipsilateral and 2.75 for contralateral targets. Further, the frequency of the various target–distractor distances differed between contra- and ipsilateral stimuli. In the 672 trials with distractor, 288 were ipsilateral and 384 contralateral. When target and distractor were ipsilateral, there were 144, 96 and 48 trials for distances of 1–3, respectively. For contralateral stimuli, there were 48, 96, 144 and 96 trials for distances of 1–4, respectively. This unequal distribution results when each distractor and target position has the same probability. Thus, it is clear that the distinction between ipsilateral and contralateral stimuli is messy and differences in target–distractor distance are very likely to contribute. There is no easy solution to this. For instance, one may want to compare ipsilateral and contralateral stimuli with a distance of 2 given that this distance was equally frequent. However, this would reduce the number of available trials drastically to only 96 (instead of 288 or 384) and yet another confounding variable would be introduced. Contralateral stimuli with a distance of 2 would be presented in the upper and lower part of the stimulus array, whereas ipsilateral stimuli would be presented on the left or right.

In sum, ipsilateral and contralateral stimuli differ in their mean distance between target and distractor. It is known that the distractor effect in the additional singleton paradigm is larger when target and distractor are close (Barras & Kerzel, 2016; Gaspar & McDonald, 2014; Mathôt, Hickey, & Theeuwes, 2010; Mounts, 2000). Consequently, interference for distractors in the same visual hemifield will be larger than interference from contralateral distractors because ipsilateral distractors are closer to the target than contralateral distractors. The distance effect was explained with respect to the larger overlap of receptive fields in the same compared to opposite hemifields, which results in stronger competition and interference (Mounts, 2000).

While the comparison between ipsilateral and contralateral stimuli is complicated by concomitant variations in target–distractor distance, it is safe to compare LVF and RVF for ipsilateral or contralateral stimuli separately because the mean target–distractor distance was the same. More specifically, the larger distractor effect in the RVF than in the LVF with contralateral targets cannot be ascribed to differences in target–distractor distance because these were exactly the same for RVF and LVF stimuli. Similarly, the smaller distractor

effect in the RVF than in the LVF for ipsilateral stimuli does not confound distance, but has to be explained by asymmetries between hemispheres.

Experiment 2: same-dimension distractors

In Experiment 1, interference from the distractor was limited because target and distractor were defined along separate dimensions. That is, the target was defined by shape, whereas the distractor was defined by colour. Therefore, participants could employ a search strategy where they searched for a singleton shape instead of searching for a particular shape. This search strategy is referred to as singleton detection mode (Bacon & Egeth, 1994). In Experiment 2, we used a target that was defined on the same dimension as the distractor to prevent singleton detection mode and to force observers into feature search mode. By combining a colour target with a colour distractor, participants were required to focus on a particular colour to locate the target and could no longer search for an element that was unique on some dimension. This search strategy is referred to as feature search (Bacon & Egeth, 1994). Also, we chose the target colour to be similar to the distractor colour to increase interference (Duncan & Humphreys, 1989), but as in Experiment 1, the distractor was the most salient display element.

Methods

The methods were the same as in Experiment 1, but the target was not a shape singleton, but defined by its yellow colour. Yellow was created by mixing green and red to same amounts, so it was more similar to the green nontargets than the red distractor. Therefore, the distractor was more salient than the target (see Figure 1). The distractor/nontarget colours (red or green) were swapped after the first session, but the target colour remained the same (yellow). Otherwise, the same variables were counterbalanced as in Experiment 1. All stimuli had the same luminance. Thirty right-handed students participated (18–37 years, 1 male), but the data of one had to be removed because of excessive choice errors (27%).

Results

There were less than 0.1% late responses, 5% choice errors and 2% outliers. We compared RTs in response to LVF and RVF targets on distractor-absent trials. As shown in the top right panel of Figure 2, RTs were 13 ms shorter with RVF than LVF targets (653 vs. 666 ms), $t(28) = 3.68$, $p = .001$, replicating the results from Experiment 1.

Next, we conducted a 2 (distractor hemifield: left, right) \times 2 (relative target hemifield: ipsilateral, contralateral) repeated-measures ANOVA on the

distractor effect. As shown in the bottom right panel of [Figure 2](#), we found the distractor effect to be larger with ipsilateral than contralateral targets (74 vs. 52 ms), $F(1, 28) = 43.01$, $p < .001$, $\eta_p^2 = .606$, replicating the results of Experiment 1. However, the main effect of distractor hemifield and the interaction of distractor hemifield with relative target hemifield, which would provide evidence for asymmetric interference, were not significant, $F_s < 1$, $p_s > .344$.

We ran the same ANOVA on the proportion of choice errors. The distractor effect was larger with ipsilateral than contralateral targets (2% vs. 1.1%), $F(1, 28) = 6.28$, $p = .018$, $\eta_p^2 = .183$. No other effect reached significance.

To test for differences between Experiments 1 and 2, we subjected the data to a mixed-factors ANOVA. The first ANOVA was conducted on distractor-absent trials. A 2 (Experiment: 1, 2) \times 2 (target hemifield: left, right) confirmed that RTs were 18 ms shorter with RVF compared to LVF targets (643 vs. 661 ms), $F(1, 56) = 34.45$, $p < .001$, $\eta_p^2 = .381$. No other effects reached significance, $F_s < 1.62$, $p_s > .209$. In particular, overall RTs did not differ between Experiments 1 and 2 (645 vs. 659 ms). The second ANOVA was conducted on the distractor effect. A 2 (Experiment: 1, 2) \times 2 (distractor hemifield: left, right) \times 2 (relative target hemifield: ipsilateral, contralateral) ANOVA showed that the distractor effect was larger in Experiment 2 than in Experiment 1 (65 vs. 15 ms), $F(1, 56) = 42.49$, $p < .001$, $\eta_p^2 = .431$. Further, the effect of relative target hemifield, $F(1, 56) = 44.83$, $p < .001$, $\eta_p^2 = .445$, the interaction of experiment and relative target hemifield, $F(1, 56) = 7.27$, $p = .009$, $\eta_p^2 = .115$, the interaction of distractor hemifield and relative target hemifield, $F(1, 56) = 13.62$, $p = .001$, $\eta_p^2 = .196$, and the three-way interaction, $F(1, 56) = 5.85$, $p = .019$, $\eta_p^2 = .095$, were significant. The three-way interaction shows that the pattern of results was reliably different between Experiments 1 and 2.

Discussion

Interference with colour targets in the present experiment was greater than with shape targets in Experiment 1, showing that interference was increased when target and distractor were defined on the same perceptual dimension. While we replicated the shorter search times on distractor-absent trials for targets in the RVF that we already observed in Experiment 1, we did not find asymmetric interference. That is, interference with contralateral targets was equal for distractors in the LVF and RVF, whereas it was larger for distractors in the RVF in Experiment 1. Thus, the RVF orienting-bias hypothesis is limited in scope and is modulated by the type of search task. In particular, we found the orienting-bias hypothesis to hold with low target–distractor similarity in Experiment 1, but not with high target–distractor similarity in Experiment 2. Finally, we confirmed larger interference with ipsilateral than contralateral targets, which is likely to result from the smaller target–distractor distance.

General discussion

We evaluated the RVF orientation-bias hypothesis (Pollmann, 1996, 2000) in two experiments. In both experiments, the distractor was a salient colour stimulus, but the nature of the target was varied: It was a shape target in Experiment 1 and a colour target in Experiment 2. In both experiments, we observed that search times were shorter for targets presented in the RVF, which is broadly consistent with the RVF orienting-bias. In Experiment 1, we observed that interference from the colour distractor was stronger in the RVF with contralateral targets, providing direct support for Pollmann's RVF orienting-bias hypothesis. In contrast, we found no evidence for stronger interference from RVF distractors in Experiment 2 where target–distractor similarity was increased.

Stronger interference from RVF distractors

The present study provides converging evidence for the conclusion that attentional asymmetries may change as a function of task demands. Whereas tasks with high temporal uncertainty (RSVP) promote stronger interference from LVF distractors (Asanowicz et al., 2013; Burnham et al., 2011; Du & Abrams, 2010; Śmigasiewicz et al., 2014), tasks without temporal uncertainty, but with strong spatial competition promote stronger interference from RVF distractors (Pollmann, 1996, 2000). However, the latter conclusion is further qualified by the search strategy. While RVF distractors caused stronger interference when target and distractor were unique elements on different dimensions in Experiment 1, partially allowing for stimulus-driven search, RVF distractors were not different from LVF distractors when target and distractor were defined on the same perceptual dimension in Experiment 2, forcing stronger top-down control on distractor-present trials.

In contrast, there is evidence that the LVF advantage in RSVP tasks increases when the involvement of top-down search goals increases. Notably, the LVF advantage with central RSVP streams was observed when the peripheral distractor matched the target colour, that is, when the distractor matched the top-down search goal of the observer (Burnham et al., 2011; Du & Abrams, 2010). Further, the LVF advantage for matching distractors was attenuated when the colour target in the RSVP task was easy to find because it was a singleton (Burnham et al., 2011), suggesting that the LVF advantage decreased when bottom-up control increased. Strong top-down control is also evident in the LVF bias in experiments with two RSVP streams with letter stimuli, where participants were required to first detect a letter with a different colour and then a digit with the same colour as the letters (Asanowicz et al., 2013; Śmigasiewicz et al., 2014). An LVF advantage was observed for identification of the digit, which cannot be identified on the basis of bottom-up saliency signals because digits and letters are very similar.

In the present study, we observed the opposite. The RVF bias disappeared when top-down control increased. When the target was distinct from the distractor in Experiment 1, search on distractor-present trials was more strongly driven by bottom-up saliency signals from the target. Consequently, interference from the distractor was small. In Experiment 2, target–distractor similarity was greater and top-down search goals were more important to locate the target on distractor-present trials. Consequently, the interference from the distractor was much larger. Thus, task requirements that require greater top-down control appear to eliminate the RVF orienting-bias, whereas the LVF advantage in RSVP tasks persists in tasks with strong top-down control.

In sum, the conditions for stronger interference by LVF distractors involve temporal competition and high target–distractor similarity whereas the conditions for stronger interference by RVF distractors involve spatial competition and low target–distractor similarity. However, the same distractor feature (colour) may yield LVF and RVF advantages depending on the task requirements.

Faster responses to RVF targets

We observed that search for targets in the RVF was facilitated compared to targets in the LVF. In previous studies on search asymmetries, a dominance for the LVF was reported when search was efficient, whereas dominance of the RVF was reported when search was inefficient (Poynter & Roberts, 2012). Similarly, Polich observed that same/different judgements were better in the LVF when the deviant line orientation was easy to detect (Polich, 1984), whereas there was a RVF advantage when the deviant line orientation was difficult to detect because the arrangement of the lines was irregular (Polich, DeFrancesco, Garon, & Cohen, 1990). These findings are consistent with the notion of an LVF specialization for global properties (e.g., low spatial frequency) whereas there is a RVF specialization for local properties (e.g., high spatial frequencies) (Delis, Robertson, & Efron, 1986; Kitterle, Christman, & Hellige, 1990; Weissman & Woldorff, 2005).

In contrast to previous studies, participants in our experiments searched for a compound stimulus where observers reported a feature (i.e., the line orientation) inside the shape or colour target. The search for shape singletons in Experiment 1 was similar to the feature search condition in Poynter and Roberts (2012), because the shape singleton was also a pop-out target. However, the line orientation inside the stimulus elements did not allow for feature search because there were as many horizontal as vertical bars. Thus, the discrimination of line orientation was closer to the less efficient conjunction search in Poynter and Roberts (2012) than to feature search. Because the compound task involved a global feature search component and a local line orientation discrimination, it may be possible that the

performance asymmetries cancel out. However, our results provide a clear answer. In both experiments, there was a consistent RVF advantage, suggesting that the orientation task, which was local in nature, determined the dominant hemifield. If one assumes that the pop-out stimulus was localized before the line orientation was determined, it would also be the last of two processing stages that is reflected in the hemifield advantage. Thus, we speculate that in a chain of visual processes, asymmetries do not cancel, but the last determines the hemispheric asymmetry.

Acknowledgements

We wish to thank Alina Miny, Elsa Gogniat, Vera Bignoli and Greta Miknevičute for their help in running the experiments.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Swiss National Foundation (SNF 100014_156487).

References

- Asanowicz, D., Smigajewicz, K., & Verleger, R. (2013). Differences between visual hemifields in identifying rapidly presented target stimuli: Letters and digits, faces, and shapes. *Frontiers in Psychology, 4*, 452. doi:10.3389/fpsyg.2013.00452
- Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Perception & Psychophysics, 55*(5), 485–496. doi:10.3758/BF03205306
- Barras, C., & Kerzel, D. (2016). Active suppression of salient-but-irrelevant stimuli does not underlie resistance to visual interference. *Biological Psychology, 121*, 74–83. doi:10.1016/j.biopsycho.2016.10.004
- Burnham, B. R., Rozell, C. A., Kasper, A., Bianco, N. E., & Dellituri, A. (2011). The visual hemifield asymmetry in the spatial blink during singleton search and feature search. *Brain and Cognition, 75*(3), 261–272. doi:10.1016/j.bandc.2011.01.003
- Delis, D. C., Robertson, L. C., & Efron, R. (1986). Hemispheric specialization of memory for visual hierarchical stimuli. *Neuropsychologia, 24*(2), 205–214. doi:10.1016/0028-3932(86)90053-9
- Du, F., & Abrams, R. A. (2010). Visual field asymmetry in attentional capture. *Brain and Cognition, 72*(2), 310–316. doi:10.1016/j.bandc.2009.10.006
- Duncan, J., & Humphreys, G. W. (1989). Visual search and stimulus similarity. *Psychological Review, 96*, 433–458. doi:10.1037/0033-295X.96.3.433
- Gaspar, J. M., & McDonald, J. J. (2014). Suppression of salient objects prevents distraction in visual search. *Journal of Neuroscience, 34*(16), 5658–5666. doi:10.1523/JNEUROSCI.4161-13.2014
- Grabowska, A., Herman, A., Nowicka, A., Szatkowska, I., & Szelag, E. (1994). Individual differences in the functional asymmetry of the human brain. *Acta Neurobiologiae Experimentalis, 54*(2), 155–162.

- Heilman, K. M., & Van Den Abell, T. (1979). Right hemispheric dominance for mediating cerebral activation. *Neuropsychologia*, 17(3–4), 315–321. doi:10.1016/0028-3932(79)90077-0
- Kinsbourne, M. (1993). Orientational bias model of unilateral neglect: Evidence from attentional gradients within hemispace. In I. H. Robertson & J. C. Marshall (Eds.), *Unilateral neglect: Clinical and experimental studies*. Hove: LEA.
- Kitterle, F. L., Christman, S., & Hellige, J. B. (1990). Hemispheric differences are found in the identification, but not the detection, of low versus high spatial frequencies. *Perception & Psychophysics*, 48(4), 297–306. doi:10.3758/BF03206680
- Mathôt, S., Hickey, C., & Theeuwes, J. (2010). From reorienting of attention to biased competition: Evidence from hemifield effects. *Attention, Perception, & Psychophysics*, 72(3), 651–657. doi:10.3758/APP.72.3.651
- Śmigajewicz, K., Asanowicz, D., Westphal, N., & Verleger, R. (2014). Bias for the left visual field in rapid serial visual presentation: Effects of additional salient cues suggest a critical role of attention. *Journal of Cognitive Neuroscience*, 27(2), 266–279. doi:10.1162/jocn_a_00714
- Śmigajewicz, K., Westphal, N., & Verleger, R. (2017). Leftward bias in orienting to and disengaging attention from salient task-irrelevant events in rapid serial visual presentation. *Neuropsychologia*, 94, 96–105. doi:j.neuropsychologia.2016.11.025
- Mounts, J. R. (2000). Evidence for suppressive mechanisms in attentional selection: Feature singletons produce inhibitory surrounds. *Perception & Psychophysics*, 62(5), 969–983. doi:10.3758/Bf03212082
- Polich, J., DeFrancesco, D. P., Garon, J. F., & Cohen, W. (1990). Hemispheric differences in visual search of simple line arrays. *Psychological Research*, 52(1), 54–61. doi:10.1007/BF00867212
- Polich, J. (1984). Hemispheric patterns in visual search. *Brain and Cognition*, 3(2), 128–139. doi:10.1016/0278-2626(84)90012-5
- Pollmann, S. (1996). A pop-out induced extinction-like phenomenon in neurologically intact subjects. *Neuropsychologia*, 34(5), 413–425. doi:10.1016/0028-3932(95)00125-5
- Pollmann, S. (2000). Extinction-like effects in normals: Independence of localization and response selection. *Brain and Cognition*, 44(3), 324–341. doi:10.1006/brcg.1999.1195
- Posner, M. I., & Cohen, Y. (1984). Components of visual orienting. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and performance X* (pp. 531–556). Hillsdale, NJ: Erlbaum.
- Poynter, W., & Roberts, C. (2012). Hemispheric asymmetries in visual search. *Laterality: Asymmetries of Body, Brain and Cognition*, 17(6), 711–726. doi:10.1080/1357650X.2011.626558
- Shulman, G. L., & Corbetta, M. (2012). Two attentional networks: Identification and function within a larger cognitive architecture. In M. I. Posner (Ed.), *Cognitive neuroscience of attention* (Vol. 2, pp. 113–128). New York, NY: Guilford Press.
- Theeuwes, J. (1991). Cross-dimensional perceptual selectivity. *Perception & Psychophysics*, 50(2), 184–193. doi:10.3758/BF03212219
- Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception & Psychophysics*, 51(6), 599–606. doi:10.3758/BF03211656
- Vallar, G. (1998). Spatial hemineglect in humans. *Trends in Cognitive Sciences*, 2(3), 87–97. doi:10.1016/S1364-6613(98)01145-0
- Weissman, D. H., & Woldorff, M. G. (2005). Hemispheric asymmetries for different components of global/local attention occur in distinct temporo-parietal loci. *Cerebral Cortex*, 15(6), 870–876. doi:10.1093/cercor/bhh187