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Automatic focusing of attention on object size and shape

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In two experiments we investigated the automatic adjusting of the attentional focus to simple geometric shapes. The participants performed a visual search task with four stimuli (the target and three distractors) presented always around the fixation point, inside an outlined frame not related to the search task. A cue informed the subject only about the possible size and shape of the frame, not about the target. The results of the first experiment showed faster target detection in the valid cue trials, suggesting that attention was captured automatically by the cue shape. In the second experiment, we introduced a flanker stimulus (compatible or incompatible with the target) in order to determine if attentional resources spread homogenously inside and outside the frame. The results showed that performance depended both on cue validity and frame orientation. The flanker effect was dependent on compatibility and flanker position (vertical or horizontal meridian). The results of both experiments suggest that the form of an irrelevant object can capture attention despite participants' intention and the results of the second experiment suggest that the attentional resources are more concentrated along the horizontal meridian.

In the last 25 years, the study of visual attention has been dominated by focus theory. Posner and his colleagues (Posner, 1980; Posner, Snyder & Davidson, 1980) endorsed an analogy according to which attention travels through the visual field, in the absence of ocular movements, such as the focus of a spotlight in a dark room, illuminating only restricted regions of the space. Stimuli located in the area covered by the attentional focus are processed faster than stimuli outside the focus. Besides moving through space, the attentional focus would have a flexible size being able to be concentrated in a small point or to be extended to enclose a large region. The concentration of the attentional resources would be inversely proportional to the size of the attended area. In this way the attentional focus would be analogous to an optical zoom lens that, with the open zoom, could enclose a great area, with a

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low power of resolution, and with closed zoom at one specific point, it would permit analysis of much detail, but within a restricted region of the visual field. Given the fixed amount of resources and its homogeneous distribution inside the focused area the processing of the stimuli under the extended focus would be slower than the processing inside a smaller area (Eriksen & Yeh, 1985; Eriksen & St. James, 1986).

The adjustment of the size of the attentional focus was investigated by Castiello and Umiltà (1990) in an experimental paradigm similar to that used by Posner (1980). The experimental task was a simple detection, and the place where the imperative stimuli would be presented was 10 degrees of visual angle to the right or to the left of the fixation point. The stimulus place was cued by an outline square of variable size, and the cue remained visible until the end of the trial. The imperative stimulus was presented inside the square. The response time (RT) to the imperative stimulus presented inside the cued area was inversely proportional to the cue size. But the cue size effect was significant only when the interval between cue and stimulus was long, around 500 ms. According to the authors, this interaction between cue size and cue-to-stimulus interval suggests that two processes can be involved: the orientation of the attentional focus to the cued place, and adjustment of the attentional focus to the size of the cued area.

In order to study the dependence between the focalization and orienting, Maringelli and Umiltà (1998) used an experimental paradigm in which the imperative stimulus and the cue were presented always in the center of the screen, eliminating the requirement of the orienting process. The procedure involved the presentation of an outline square (3 x 3 or 6 x 6 degrees of visual angle) in the center of the screen, followed by the imperative stimulus 100 ms later. The participants were instructed to pay attention to the cue. It should be noted, however, that this instruction was irrelevant since the cue was completely uninformative regarding the detection task. The results showed that the detection of the imperative stimulus was faster when the cue was small than when it was large, suggesting that the focalization process can happen early when the orienting aspect was eliminated. According to the authors, the cue size effect obtained with short intervals (100 ms) suggests that the focalization process is automatic. The simple presentation of the cue in the visual field would capture the attention reflexively, such as proposed by Remington, Johnston and Yantis (1992).

Turatto, Benso, Facoetti, Galfano, Mascetti and Umiltà (2000) have used the criterion of intentionality, proposed by Yantis and Jonides (1990) to investigate the automatic characteristics of the focalization process. According to the criterion of intentionality, an automatic process cannot be submitted to voluntary control. It can also not be facilitated by the focalization of attention at a stimulus, nor inhibited by the focalization of attention at another stimulus (Kahneman & Treisman, 1984). The procedure adopted by Turatto et al. involved the presentation of a cue, a large or small circle, for 738 ms, followed by a second cue, large or small circle, inside of which the target would be presented 66 ms later. The results showed that the appearance of the second cue with a different size produced a readjustment of the size of the attended area, even when the participant was instructed to pay attention only to the first cue and to ignore the second. The results suggest that the focalization is independent of orienting, and that it is based on an automatic mechanism, which is released by the abrupt appearance of an object in the visual field. Turatto et al. identified this process as the focalization reflex, analogous to the orienting reflex proposed by Posner et al. (1980).

In the present study we explored the possibility that the focalization reflex would be sensitive also to other aspects of the cue, like its shape, and not only to its size. Initial studies designed to disentangle the contribution of cueing the shape and cueing the spatial position to the performance of a detection task had failed to show any effect of shape. When compared with the information about the spatial position where the stimulus would appear, the information about shape of the imperative stimulus, or the shape inside which the imperative stimulus would be presented, had no effect on stimulus processing efficacy (Posner et al., 1980; Theuwees, 1989). In a recent study, Schendel, Robertson and Treisman (2001) evaluated separately the effect of a cue for the object and the effect of a cue for the position in which the imperative stimulus would be presented. Their results showed the classic effect of facilitation that follows the cueing of spatial position. They also showed that the identity (shape) of the position marker had little if any influence on the mechanisms of automatic orienting of attention.

Other studies have shown that attention can voluntarily privilege the processing of stimuli presented in regions with specific spatial distributions or shapes. For example, Egly and Homa (1984; see also Juola, Bouwhuis, Cooper & Warner, 1991; Heinze, Luck, Münte, Gös, Mangun & Hillyard, 1994; Muller & Hubner, 2002) have shown a privileged processing of stimuli presented in annulus-shaped regions. Our studies also have shown that the attentional focus can be voluntarily adjusted to a particular shape that specifies the region in which the search stimuli will be presented (von Grünau, Panagopoulos, Galera & Savina, 2002; Panagopoulos, von Grünau & Galera, 2004). However, Usai, Umiltà and Nicoletti (1995) showed that participants were incapable of ignoring the information coming from inside a critical area that they had been instructed to ignore, suggesting that although the focus can be enlarged to cover an area with specific shape, it has a reduced flexibility.

In the present study we intended to investigate the reflexive capture of attention by an object that was completely irrelevant to the given task. The assumption underlying the experimental paradigm is common to many studies of attentional capture: if attention is directed to an object that is irrelevant to an ongoing task but affects performance negatively, then the attentional allocation can be considered involuntary, independent of the intention of the observer (Pashler, Johnston & Ruthruff, 2001). It is also true that attention that is involuntarily allocated to irrelevant objects can improve the performance of the relevant task, provided the relevant and irrelevant stimuli are close to each other. When an irrelevant stimulus is presented next to the place where the relevant stimulus will be presented there is an improvement in performance, even if the participant knows that the irrelevant stimulus should be ignored (Theeuwes, 1991).

The experimental paradigm we used involved the presentation of the stimuli of a visual search task within a frame defined by a geometric figure, not related to the search task. The stimuli of the search task and the frame were preceded by a cue, that could be equal to (valid cue) or different from (invalid cue) the frame. The assumption was that the shape of the cue could act as a prime for the shape of the frame, speeding up its processing and the processing of the stimuli presented within it.

EXPERIMENT 1

METHOD

Participants. The first author and eleven students of USP at Ribeirão Preto, both male and female, aged between 17 and 47 years, with normal or corrected-to-normal acuity, participated in this experiment. The students received approximately US$ 5.00 for their participation.

Materials and stimuli. The experiment was controlled by E'Prime (Psychological Software Tools Inc.) running on a Pentium III. The stimuli were presented on a Nec Multisync FE-950 monitor, with a 60Hz refresh rate. The distance from the screen to the subject's eye was approximately 60 cm. The stimuli of the search task, the target and three distractors, were black Ts (0.9 cd/m^2) presented on a white screen (70 cd / m^2). The target was a T rotated 90 degrees to the left or the right. The distractors were Ts in the normal position or upside-down. The T segments had 0.6 x 0.6 degrees of visual angle and a thickness of 0.08 degrees. The search stimuli were presented in the four cardinal positions around the fixation point, a plus sign (+) with 0.4 degrees of visual angle, presented in black in the center of the monitor screen. The distance between the geometric center of each stimulus and the center of the fixation point was 1.1 degrees of visual angle. Cues and frames could be presented in three shapes: a square (3.4 x 3.4 degrees), a vertical and a horizontal rectangle (9.8 x 3.4 degrees), outlined in black with edge thickness of 0.11 degrees. In trials without a cue, a warning signal, namely the fixation point being presented in green, signaled the moments where the cue or the frame would have to be presented.

Procedure. The participant's task was to discriminate as fast and accurately as possible the orientation of the target in a visual search task. Each trial began with the presentation of the trial number for 500 ms. The fixation point was presented one second after the trial identification number and remained in the center of the screen until the end of the trial. The cue was presented 500 ms after the beginning of the fixation point and remained on the screen for 50 ms. Between the presentation of the cue and the presentation of the frame and stimuli there was a 50 ms inter-stimulus-interval during which only the fixation point was present (SOA = 100 ms). The frame and the stimuli remained on the screen for 50 ms and were followed by a blank screen just with the fixation until a response was given. Response time (RT) was measured from the beginning of stimulus presentation.

The combination of the three geometric shapes (square, horizontal and vertical rectangles) produced three types of valid cues for size and shape (square-square, vertical-vertical, horizontal-horizontal), four types of invalid cues for size and shape (square-horizontal, square-vertical and vice versa), and two types of invalid cues for shape (horizontal-vertical and vertical-horizontal). There was a condition without a cue, in which no shape was presented. In this case, to keep the same temporal sequence of events as in the cue trials, the color of the fixation point changed to green at the moment when the cue or frame would otherwise have occurred (in these trials neither the cue nor the frame were presented).

Each participant took part in one experimental session lasting approximately 40 minutes. Before the beginning of the session the participant was informed regarding the nature of the task and was instructed to ignore the geometric shapes, since these stimuli were not relevant to the search task. The participants were also instructed to always look at the fixation point and not to move the eyes. It was explained that this would be the best strategy to answer fast and accurately. At the beginning of the session, there were 20 training trials with the same characteristics as the experimental trials; these training trials were not taken into account for the analysis of the results. In each session there were 192 trials with a valid cue, 64 trials with an invalid cue for size, 32 trials with an invalid cue for shape and 32 trials without cue, totaling 320 trials presented in random order.

RESULTS AND DISCUSSION

The RTs of the incorrect responses (0.69%) were not analyzed. The mean RTs of each subject were submitted to a one way analysis of variance with repeated measures on the three different cue type treatments (valid, invalid and without cue; $F(2,20) = 6.84$; $p = 0.005$). A post-hoc test (Newman-Keuls, $p = 0.05$) showed that the RT obtained with valid cues (613 ms) was faster than that obtained with invalid cues (638 ms) and also faster than that obtained in the no-cue trials (647 ms).

A second analysis of variance was conducted with the eight treatments that resulted from the combination of the three geometric shapes (square, vertical and horizontal rectangles) and the no cue trials (Figure 1). RT varied significantly between treatments ($F(7,70) = 4.13$, $p = 0.001$). The post-hoc test (Newman-Keuls, $p = 0.05$) showed that for the valid cue trials RT obtained with the square (609 ms), the vertical (612 ms) and horizontal (617 ms) cue shapes were not different from each other, and all were faster than the RT obtained in the vertical-horizontal invalid cue trials (665 ms) and in the no cue trials (647 ms). None of the invalid cue conditions was accompanied by a significant cost as compared to the no-cue trials.

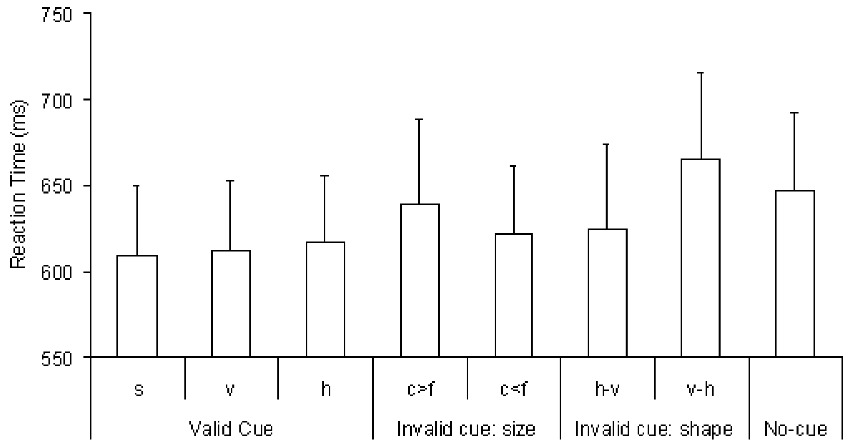

Figure 1. Mean reaction times and SE of the mean (bars) in Experiment 1 for different types of valid and invalid cues and for no cue trials. s = square, v = vertical rectangle and h = horizontal rectangle; c > f and f > c stand for trials where the cue size was lager than the frame, and smaller than the frame, respectively; h-v and v-h stand for trials where the cue was horizontal and the frame was vertical, and trials where the cue was vertical and the frame was horizontal.

According to the zoom lens model (Eriksen & Yeh, 1985; Eriksen & St. James, 1986; Laberge, 1983; Castiello & Umiltà, 1990), we should have obtained a cue size effect, but in our data it appears only as a tendency. In the valid cue trials, where the size effect could have been revealed more clearly, there is only a tendency without statistical significance of slower responses in trials with the rectangles (larger area, 614 ms) than in trials with the square (smaller area, 609 ms). With an invalid cue for size, RT tends to be faster in the presence of the large frame (c<f; 622 ms) than in the presence of the small frame (c>f; 639 ms), going in the direction opposite to the expected cue size effect, and contrary to what could be expected if readjustment of the size of the attentional focus to the frame had occurred, such as suggested by Turatto et al. (2000). If one assumes, however, that at the moment the stimuli and frame are presented, the attentional focus keeps the cue size (and perhaps its shape), and the attentional focus is directed to the search task stimuli, without readjusting to the frame, the present results can be understood.

An interesting and unexpected result was the difference in the RTs in invalid cue trials with stimuli presented inside of the vertical (h-v) and horizontal frame (v-h). While there was a tendency for a gain in the trials with the vertical frame (h-v), trials with the horizontal frame (v-h) resulted in longer

RTs. This result suggests that, if a readjustment in the shape of the attentional focus occurred, it was not symmetrical. It appears easier to readjust the orientation of the focus from the horizontal to the vertical than vice versa. Another possibility is that the stimuli presented on the horizontal meridian receive a different kind of processing than the stimuli presented on the vertical meridian (see next experiment).

According to our results, the information given by the irrelevant cue was used to privilege the processing of the stimuli presented inside the cued geometric shape, in a way analogous to what happens with a spatial cue. According to the zoom lens model, the appearance of the cue starts an automatic redistribution of the attentional resources that are initially distributed throughout the visual field. This redistribution will affect task performance as a function of the size of the area within which the attentional resources are concentrated. Our results show that this redistribution of resources depends not only on the size of the geometric form, as shown by Turatto et al. (2000), but also on its shape.

EXPERIMENT 2

Once it had been shown that information about object shape or orientation can affect the performance in the search task, the next question to be investigated concerned the edge of the attentional focus. If the edges of the focal area can be molded by experimental manipulations, we must show that the processing inside the edges is different from that outside. We evaluated the processing difference inside and outside of the attentional focus by comparing the effect of a flanker stimulus located inside or outside the area that is supposedly covered by the focus. If there are no differences between the processing of stimuli inside and outside the focus, then we will be able to conclude that attention is not restricted to the specified area. This method was used initially by Eriksen and Eriksen (1974), and several studies have shown that the deleterious effect of a flanker stimulus on the recognition task depends on the compatibility between the flanker and the relevant stimuli. The RT tends to be slower with an incompatible flanker than with a compatible one (eg. Miller, 1991; Sanders & Lamers, 2002). Facoetti and Molteni (2000) showed that performance is more affected when an incompatible flanker is present in the visual scene, and that the effect of the type of flanker depends on the size of the cued area and/or the position of the flanker in relation to the attended area. Shomenstein and Yantis (2002) showed that the effect of a flanker is larger when it is presented in the same object as the target, but this effect depended on the position of the flanker only when the position of the relevant stimuli was uncertain. Just in this case does the distribution of attention seem to have been limited by the edges of the object that enclosed the target.

In the present experiment we evaluated the effect of a flanker inside and outside the cued shapes. If the shape of the focus depends on the shape of the object, and if the concentration of resources is bigger inside the focus, then the effect of the flanker should be larger when it is presented inside as opposed to outside of the area delimited by the frame in the valid cue trials.

METHOD

Participants. The first author and nine volunteers, all with normal or corrected-to-normal acuity, participated in this experiment. The volunteers received approximately US$ 5.00 to participate in one experimental session.

Materials and Stimuli. This experiment was carried out with the same equipment and the same search stimuli and rectangles used in the previous experiment. The flanker was a letter T turned to the right or left, like the target, but presented at the four cardinal positions at 3.6 degrees of visual angle around the fixation point (Figure 2).

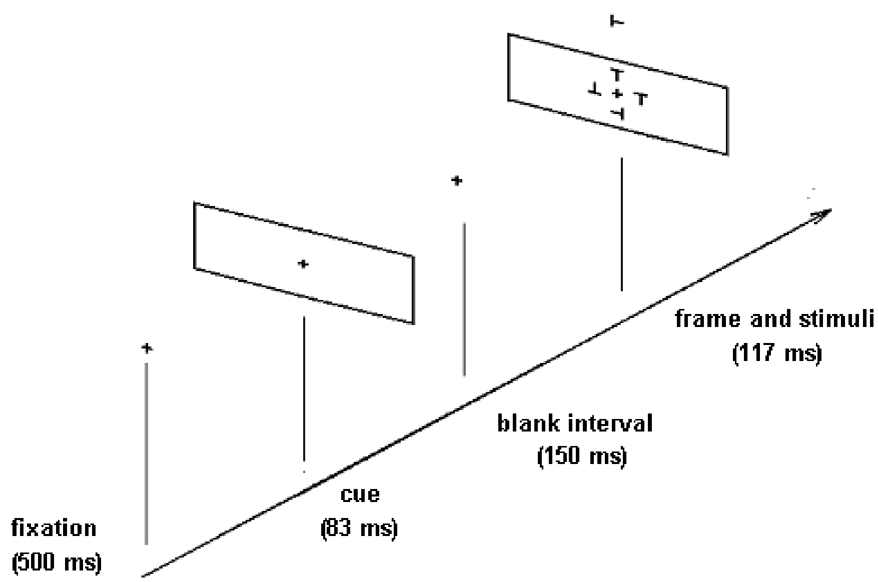

Figure 2. Sequence of events and example of stimuli of the visual search task (target rotated to right) and an incompatible flanker (rotated to left) used in Experiment 2.

Procedure. The visual task was the same as in the previous experiment, except that the flanker was present. Each trial started with the presentation of its number in the center of the screen for 500 ms. One second after the trial number had disappeared, a fixation cross was presented at the center of the screen and remained there until the end of the trial. 500 ms after the onset of fixation, the first cue was presented for 83 ms. There was a 150 ms blank interval and then the stimuli and the frame were presented for 117 ms (SOA = 233 ms). Four experimental factors were manipulated: cue shape (horizontal, vertical), cue validity (valid, invalid, without cue), flanker compatibility (compatible, incompatible), and position of the flanker (horizontal, vertical meridian). The cue was horizontal on half of the trials, and vertical on the other half. The flanker was present on each trial and could be compatible or incompatible with the target. In trials with valid and invalid cues, the flanker was inside the area covered by the cue on half of the trials, and outside on the other half. The participants took part in one experimental session with 448 trials, 256 with a valid cue, 128 with an invalid cue and 64 trials without cue.

RESULTS AND DISCUSSION

In a first analysis, the RTs of the correct answers (98.8%) were submitted to a one way analysis of variance with repeated measures on the three different cue type treatments (valid, invalid and without cue). The RTs obtained in the valid (570 ms) and invalid cue trials (574 ms) were faster than RTs obtained in the no cue trials (598 ms; $F(2,18) = 19.84$; $p < 0.001$).

In a second analysis, the RTs obtained on valid and invalid cue trials were analyzed separately as a function of frame orientation (horizontal, vertical), flanker position (horizontal, vertical) and flanker compatibility (compatible, incompatible). In the no-cue trials, RTs were analyzed for flanker position and compatibility. For the valid cue trials (Figure 3A), the performance on the search task was affected by the flanker compatibility only when the flankers were presented on the horizontal meridian ($F(1,9) = 7.29$; $p = 0.024$). In general, the incompatible flanker resulted in longer RTs (575 ms) than the compatible flanker (565 ms; $F(1,9) = 6.69$; $p = 0.029$). When the flanker was presented on the vertical meridian it resulted in shorter RTs (560 ms) than when presented on the horizontal meridian (580 ms; $F(1,9) = 13.17$; $p = 0.005$). Performance was marginally better in the trials with vertical (564 ms) than with horizontal shapes (575 ms; $F(1,9) = 4.54$; $p = 0.062$). On the invalid cue trials (Figure 3B), the search task performance was affected only by the flanker compatibility, the incompatible flanker having a larger effect (583 ms) than the compatible one (564 ms; $F(1,9) = 12.30$; $p = 0.01$).

On the no-cue trials (Figure 3C), the flanker also had a more deleterious effect when presented on the horizontal (620 ms) than on the vertical meridian (590 ms, $F(1,9) = 10.69$; $p = 0.01$), and the incompatible flanker had a more deleterious effect (618 ms) than the compatible one (592 ms, $F(1,9) = 11.95$, $p = 0.007$). In these trials, the interaction between flanker position and compatibility was not significant ($p = 0.31$).

In order to compare the effect of the flanker inside and outside of the area covered by the cue and frame in the valid cue trials, we conducted a separate analysis of variance with the RTs obtained with horizontal and vertical frames. Each of these analyses took into account the flanker compatibility (compatible, incompatible) and flanker position (horizontal, vertical) as experimental factors. In the trials with the horizontal cue, the interaction between compatibility and position of the flanker showed that the incompatible flanker led to longer RTs (602 ms) than the compatible flanker (572 ms) only when it appeared inside the frame ($F(1, 9) = 12.46$; $p < 0.006$). Both compatible and incompatible flankers had the same effect (565 ms) outside the horizontal cue. This analysis showed that the flanker presented inside the frame resulted in longer RTs (587 ms) than the flanker presented outside the frame (565 ms; $F(1,9) = 9.94$; $p = 0.01$). The same analysis, conducted on the trials that used the vertical cue showed only that the effect of the incompatible flanker was larger (567ms) than that of the compatible flanker (560 ms; $F(1, 9) = 5.22$; $p = 0.05$). We made a similar analysis on the invalid cue trials in terms of frame orientation. In these trials, the flanker compatibility had a significant effect only with the horizontal frame [$F(1,9) = 7.81$, $p = 0.021$], but did not matter when the flanker was presented at the horizontal or at the vertical meridian, that is, inside or outside the frame ($p = 0.98$). In trials with the vertical frame neither the compatibility nor the position of the flanker had a significant effect.

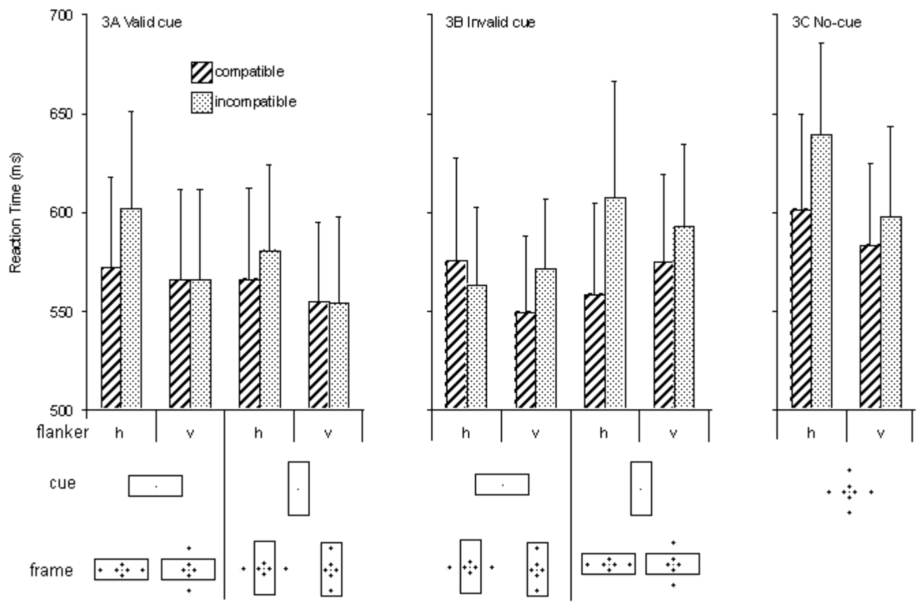

Figure 3. Mean reaction times and SE of the mean (bars) in Experiment 2 for valid (3A), invalid (3B), and no-cue (3C) trials for both compatible and incompatible flanker. Frames with a schematic representation of the stimuli, as well as the possible positions being occupied by the flankers (h = horizontal, v = vertical meridian).

In this experiment, the results show that RT was shorter in trials with valid and invalid cues in comparison to the no-cue trials. According to the intentionality criterion, the improvement in the valid cue trials suggests a reflexive capture of attention. The facilitation also occurred for trials with invalid cues, where the cue and frame orientation changed. The zoom lens model is not clear about the effect of invalid cues on RT performance. According to Theuwees (1989), the zoom lens model assumes a gain in the processing of the valid cue trials, but does not consider a cost in the invalid cue trials, because the cost would be associated with controlled processes and not with automatic processes. The latter seem to be involved in our task.

RT was faster when the stimuli were presented inside the vertical rather than inside the horizontal shape. The effect of the flanker also was smaller when these stimuli were presented inside the vertical shape and larger when presented inside the horizontal shape. This difference between vertical and horizontal meridian suggests an asymmetry in the distribution of the attentional resources in the visual field, which has been reported previously. Sanders and Brück (1991), for example, suggested that the attentional resources would be more concentrated along the horizontal meridian. Carrasco, McElree and Giordano (2002) also showed the information processing rate to be faster along the horizontal than the vertical meridian; but the information accrual is more accelerated at the least privileged locations, on the vertical meridian.

The present results obtained with the flanker are consistent with the effect found in other studies and can be interpreted in terms of the conflict between the different responses activated by the target and the flanker (Eriksen & Eriksen, 1974; Eriksen & Schultz, 1979). The incompatible flanker has a more accentuated effect when presented on the horizontal meridian. On the valid cue trials, this effect tends to be larger when both frame and flanker are presented on the horizontal meridian, as opposed to when they are presented on the vertical meridian.

GENERAL DISCUSSION

The automatic processing of an event or stimulus affects the performance of a priority task even when it is in the interest of the participant to ignore it. The automatic process is under the control of the stimulus and not under the control of the intentions, strategies and plans of the participant (Theeuwes, 1991). In our experimental paradigm we intended to determine if the performance of a search task would be affected by the presence of a geometric shape that framed the stimuli of the search task, to which the frame was not related. Our basic assumption was that the presentation of the cue would start a reflexive capture of attention, priming the object shape. The subsequent presentation of the search task stimuli inside the cued shape would allow its privileged processing, in an analogous way to what happens with stimuli presented in cued objects and spatial positions (eg. Egly, Driver & Rafal, 1994; Posner et al., 1980).

In the two experiments, the valid cue provided an improvement in performance in relation to no-cue trials, suggesting that information about the size and orientation of the frame could be used to privilege the processing of stimuli presented inside the cued shapes. The fact that this facilitation happened despite the instruction given to the participant to ignore the frames and despite the irrelevance of the frame to the search task, suggests that the capture is involuntary. The efficiency with which this information can be used depends on the characteristics of the object shapes (size and orientation) and on cue validity.

The results also suggest that the distribution of attentional resources may be more concentrated on the horizontal meridian. The attentional resources seem not to be homogeneously distributed in the visual field as assumed by the zoom lens model. The largest cue effects were obtained with horizontal frames and with flankers presented on the horizontal meridian. Other studies confirm that, in fact, performance is worse in trials with a horizontal than with a vertical frame (Galera & von Grünau, 2003). Other studies have also shown that the attentional resources seem to be more concentrated on the horizontal meridian of the visual field (Sanders & Brück, 1993), or that the processing speed is different in the two meridians (Carrasco et al., 2002). Therefore, if the attentional resources are more concentrated along the horizontal meridian, why would the horizontal cue provide a smaller gain than the vertical cue? Our initial answer is that the attentional focus can work not only through privileged processing of some stimuli, but also through the inhibition of other irrelevant stimuli. If the stimuli presented on the horizontal meridian receive more attentional resources, or are processed more quickly, it is possible that they are processed in greater depth and therefore cost more to be inhibited.

It seems inadequate to think of the cueing effect obtained here as a filtering process. According to Kahnemann, Treisman and Burkel (1983), the irrelevant stimuli present in the visual field compete for the attentional resources needed by the relevant task at hand, delaying the appropriate deployment of attention to the relevant stimuli. According to this, the irrelevant stimuli, the geometric shapes in our experiment, would have to be filtered out, thus delaying target detection, which is not evident in our results. If we consider that in the valid cue trials, the anticipated presentation of the shape of the frame could have facilitated the filtering process, it would be difficult to explain the gain in processing obtained in these trials. Even a very efficient filtering, that would not be accompanied by costs, would not produce gains as were obtained in this experiment. Moreover, if we admit that filtering could be facilitated in the valid trials, it would then be difficult to explain, by the same mechanism, why filtering would also be efficient in the invalid trials, when the object shape changes.

Duncan (1984) suggested that the attentional focus takes the shape of the objects segmented on the basis of the Gestalt grouping principles. The information about the shape of an object could then be used to privilege, through a mechanism of priming, the processing of the object and its characteristics, components or details. The stimuli presented in an object that was already primed would enjoy privileged processing. This is what seems to happen in the valid cue trials. In the valid cue trials, it is also possible that the stimuli of the search task would have the advantage of being the new stimuli in the field, attracting for themselves the available attentional resources. In the invalid cue trials, both the frame and the stimuli of the search task are new, and would compete for the attentional resources. The relevant stimuli would be benefited in this dispute because they were part of the participant's attentional set.

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