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SIZE OF THE ATTENTIONAL FOCUS AND EFFICIENCY OF PROCESSING *

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By following Eriksen and St. James (1986) the experiments reported in this study focused upon three questions: (a) Can the spatial extent of the attentional focus be made to vary in response to precues? (b) As the area of the attentional focus increases, is there a decrease in processing efficiency for stimuli within the focus? (c) Is the boundary of the focus sharply demarked from the residual field or does it show a gradual dropoff? The results seem to provide answers to these questions: (a) the size of the attentional focus can be adjusted so that it covers areas of the visual field of different size; (b) there is a decrease in processing efficiency when the area of the attentional focus increases; and (c) there is a gradual dropoff in processing efficiency around the attentional focus.

Introduction

Several two-stage models of attentional selection have been proposed (Bergen and Julesz 1983; Duncan 1980; Hoffman 1978, 1979; Schneider and Shiffrin 1977), among which that put forward by Jonides (1983) has been the most influential. According to it, there are two modes of attending a visual display: attention can be allocated evenly across the entire display or can be focused on one display location only. In the first mode, all the display elements are processed in parallel at a uniform, and relatively slow, rate. In the second mode, processing of the precued element is facilitated, whereas processing of the other elements is inhibited.

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A common metaphor of the deployment of focal attention is one that likens the focus of attention to the beam of a 'spotlight', which possesses three important properties: it moves from one location to another; it moves in analogue fashion rather than jumping instantaneously from one location to another; and it is characterized by a specific size.

A slightly different metaphor is that proposed by Eriksen and St. James (1986) and Eriksen and Yeh (1985), who believe that a zoom, or variable power, lens is a more apt analogy than a spotlight. In essence, the two metaphors differ only because that of a zoom lens explicitly predicts an inverse relationship between size of the attentional focus and efficiency of processing, whereas that of a spotlight does not necessarily make such a prediction.

Eriksen and St. James (1986) asked three interesting questions about the attentional focus. The first was whether its spatial extent can vary. The second was whether there is a decrease in processing efficiency when the area of the focus increases. The third was whether the boundary of the focus is sharply demarked from the residual field or shows a gradual dropoff. So far, not enough empirical evidence has been gathered to provide definite answers to these questions.

Egeth (1977) was perhaps the first to study whether the size of the attentional focus could vary and whether there was a concomitant reciprocal variation in processing speed. In his study there were large and small visual areas in which targets were presented. Egeth measured recognition latency in a central location that was common for both focus sizes and found that responses were faster with the small than with the large area. Even earlier, similar results were reported by Beck and Ambler (1973), who found that discrimination accuracy was higher when attention was focused than when it was distributed.

More recently, a study by LaBerge (1983) dealt with the question of the spatial extent of focused attention. In it, the primary task was that of identifying five-letter words, or the middle letter of a string of five letters, which could constitute words or nonwords. The probe task required the subjects to respond when a specific digit appeared in one of the five possible letter positions. The idea was that, when attention was narrowly focused to indentify a single letter, the response to a probe shown in that position should be faster than a response to a probe shown in any of the other four positions. When the attentional focus was set to cover the entire five-letter word, the response to the probe should be invariant across the five positions. In accordance with these predictions, for the letter indentification task, reaction times (RTs) to the probe produced a function with a minimum at the middle position, whereas a flat function was found for the word categorization task. Based on these results, LaBerge concluded that the size of attentional focus could vary according to task demands.

LaBerge (1983) also asked the question of the possible inverse relationship between size of the attentional focus and processing efficiency. That is, whether processing was faster when attention was narrowly focused on a single letter than when it was spread to cover five letters. Unexpectedly, the results showed that responses were faster when the focus of attention was wider. In a subsequent study (LaBerge and Brown 1986), this paradoxical finding was not replicated. Rather, it was found that RT at the center location did not depend on the size of the attentional focus.

The hypothesis of an inverse relationship between size of the attentional focus and processing efficiency was addressed also in the study by Eriksen and St. James (1986). In this study subjects were required to search eight-letter circular displays for one or two target letters and RTs were measured. What was manipulated was the number of precued locations and the distance of the distractors from the precued area. The zoom lens analogy predicts that the attentional focus can be enlarged to include all precued locations, provided that they are adjacent, and that speed of response should be inversely related to the size of the precued area. The distance variable allowed to determine whether the focus of attention was sharply demarked or tapered off into the surrounding area. In accordance with the model, speed of response decreased as the size of the precued area increased. In addition, the results suggested that the edge of the attentional focus was not sharply demarked, but was, rather, a graded dropoff. Note, however, that an alternate to the notion that there was a graded dropoff of the attentional focus is that its exact size varied randomly from trial to trial, so that the average effect gave the illusion of a graded dropoff.

In conclusion, of the three questions asked by Eriksen and St. James (1986), the first only has received a reasonably clear answer. It is apparent that the size of the attentional focus is variable and changes according to task demands. Much less certain is whether there is a decrease in processing efficiency as the area of the attentional focus increases. The third question was addressed by only one study that showed a gradual dropoff around the attentional focus.

The present study aimed at gathering further empirical evidence concerning the relationship between the size of the attentional focus and the degree of processing efficiency. However, as will be seen, the results are also of some relevance for what concerns the other two questions, namely whether the size of the attentional focus can change and whether it is surrounded by a sort of attentional fringe.

Before describing the experiments, another feature of the attentional focus must be discussed. The spotlight and the zoom lens metaphors assume that attention cannot be allocated to multiple regions of the visual field. This notion of a unitary attentional focus was supported by a number of studies that showed that benefits in processing efficiency are confined to locations adjacent to the precued one, whereas in nonadjacent locations no benefits, and very often costs, are observed (see, e.g., Eriksen and St. James 1986; Eriksen and Yeh 1985; Jonides 1983; Posner et al. 1980).

Probably, the most intriguing results for the notion that the attentional focus is unitary were those of Egly and Homa (1984). In their study the subject's task was to maintain fixation on a central location and to identify or localize a letter shown at one of eight locations on one of three rings surrounding the fixation point. On cued trials the ring containing the target was specified in advance. The notion of a unitary focus predicts that on invalid trials costs should be greater when the target falls outside the cued ring rather than inside it. Contrary to this prediction, Egly and Homa found that performance was not facilitated when the target appeared within the assumed focus of attention but not on the cued ring. For example, when the target was shown on the intermediate ring, performance was equivalent for invalid cues that indicated the internal ring or the external ring. Based on these results, the authors concluded that attention can be confined to the cued ring, at the expense of locations which fall either outside or inside it. However, Juola et al. (1987) attempted to determine whether attention can be shifted to include regions inside or outside of a circle centered on the fixation point and obtained results in partial disagreement with those of Egly and Homa.

As will be seen, the results of the present study have also some relevance for the issue of whether the attentional focus is unitary or not.

Experiment 1a

In this experiment we adopted Posner's (1980) paradigm, which exploits the covert orienting of attention. In it, differences in RT to stimuli at expected and unexpected positions are used as a measure of the efficiency of detection attributable to the orienting of attention toward the expected position.

Usually there are two well circumscribed locations where the imperative stimulus can be presented. Both positions are clearly marked by two empty boxes (see fig. 1). The subject is instructed (a) to press a key as fast as possible upon stimulus detection, regardless of where the stimulus occurs (simple RT); (b) to fixate the center mark and not to shift gaze; and (c) to orient attention covertly in accordance with the instructions and/or stimulus probability.

On some trials both positions are precued and the stimulus is equally likely to occur in either position (neutral trials). On other trials one position only is precued and the probability is much higher that the stimulus will occur in that position (valid trials) than in the other (invalid trials). By calculating the difference in speed of response

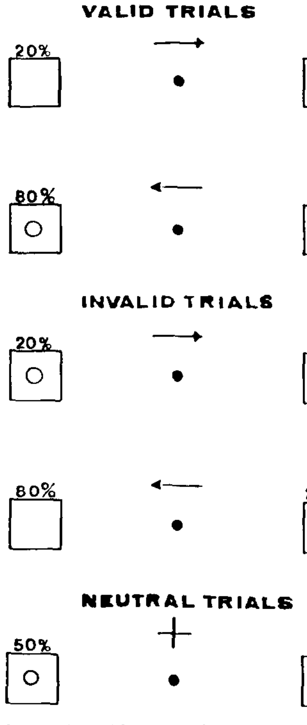

Fig. 1. Schematic drawing of Posner's (1980) paradigm for the study of the covert orienting of attention.

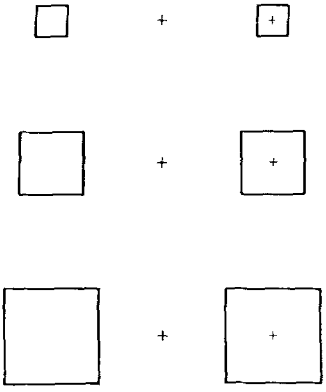

Fig. 2. Schematic drawing of the visual display employed in experiment 1a. In the valid condition only one box was shown whereas both boxes were shown in the neutral condition.

between neutral and valid trials and between invalid and neutral trials, it is possible to estimate the benefits and the costs caused by the covert orienting of attention. The procedure of the first experiment to be described differed slightly from Posner's basic paradigm: there were only neutral and valid trials and the boxes that marked the possible stimulus positions varied in size (see fig. 2). Invalid trials were not used because we thought that subjects could adapt the size of the attentional focus to the size of the box only at the expected position.

Method

Subjects

Eight students (4 males and 4 females) of the University of Parma participated in the experiment and were paid for their collaboration. They were all right-handed according to the Edinburgh Inventory (Oldfield 1971), had normal or corrected vision and were ignorant as to the purpose of the experiment.

Apparatus

The subject sat in front of a CRT screen driven by an Apple IIe personal computer. The head was positioned in an adjustable head-and-chin rest, so that the distance between the eyes and the screen was approximately 50 cm. The visual display (see fig. 2) comprised the following items: the fixation cross (0.5×0.5 deg), two boxes of variable size (1×1, 2×2 and 3×3 deg) and the imperative stimulus (a cross of 0.4×0.4 deg with a luminance about 32 cd/m^2). The fixation cross was shown at the center of the screen, the two boxes were shown 10 deg (center to center) to the left or right of it, and the imperative stimulus was shown in the center of one of the two boxes. The response to the imperative stimulus was emitted by pressing a key on the computer keyboard (character 'B') using the right index finger.

Procedure

On each trial the sequence of events was as follows. The fixation cross was presented and stayed on until the end of the trial. After a 500-msec interval one (valid trials) or two (neutral trials) boxes were shown. Then, after a further interval of 40 or 500 msec the imperative stimulus appeared within the only box in the case of valid trials (100% probability) or within one of the two boxes in the case of neutral trials (50% probability). In 10% of the trials (catch trials) no imperative stimulus was presented. The subject's task was to fixate the center cross while directing attention to the only box or to split attention between the two boxes.

Eye position was videotaped throughout the experiment. Later the videotape was played on a monitor on which markers showed the fixation point and two points 0.5 deg to the right or left of it. This procedure allowed to detect eye movements of 0.5 deg or larger. RTs for the trials in which an eye movement in excess of 0.5 deg was observed were discarded.

The subject was instructed to press the key as fast as possible in response to the imperative stimulus and RT was measured from stimulus onset to response emission. Of course, the subject had to refrain from responding in the case of catch trials. Trials for which RT was less than 150 msec or in excess of 1000 msec were considered errors and were replaced at the end of the session. Each subject was run in 4 experimental sessions of 200 trials each. Therefore, for every subject there were 800 trials overall: 528 valid trials, 192 neutral trials and 80 catch trials. On half of the trials the interval between the box or boxes and the imperative stimulus was 40 msec, whereas on the other half the interval was 500 msec. Before the beginning of the first experimental session the subject performed in a practice session of 200 trials.

Results and Discussion

Errors, including eye movements, were rare (less than 3%) and were not analyzed. Only 3 false alarms, that is responses to catch trials, were observed and the corresponding RTs were discarded. RTs were entered into a four-way repeated-measures analysis of variance in which the factors were: Field of stimulation (right or left), Type of trial (valid or neutral), Interval (40 msec or 500 msec) and Size of the box or boxes (1, 2 or 3 deg).

Three main factors were significant: $F(1, 7) = 254.29$, $p < 0.001$ for Type of trial, $F(1, 7) = 37.3$, $p < 0.001$ for Interval, and $F(2, 14) = 22.37$, $p < 0.001$ for Size. RT was faster for valid than for neutral trials (284 vs. 316 msec) and with an interval of 500 than of 40 msec (269 vs. 330 msec). RT was also inversely related to the size of the box in which the imperative stimulus appeared (285 msec for the smallest box, 301 msec for the intermediate box and 314 msec for the largest box). Pairwise comparisons with the Neumann-Keuls method showed that all differences due to box size were significant ($ps < 0.05$ or less).

Only one interaction was significant, namely the first order interaction between Interval and Size, $F(2, 14) = 19.03$, $p < 0.001$. It showed that the effect of size was present with the long interval (239, 272 and 297 msec; all differences significant at $p < 0.05$ or less) but absent with the short interval (330, 329 and 332 msec).

No other source of variance was significant. Among the nonsignificant sources, the relevant ones were the first order interaction between Type of trial and Size, $F(1, 7) = 0.46$, the second order interaction concerning Interval, Type of trial and Size, $F(2, 14) = 2.26$, and the first order interaction between Interval and Type of trial, $F(1, 7) = 0.86$.

Considering the purposes of the experiment, the most interesting findings were the main effects of Type of trial and Size and the interaction between Interval and Size. It seems apparent that the subjects were able to make use of the cue and to direct attention accordingly. This produced a benefit of 32 msec, which is comparable to the benefits found in other studies that employed similar paradigms (see, e.g., Posner 1980). The fact that the benefit was of more or less the same magnitude for the two intervals (29 msec with the shorter and 36 msec with the longer interval; see the nonsignificant interaction between Type of trial and Interval) demonstrates that 40 msec were enough for the subject to orient attention toward the position signaled by the cue.

The main effect of Size confirms the findings of those previous studies that had found that the extent of the attentional focus can vary (Egeth 1977; Eriksen and St. James 1986; Eriksen and Yeh 1985; LaBerge 1983; LaBerge and Brown 1986) and that efficiency of processing decreases when the area of the attentional focus increases (Egeth 1977; Eriksen and St. James 1986). Even more interesting is the finding that the inverse relationship between extent of the attentional focus and processing efficiency is present only for the longer interval (see the significant interaction between Interval and Size). It appears that the process of narrowing the attentional focus takes time and has not yet been completed after 40 msec. Therefore, the results of the present experiment show that an interval of 40 msec between the cue and the imperative stimulus is long enough to orient attention but not to vary the size of the attentional focus.

The lack of a significant interaction between Size and Type of trial is surprising. Taken at face value, this finding seems to counter the notion that the attentional focus is unitary and to show that the subject is able to narrow the size of the attentional focus in two regions of the visual field which are not contiguous. In effect, the inverse relationship between size of the boxes and speed of processing was very similar for either valid (270, 284 and 297 msec) or neutral (299, 318, and 331 msec) trials. There is, however, a different interpretation, which does not imply the notion of two attentional foci operating simultaneously on separate portions of the visual field. [1] On neutral trials the subject cannot direct the attention to one of the boxes before stimulus presentation because the cue is not informative. After stimulus presentation, however, the attentional focus would be directed toward the stimulus box and fitted to its size.

Finally, the main effect of Interval, though unexpected, can be easily explained by assuming that the cue acted also as a warning signal, which was more easilly exploited with the longer interval.

[1] We thank Maurits W. van der Molen for suggesting this alternate interpretation.

Experiment 1b

In experiment 1b there were invalid trials, that is sometimes the cue directed attention away from the position in which the imperative stimulus was to be shown. Eight students (4 males and 4 females), who had not taken part in the previous experiment, were paid for participating in the experiment. The apparatus was the same already described for experiment 1a with the exception that there were always two boxes, one with solid and the other with dashed contours (see fig. 3). Also the procedure was identical to that already described, except for the fact that now invalid trials were used in place of neutral trials. The subject was instructed to direct attention to the box with solid contours, where the imperative stimulus was presented in 80% of the trials (valid trials). In 20% of the trials the imperative stimulus appeared within the box with dashed contours (invalid trials).

Results and Discussion

Errors, including eye movements, were less then 5% and were not analyzed. No responses to catch trials were observed. RTs were entered into a four-way repeated-measures analysis of variance with the same factors considered in experiment 1a.

The following sources of variance that had been significant in experiment 1a were significant also in experiment 1b: Interval, $F(1, 7) = 74.52$, $p < 0.001$; Size, $F(2, 14) = 5.84$, $p < 0.025$; Type of trial, $F(1, 7) = 122.84$, $p < 0.001$; and Interval by Size, $F(2, 14) = 30.74$, $p < 0.001$. Valid trials produced faster RTs than invalid trials (274 vs. 336 msec). RT was faster with the longer than the shorter interval (271 vs. 339 msec) and when box size was small or intermediate than when it was large (300, 300 and 316 msec). The interaction showed that with the longer interval RT increased as a function

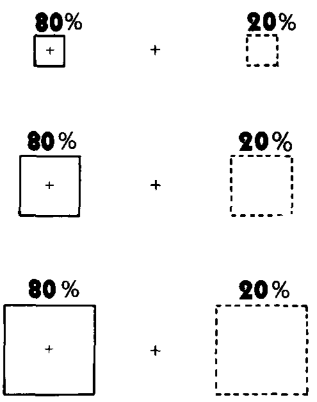

Fig. 3. Schematic drawing of the visual display employed in experiment 1b. The box with solid contours and the box with dashed contours were shown simultaneously.

Table 1
RTs (in milliseconds) for the interaction Interval × Size × Type of trial in experiment 1b.

	Interval			
	40 msec		500 msec	
	Valid trials	Invalid trials	Valid trials	Invalid trials
Size of boxes				
1 deg	329	364	202	304
2 deg	311	343	235	310
3 deg	312	379	258	315

of size (253, 272 and 287 msec), whereas no such orderly relationship was present with the shorter interval (346, 327 and 345 msec).

The sources that were significant here but not in experiment 1a were the main effect of Field, $F(1, 7) = 11.15$, $p < 0.025$; the interaction between Interval and Type of trial, $F(1, 7) = 26.79$, $p < 0.001$; and the interaction involving Interval, Size and Type of trial, $F(2, 14) = 12.23$, $p < 0.001$. RT was faster in the right than the left visual field (300 vs. 310 msec). The difference between valid and invalid trials, though present at both intervals, was greater for the longer than the shorter interval (232 vs. 310 msec and 317 vs. 362 msec, respectively). The results relevant for the interaction Interval by Size by Type of trial are reported in table 1. In essence, they show that the effect of size was present only for valid trials with the longer interval. In no other condition the effect of size was present, even though a slight tendency in that direction could be observed for invalid trials with the longer interval.

The sources of variance that were also significant in experiment 1a simply confirmed what was said in discussing those results. [2]

Among the effects that were significant here but not in experiment 1a, the difference in favor of the right field is in agreement with the results of other experiments conducted in our laboratory (see Gawryszewsky et al. 1987; Umiltà and Liotti 1987; Umiltà and Nicoletti 1985) and can be interpreted in the sense of a right-side bias for the orienting of attention. The interaction between Interval and Type of trial showed that the difference between valid and invalid trials (i.e., costs plus benefits) was greater for the longer interval. Perhaps with the longer interval attention becomes more firmly engaged on the expected position and thus proves more difficult to disengage when the imperative stimulus appears elsewhere.

The three-way interaction was no doubt more interesting. It showed that the size of the boxes affected speed of response only for valid trials when the interval was 500

[2] Note that the visual character of the informative display changed from experiment 1a (a single box) to experiment 1b (a solid and a dashed box). However, changing the characteristics of the display did not affect the time required to direct and focus attention, as shown by the fact that RT for valid trials was very similar in the two experiments (284 vs. 274 msec.) Also a previous study by Umiltà and Liotti (1987) had demonstrated that, in a spatial compatibility paradigm, those two displays were equally effective in directing attention to the expected positions.

msec. This finding can be interpreted by assuming that the subjects could fit the attentional focus to the size of the box only when they were given enough time to do so (i.e., when the trial was valid and the interval was long enough). By contrast, if there was not enough time for this operation (i.e., when the interval was too short) or if the focusing of attention occurred in the wrong position (i.e., on invalid trials), the attentional focus did not match the size of the box.

This finding allows to choose between the two interpretations offered to explain the absence of a significant interaction between Type of trial and Size in experiment 1a. According to one interpretation, on neutral trials the zooming operation took place after stimulus presentation. If this were correct, one would expect an effect of box size also on invalid trials because also on invalid trials the attentional focus could be directed to the stimulated box and fitted to its size after stimulus presentation. The fact that instead in experiment 1b box size had an effect only for valid trials seems to favor the alternate interpretation. It appears, therefore, that when there are two equally likely positions for the imperative stimulus, attention can be split between them. In contrast, attention is not split when one of the two positions is much less likely than the other to contain the imperative stimulus.

One feature of experiments 1a and 1b might cast doubt on the interpretation of the results as discussed above. One could maintain that what mattered was not the size of the box (and, by implication, the size of the attentional focus), but the uncertainty of the locus of stimulation, which increased as a function of box size. In other words, it could be that the subject always tried to focus attention on the geometrical center of the box and this operation was more successful when the size of the box was smaller. This interpretation was tested in the following experiment by presenting the imperative stimulus in different positions within the box. In this experiment the imperative stimulus could also appear outside the box to test whether the attentional focus was sharply demarked or showed a gradual dropoff.

Experiment 2

This experiment was identical to experiment 1a except for the following differences. There were only two sizes of the box and the interval between the cue and the imperative stimulus was always 500 msec. We decided to use this interval because the previous experiments had demonstrated that with the shorter interval there is not enough time for the subject to focus attention on the box. Another difference concerned where the imperative stimulus was shown. Before it was shown always at the geometrical center of the box, whereas now it could appear in five different positions (see fig. 4).

Method

Subjects

Twelve students (6 males and 6 females) were paid for participating in the experiment. They were selected as before and ignored the purpose of the experiment. None had taken part in the previous experiments.

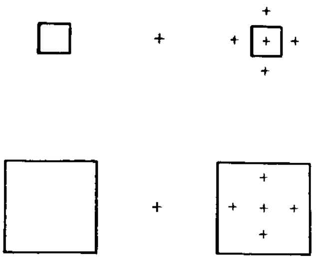

Fig. 4. Schematic drawing of the visual display employed in experiment 2. In the valid condition only one box was shown, whereas both boxes were shown in the neutral condition.

Apparatus

The apparatus was the same as already described for experiment 1a. The imperative stimulus was presented in five different positions, one of which was at the geometrical center of the box. The other four were displaced 1 deg from the geometrical center of the box along either the vertical or the horizontal axis. As shown in fig. 4, the four eccentric positions laid outside the borders of the smaller box but inside the borders of the larger box.

Procedure

The procedure was that already described for experiment 1a. That means that there were valid and neutral trials only. Note, however, that there the interval between the cueing box (valid trials) or boxes (neutral trials) and the imperative stimulus was always 500 msec. The imperative stimulus was presented with equal probability in one of the five possible positions.

Results and Discussion

Errors, including eye movements, were extremely rare (less 1%) and were not analyzed. Only 2 RTs were discarded because of responses on catch trials. RTs were entered into a four-way repeated-measures analysis of variance with the following factors: Field of stimulation (right or left), Type of trial (valid or neutral), Size of the box or boxes (1 or 3 deg), and Position of the imperative stimulus (central or eccentric).

The four main effects were all significant. RT was faster in the right than in the left field (262 vs. 268 msec), $F(1, 11) = 6.24$, $p < 0.05$, for valid than for neutral trials (247 vs. 282 msec), $F(1, 11) = 118.56$, $p < 0.001$, and with the smaller than with the larger box (249 vs. 281 msec), $F(1, 11) = 57.50$, $p < 0.01$. RT depended also on the position of the imperative stimulus, being faster for the central position than for the eccentric ones (263 vs. 266 msec), $F(1, 11) = 19.14$, $p < 0.01$.

Among the interactions, only that between Size and Position reached statistical significance, $F(1, 11) = 10.02$, $p < 0.01$. It showed that in the case of the smaller box the central position produced faster RT than the eccentric positions (245 vs. 253 msec; this difference was significant at $p < 0.05$). By contrast, with the larger box there was no difference between the central position and the eccentric positions (281 vs. 280 msec).

The effects of Type of trial and Size confirmed that the subject enhances processing efficiency in the cued position and that processing efficiency increases as the size of the attentional focus decreases. This time, however, an interpretation in terms of uncertainty of stimulus position can be rejected because the imperative stimulus could appear in five equally likely positions.

Also here, as in experiment 1a, the lack of a significant interaction between Size and Type of trial seems to indicate that the subject can adjust the focus of attention to the size of the box also in the case of neutral trials. In the present experiment this finding was rendered even more intriguing by the fact that the interaction almost reached significance ($p < 0.1$), and showed that the effect of size was, if anything, greater on neutral trials (263 vs. 302 msec) than on valid trials (235 vs. 260 msec).

The interaction between Position and Size showed that the stimuli presented off the geometrical center of the box produced slower responses only when they fell outside the border of the smaller box. This finding can be interpreted by assuming that the focus of attention overlapped rather precisely with the size of the box. In the case of the larger box, all stimuli fell within the focus of attention and thus were processed with the same efficiency. In the case of the smaller box, instead, only the stimulus shown in the center fell within the focus of attention. Because of this, the eccentric stimuli were processed less efficiently. However, the fact that the eccentric stimuli outside the smaller box produced RTs that were faster than those produced by the eccentric stimuli within the larger box (253 vs. 280 msec) indicates that the focus of attention is not sharply demarked. Rather, it seems to drop off gradually from the smaller box so that the eccentric stimuli positioned near its borders could still benefit from it, at least partially.

The lack of a significant interaction involving Type of trial, Size and Position ($F = 0.20$) indicated that the foregoing effects occurred for both valid and neutral trials. This can be taken as further evidence that the subject adjusted the focus of attention to the size of the box in both fields simultaneously.

The last significant effect was the overall advantage of the right over the left visual field. As already said, this seems to indicate that orienting attention toward the right visual field is somewhat easier than orienting attention toward the left visual field. This right-side bias, although found in other studies (see references above), is not consistently observed. For example, it was absent in experiment 1a of the present paper.

Conclusion

By following Eriksen and St. James (1986) we addressed three issues concerning the features of the attentional focus. The first was whether the spatial extent of the attentional focus can vary in accordance with task demands. The second was whether efficiency of processing is inversely related to the area covered by the attentional focus. The third was whether the boundary between the area covered by the attentional focus and the rest of the visual field is sharply demarked.

Our results seem to provide clear answers to these questions. The size of the attentional focus can be adjusted so that it covers areas of different size in the visual field. There is a decrease in processing efficiency when the area of the attentional focus increases. There is a gradual dropoff in processing efficiency around the attentional focus.

Our results are also relevant for two other issues that were not directly addressed by the study. It appears that the subject is able to vary the size of the attentional focus in two regions of the visual field that are not contiguous, provided that they are equally likely to contain the imperative stimulus. Finally, there seems to be a bias for orienting attention toward the right visual field.

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