

Facilitatory and Inhibitory Components of Orienting in Visual Space

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ABSTRACT

Posner and Cohen (1980) demonstrated that a brief noninformative visual cue presented in the periphery speeds the simple detection response to a target if it appears within 100 msec of the cue and in the same location, compared to a target in a different location. This *facilitation* was attributed to externally controlled covert orienting, that is, the alignment of attention with a location in visual space as the result of an external stimulus event. However, if the target appears more than 300 msec after the cue, the response is slower to a target in the same location (*inhibition*). Experiments designed to investigate further both the facilitatory and inhibitory components of visual orienting are reported in this chapter. In addition to the facilitation of both simple and choice manual responses, a target from the same location in the periphery as the cue appears to occur earlier than one from a different location, for intervals between the cue and the target of up to 500 msec. Although temporal judgments are unaffected at longer cue-target intervals, both manual and ocular responses are slower to a target appearing between 300 and 1300 msec after a cue in the periphery and in the same location than to one appearing elsewhere. It is argued here that externally controlled orienting is a necessary condition to produce inhibition. However, not every event in the visual periphery results automatically in externally controlled covert orienting. Indeed, such orienting can be reduced or even prevented by additional information present in the visual field, or by the requirements of secondary tasks. The facilitatory and inhibitory components of externally controlled orienting appear to act together to direct the eye-movement system and to maintain selectivity in visual space.

INTRODUCTION

Visual orienting has been described as the aligning of peripheral or central mechanisms with a source of sensory input (Posner, 1980). Overt orienting refers to a change in the alignment of sensory receptors (that is, eye and head movements), whereas covert orienting refers to a change in the alignment of the central processing system. A further distinction has been drawn between internally and externally controlled orienting. For example, eye movements can result from an internal search plan or be driven by an external stimulus event (Kahneman, 1973).

The consequences of internally controlled covert orienting have recently been well documented (Bashinski & Bacharach, 1980; Posner, Nissen, & Ogden, 1978; Posner, Snyder, & Davidson, 1980). The first experiments on externally controlled covert orienting, conducted by Jonides (1976), demonstrated that a peripheral stimulus can "involuntarily capture" a subject's attention. Target presentation was preceded by a cue that was a brief visual stimulus that could occur to the left or right of a central fixation point. Simple reaction time was faster when the target occurred on the same side of the visual field as the cue than when it appeared on the opposite side. Further work by Jonides (1981) attempted to compare internally and externally controlled covert orienting. Subjects were induced to shift their attention (but not their eyes) through the use of two types of visual cue, both indicating the possible stimulus locations in the visual field. Thus, either an arrow pointing to the left (presented at fixation) or a brief stimulus in the left visual field were used to inform the subject that a target stimulus could occur to the left of fixation. The arrow represents *symbolic* cueing, as the subject must interpret the cue in order to know the cued location. The second type of cue provides a more *direct* indication of stimulus location without requiring the subject to know and act upon the meaning of arbitrary symbols such as arrows. Direct cueing was shown to produce shifts of attention that were more consistent with a number of criteria for automaticity than shifts produced by symbolic cueing.

An important issue concerning externally controlled orienting is the question of *automaticity*. Several investigators (for example, Posner & Snyder, 1975; Schneider & Shiffrin, 1977) have distinguished between processes that are under conscious or strategic control and those that are automatic. Remington (1980) concluded that relevant stimuli in the peripheral visual field trigger both a saccade and a shift of attention, and that "to some degree" the attentional movement automatically follows the presentation of a significant peripheral stimulus. Considering also the evidence from the work of Jonides (1976, 1981), it does appear that externally controlled orienting occurs automatically.

A second major issue concerns the *consequences* of externally controlled orienting. Posner and Cohen (1980, 1984) demonstrated that a brief peripheral cue speeds the simple detection response to a target if it appears within 100 msec

of the cue and in the same location, compared to a target in a different location. This effect was termed *facilitation*. However, the early advantage to the cued location is replaced by a subsequent *inhibition*, the slowing of the response to a target in the same location. Because facilitation occurs in response to symbolic as well as direct cues, Posner and Cohen regarded it as attentional and the result of orienting to a visual location. The inhibitory effect, however, seems to depend on the presentation of sensory information in the periphery, because it does not occur when attention is directed by a symbolic cue presented to fixation.

The experiments to be described were designed to investigate further the facilitatory and inhibitory components of externally controlled orienting by addressing the two issues just outlined. First, an experiment based on Posner and Cohen's (1980) original study is presented. This is extended to compare the effects of brief noninformative direct cueing on simple and choice manual reaction time and saccade latency. Experiment 2 is a divided attention study in which the effects of a demanding secondary task on externally controlled orienting are assessed in order to investigate the attentional nature of the facilitatory component. Finally, a double-cueing paradigm and a nonspeeded response are employed in Experiments 3 and 4, respectively, to explore the relationship between facilitation and inhibition.

EXPERIMENT 1

A replication of Posner and Cohen's general result from a simple manual reaction time task was considered important for two reasons: first, to demonstrate the reliability of the effects, and second, to provide baseline data for comparison with Experiments 2 to 4. In addition, the procedure was adapted to investigate manual and ocular choice responses to peripheral stimuli. In view of the work of Remington (1980), which demonstrated that overt and covert orienting are most closely coupled in response to an important event in the visual periphery, similar results were expected in the three cases.

Subjects. The subjects in Experiments 1 to 4, all unpaid volunteers, were undergraduates, postgraduates, and staff at the University of Durham (including the author). All reported normal or corrected-to-normal vision. Fourteen, six, and six subjects participated in Experiments 1a, 1b, and 1c, respectively.

Method

Experiment 1a: Simple Manual Reaction Time. The stimuli for this experiment, which was entirely computer controlled, were displayed on an oscilloscope. Three boxes were presented on the screen, one on the left, one in the center, and one on the right. Each box measured $1.2^\circ \times 1.2^\circ$ visual angle, and

the distance between the central box and the peripheral boxes was 4.2° . Each subject was required to keep his or her eyes on a fixation point inside the central box throughout the experiment. A trial began with the cueing (that is, the brightening) of one of the peripheral boxes for 100 msec (the "cue"). This was followed after another 100 msec by a similar brightening of the central box. (Posner and Cohen [1980] included this in order to "summon attention back to the center" [p. 4]. In fact, identical results are obtained without this central cueing; see Maylor, 1983.) The target, a small stimulus appearing well above threshold inside one of the peripheral boxes, could occur at three different times following the onset of the cue: 100, 300, or 500 msec stimulus onset asynchrony (SOA). This disappeared when a detection response of a single key press had been made. The interval between the offset of the target and the onset of the next trial was randomly chosen from the range 200 to 700 msec. Trials when a response was made before or during the first 100 msec of target presentation were recorded as anticipation errors and were deleted from the analysis. The trials were divided so that there were equal numbers of each left-right/cue-target combination. The order of presentation of trials was randomized. In this way, the cue was noninformative because a cue on the left was equally likely to be followed by a target on the left as by one on the right.

Experiment 1b: Saccade Latency. Each subject was required to fixate on the central fixation point only until a target appeared in one of the peripheral boxes. A saccade then had to be made as quickly and as accurately as possible to the target that remained on the screen for between 500 and 900 msec. Following the offset of the target, the subject returned to the central fixation point in preparation for the next trial. Horizontal eye movements were recorded by a bifurcated fiber optic device (Findlay, 1974).

Experiment 1c: Choice Manual Reaction Time. The subject was required to fixate on the central fixation point throughout the experiment but, unlike the requirements for experiment 1a, he or she was asked to press a button under the left forefinger when a target occurred inside the left box, and a button under the right forefinger when a target occurred inside the right box.

Results

Experiment 1a. Subjects reported that they were unaware of the cueing procedure although they did notice that the three boxes, particularly the central one, tended to flicker throughout the experiment. The means of the median reaction times from each subject are presented in Fig. 9.1a. The term *valid* refers to a target following a cue in the same location, whereas *invalid* refers to a target appearing in the opposite location to the cue. The results are very similar in form to those of Posner and Cohen (1980). An ANOVA revealed a highly significant effect of SOA— $F(2,26) = 23.01, p < .0001$ —but not of invalid-valid trial

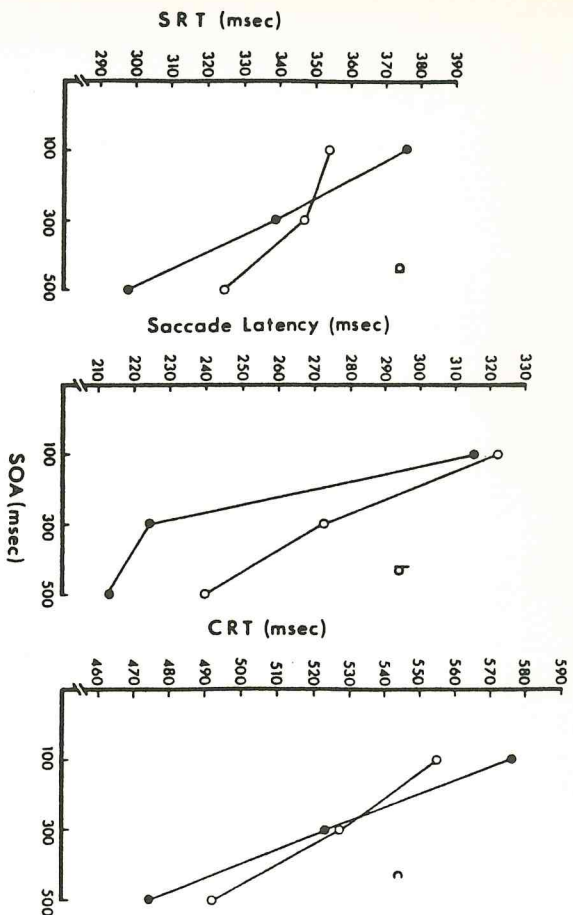


FIG. 9.1. Results of Experiment 1. Simple manual reaction time (a), saccade latency (b), and choice manual reaction time (c) as a function of SOA for valid (unfilled circles) and invalid (filled circles) trials.

type— $F(1,13) = 1.40, p > .1$. The interaction between SOA and trial type was highly significant— $F(2,26) = 63.70, p < .00001$. Thus, at the SOA of 100 msec, there is what Posner has referred to as facilitation, such that valid trials are responded to more rapidly than invalid trials. However, at the longer SOAs valid trials are actually slower, demonstrating the second effect, that of inhibition.

Experiment 1b. The median saccade latencies were analyzed with target location (left and right), SOA, and trial type as fixed-effects factors. This revealed that there was no significant effect of target location— $F(1,5) = 1.39, p > .1$ —and that it did not interact with any other factor. The means of the left and right targets for the six subjects are presented in Fig. 9.1b. Again, there was a highly significant effect of SOA— $F(2,10) = 37.27, p < .001$ —but also of trial type— $F(1,5) = 13.15, p < .05$. The interaction between SOA and trial type was significant— $F(2,10) = 4.81, p < .05$. Thus, the pattern for saccade latency is rather different from that for simple manual reaction time. No facilitatory component is present at an SOA of 100 msec and there is increased inhibition at 300 msec.

Experiment 1c. Experiments 1a and 1b differ in two fundamental ways and it is possible that the different results could be due to either or both of the following factors: The first is the *mode* of response (manual or ocular) and the second is the *type* of response (simple or choice). The results of the choice

manual reaction time task shown in Fig. 9.1c demonstrate that the results from Experiment 1b are due to the requirement to *saccade* to the target rather than to the introduction of the *choice* decision. Again, the median reaction times were analyzed with target location (left and right), SOA, and trial type as fixed-effects factors. There were no overall effects of target location— $F(1,5) = 1.43, p > .1$ —and trial type— $F(1,5) = .00, p > 0.1$ —but there was a significant effect of SOA— $F(2,10) = 17.39, p < .001$ —and an interaction between SOA and trial type— $F(2,10) = 2.26, p < .02$.

Discussion

Experiment 1 has demonstrated the effects of brief noninformative direct cueing on simple and choice manual reaction time and saccade latency to subsequent targets. For manual responses, detection of targets from a cued location is faster than from an uncued location 100 msec following the onset of the cue. This facilitation is interpreted as being due to externally controlled covert orienting—that is, the aligning of attention (but not the eyes) with the cued location. For SOAs of 300 and 500 msec, facilitation is replaced by inhibition such that detection of targets from the cued location is now slower than from the uncued location. The pattern for saccade latency is different in that the facilitatory component is absent (or at least not present at the three SOAs used) and inhibition is increased at 300 msec. Because the early anticipations made (a total of 18) were saccades in the direction of the cue, the lack of facilitation possibly reflects the need to suppress the relatively automatic eye-movement response to the peripheral cue, which then delays the saccade to a subsequent target at the same location. The similarity between the choice and simple manual reaction time results and the fact that anticipations were rarely made in the choice reaction time experiment support the view that the saccade latency result is due to the similarity at some level in the eye-movement generation system between the effect of the cue and the response required, rather than to the introduction of the element of choice.

EXPERIMENT 2

Posner and Cohen (1984) concluded that the facilitatory component is attentional. A direct cue in the periphery initially summons attention so that targets appearing in that location have an advantage (in terms of reaction time) over those in uncued locations. They noted that the inhibitory component occurs “without the need for any deliberate strategy on the part of the subject” [p. 537] and regarded it as sensory rather than attentional in origin. Their conclusion was that “some part of the pathway from the cued location is reduced in efficiency by the cueing” [p. 537], and that inhibition is the inevitable consequence of the presentation of any visual stimulus in the periphery. On the basis of this model

Posner, Cohen, Choate, Hockey, and Maylor (1984) predicted that the addition of a demanding secondary task would disrupt the facilitatory (attentional) component but would not affect the inhibitory (sensory) component of externally controlled orienting. In Experiment 2 subjects were required to carry out one of four secondary tasks in addition to the primary task of target detection. These involved predictable and unpredictable pursuit eye tracking of a slowly moving spot inside the central box. In the predictable conditions, the spot moved smoothly throughout the experiment. In the unpredictable conditions, at the moment when the peripheral box brightened, the fixation spot jumped to a different position within the central box and the subject was required to follow the movement with a small saccade. If overt orienting is required to the central fixation spot at the same time as a direct cue is presented in the periphery, this may affect facilitation because the orienting system will be dominated by the fixation requirements. If this is the case, it is important to know whether or not inhibition is also affected in order to test the model of Posner and Cohen described previously.

Subjects. Forty subjects were divided equally between the four conditions of this experiment.

Method

The primary task was as described for Experiment 1a. There were four secondary tasks in which each subject was required to track the movements of the fixation spot inside the central box. In the two smooth-pursuit conditions the spot moved sinusoidally either horizontally (H) or vertically (V) within the central box at a rate of approximately .5 Hz. For the remaining two conditions the spot moved in one dimension (horizontal or vertical) until the presentation of the direct cue in the periphery. It then jumped to moving in the other dimension until a detection response to the target appearing in the peripheral box had been made. At this point the spot returned to its original tracking dimension. Consequently, for one condition the intertrial tracking dimension was horizontal and the within-trial dimension was vertical (H→V), and for the other condition these were reversed (V→H). In this way a small saccade was required both at the trial onset and offset. These conditions are illustrated in the upper panel of Fig. 9.2.

Results

The results of the primary task are presented in Fig. 9.2. The patterns of results from the two smooth-pursuit eye-tracking tasks (H and V) are very similar. Two ANOVAs revealed significant effects of SOA— $F(2,18) = 22.63$ and 24.29 for the H and V conditions, respectively—trial type— $F(1,9) = 6.18$ and 16.26 —and interactions between them— $F(2,18) = 29.42$ and 35.33 , all $ps < .05$. Both significant facilitation at 100 msec and significant inhibition at 500 msec are

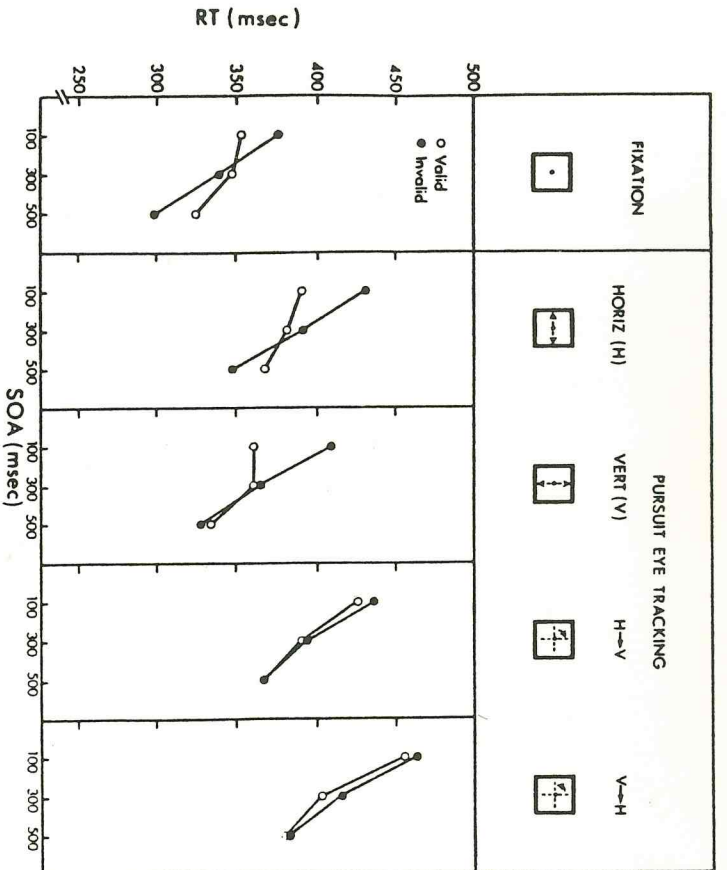


FIG. 9.2. Results of Experiment 2. The secondary tasks are illustrated in the upper panel (see text for details). The results of Experiment 1a (fixation) are included for comparison.

observed when the eyes move smoothly within the central box (H and V), although it is not clear why the former is significantly increased (H and V) and the latter decreased (V only) compared to the fixation condition.

In contrast, the requirement to prepare a small saccade at the moment when the direct cue occurs in the periphery either delays externally controlled orienting until after 500 msec or abolishes it altogether. Although it appears that there may be evidence of a small amount of facilitation at the early SOAs, this was not confirmed by the ANOVAs. There were significant effects of SOA— $F(2, 18) = 29.75$ and 31.84 for the H→V and V→H conditions, respectively, $p < .0001$ —but no effects of trial type— $F(1, 9) = 1.69$ and 1.88 , $p > .1$ —nor any interactions between them— $F(2, 18) = .24$ and $.84$, $p > .1$.

Discussion

It appears that facilitation can be abolished if the direct cue in the periphery occurs at the same time as a discontinuity in a central tracking task that requires the programming and execution of a small saccadic eye movement (that is,

externally controlled overt orienting). In addition, there is no later inhibitory component which provides support for the view that inhibition is *dependent* on prior orienting. Thus, the results of Experiment 2 argue against Cohen's (1981) suggestion that only the facilitatory component is an active one and that under dual task conditions facilitation is attenuated, while the inhibitory component continues to exert its full influence.

EXPERIMENT 3

In addition to single direct cues in the periphery (similar to those used in Experiment 1), Posner and Cohen (1980, 1984) included trials in which both the left and right peripheral boxes brightened simultaneously. Their results demonstrated reduced facilitation at an SOA of 80 msec but as much inhibition at an SOA of 500 msec for double-cued as compared to single-cued trials. They suggested that the reduced facilitation was consistent with their earlier conclusion that attention under internal control cannot be divided effectively between two locations either side of fixation (Posner et al., 1980). However, because inhibition was not similarly reduced by double cueing, Posner and Cohen concluded that the inhibitory component is due to the sensory stimulation in the periphery and not to the externally controlled orienting produced by the cue. Contrary to this conclusion, the results from the unpredictable eye-tracking conditions of Experiment 2 suggest that inhibition does not occur if facilitation is abolished. A pilot study reported by Maylor (1983) confirmed that the facilitatory component is approximately halved by double cueing. Because of the theoretical significance of Posner and Cohen's study, Experiment 3 was designed to investigate double cueing further—in particular, its effect on the inhibitory component at longer SOAs.

Subjects. Four subjects participated in this experiment.

Method

The stimuli were two red light emitting diodes (LEDs) placed 12° to the left and 12° to the right of a central fixation point (a yellow LED). Each subject was required to fixate on the central LED throughout the experiment. Each trial began with the 300-msec presentation of the left, right, or both LEDs (the 'cue'), with equal probability. After an SOA of 700, 900, or 1300 msec, the target appeared which was the LED on the left of fixation for half of the trials and the LED on the right for the remaining half. The subject was instructed to respond to the onset of the target by pressing a single key but to use the brief cue as a warning signal that a target was about to appear. The target was switched off following the detection response. The intertrial interval (the time between the offset of the target and the onset of the next trial) was randomly chosen from the range 1500 to 2500 msec.

Results

An ANOVA was conducted on the median reaction times with SOA (700, 900, and 1300 msec) and trial type (same, double, and opposite) as fixed-effects factors. The three trial types correspond to a target in the same location as a cue, a target following a double cue, and a target in the opposite location to a cue. Thus, same and opposite are equivalent to valid and invalid trial types, respectively. The overall means are presented in Fig. 9.3, and the ANOVA revealed significant effects of SOA— $F(2,6) = 9.72, p < .02$ —and trial type— $F(2,6) = 21.41, p < .005$ —but no interaction— $F(4,12) = 1.52, p > .1$. The inhibitory effect is shown by the same-opposite difference and can be seen to last some considerable time. The double cue, however, produces less inhibition than a single cue (same trials) but more than no cue (opposite trials); this was the case for all of the subjects. The conclusion from this experiment is that, contrary to the results of Posner and Cohen (1984), the simultaneous stimulation of more than one location does result in reduced inhibition. This is an important result, as the inhibitory component appears to be reduced by about the same amount as the facilitatory component—that is, both are approximately halved by double cueing compared to single cueing. This provides further support for the suggestion made earlier that inhibition occurs as a direct consequence of externally controlled

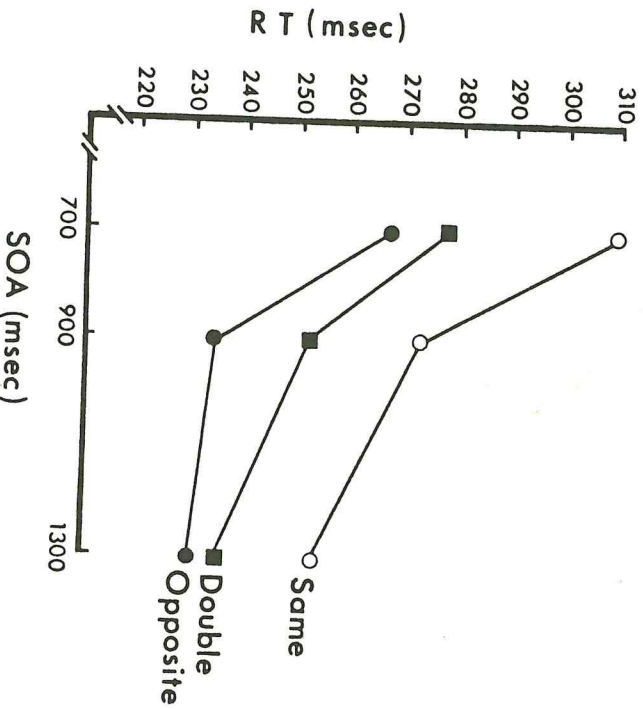


FIG. 9.3. Results of Experiment 3. Reaction time as a function of SOA for same, double, and opposite trials (see text for details).

orienting rather than as the inevitable result of sensory stimulation in the periphery.¹

The reduced facilitation for double-cued compared to valid trials at an SOA of 80 msec in Posner and Cohen's study could be attributed to maximal facilitation at one peripheral location on half of the trials. If this were the case, the reaction time distributions for double-cued trials would be bimodal and therefore would have larger variances than single-cued trials. The pilot study mentioned previously, which was based more directly on that of Posner and Cohen, enabled a comparison to be made between the semiquartile ranges (SIQRs) of valid, invalid, and double-cued trials at an SOA of 100 msec. There was no significant difference between the SIQRs (52, 47, and 45 msec, respectively). Thus, it can be concluded that on double-cued trials, orienting does not occur to one peripheral box only, as though the other box had not been cued. It would, therefore, be predicted that the SIQRs of the reaction times for the three trial types of the present experiment would also be similar. This was tested by an ANOVA on the SIQRs with SOA and trial type as fixed-effects factors, which revealed no effect of SOA or trial type and no interaction between them—all $F_s < 1$.

EXPERIMENT 4

Posner and Cohen (1984) argued that the reduced facilitation at short SOAs following double cueing, combined with the evidence from Posner et al. (1980) that attention (under internal control) cannot be divided effectively between two locations either side of fixation, provides support for the view that the facilitatory component is attentional. The "prior-entry" hypothesis (see, for example, Sternberg & Knoll, 1973) states that given two simultaneous events, the attended event will be reported as occurring earlier in time than the unattended one. Experiment 4, therefore, employed a temporal order judgment paradigm in an attempt to provide converging evidence for the attentional nature of the facilitatory component.

Subjects. Two subjects participated in this experiment.

Method

Two boxes were displayed on the screen, 4.2° to the left and 4.2° to the right of a central point. The subject was required to fixate on this point throughout each of four experimental sessions. On a third of the trials no cue was presented. The

¹Note that if two locations either side of fixation are stimulated successively, each will exhibit inhibition comparable with single cueing (Maylor, 1983). For example, a response to a target from one location may be inhibited by the cue of the current trial, while one to a target from the other location is inhibited by the target from the previous trial, the two events being separated by the intertrial interval of between 200 and 700 msec.

remaining two-thirds of the trials were divided equally between a cue on the left (the brightening of the left box for 100 msec) and a cue on the right. The experimental sessions differed according to SOA (100, 300, 500, and 1000 msec), which was defined as the time from the onset of the cue (or the onset of the trial in the case when no cue was presented) to the onset of the *first* target. Target 1 was then presented inside either the left or the right box with approximately equal probability. This was followed after an interval by the second target, which appeared in the other box. Both targets remained on the screen until the subject made a response. Each subject was given two buttons, labeled "left" and "right", and was asked to press the button corresponding to the target that appeared *first*. Following the decision there was an intertrial interval of 1500 msec before the onset of the next trial. The subject was informed that on some trials one of the boxes would appear to flash briefly but that this was to be ignored, as it was noninformative regarding the temporal order of the targets. A psychophysical procedure known as APE (Adaptive Probit Estimation; see Watt & Andrews, 1981) was used to determine the target intervals that were tested.²

Results

The proportions of "right-target-first" responses were plotted as a function of the lead of the right target for the three cues (left, right, and no cue). The means of the distributions—that is, the points of subjective simultaneity or PSS—were determined by Probit Analysis (Finney, 1971). All the response distributions were normal sigmoids (tested by chi-square tests of goodness of fit). The results were further analyzed by calculating the quantity $[\text{mean}(\text{left box cued}) - \text{mean}(\text{right box cued})] \div 2$, which is a measure of the interval required (in msec) between the valid and invalid targets (as defined in Experiment 1) for subjective simultaneity. The results are presented in Fig. 9.4. It can be seen that for both subjects the invalid target must occur *before* the valid target, particularly for the first two SOAs, in order for the two targets to appear simultaneous. The effect is large (around 70 msec) at the SOA of 100 msec and decreases to zero by 1000 msec.

Experiment 4 supports the view that the presentation of a brief peripheral stimulus produces covert orienting. This is reflected in both the facilitation of manual reaction time to a subsequent stimulus in the same location and a corresponding bias of temporal order judgments. The consequence of such orienting is a type of response inhibition that affects the speed of response (both manual and ocular) to a repeated peripheral stimulus, but not judgments about its temporal properties.

²APE, an adaptive version of the Method of Constant Stimuli, selects from a number of present magnitudes in order to obtain a psychometric function.

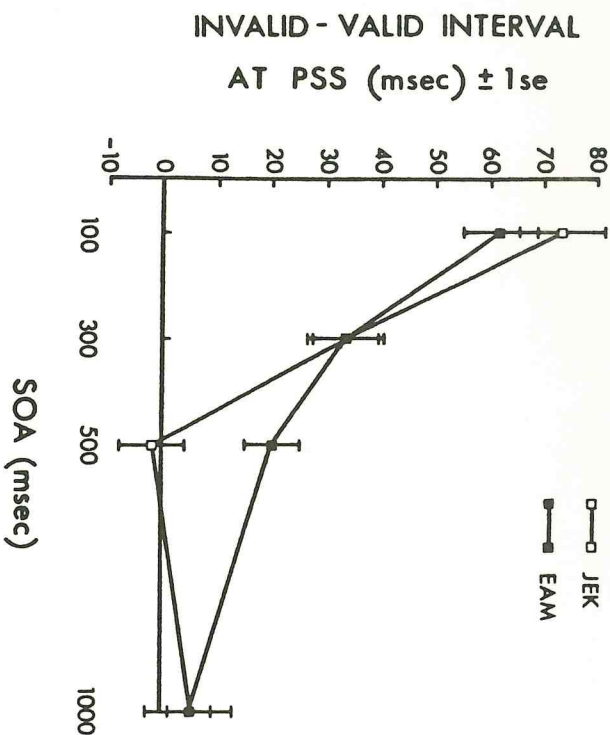


FIG. 9.4. Results of Experiment 4. The interval required between the invalid and valid targets for subjective simultaneity as a function of SOA.

GENERAL CONCLUSIONS

The Facilitatory Component

A target appearing immediately after, and in the same location as, a direct cue in the periphery is responded to more quickly (at least for manual responses) and judged to be occurring earlier than a target in a different location. Recent experiments have extended this conclusion by establishing effects of externally controlled orienting on perceptual sensitivity (Remington, 1980) and on figural and positional judgments (Krumhansl, 1982). Thus, it is suggested that after a salient event in the visual periphery (for example, a luminance change), but before overt orienting takes place, externally controlled covert orienting occurs that results in enhanced responding to and processing of further stimuli from that location for approximately 100 msec.

The Inhibitory Component

If a target appears 300 msec or more after a direct cue in the periphery and in the same location, there is an inability to respond to it as quickly, either manually or ocularly, as to a target in a different location. This inhibitory component is

regarded as a consequence of externally controlled covert orienting to the cue. At least for manual responses, inhibition does not result from the need to prevent responding to the cue (Maylor, 1983). However, the complete absence of an inhibitory component using a temporal order judgment paradigm is taken as evidence that inhibition is a response-related process—that is, it reflects a reluctance to respond rapidly to a stimulus appearing in the same peripheral location as a previous one that produced orienting. It is important to note that inhibition is also observed as a result of externally controlled overt orienting, so that following an eye-movement toward and then away from an event in the periphery, both manual responses (Cohen, 1981; Posner & Cohen, 1984) and saccades (Vaugan, 1982) are slower to a target appearing in the previously fixated location than to one appearing elsewhere.

From the results of their double-cueing experiment, Posner and Cohen (1984) argued that the inhibitory component does not arise from attentional orienting but from the sensory information presented at the cued location. In their study double cueing resulted in reduced facilitation but the usual amount of inhibition, in comparison with the effects of single cueing. They concluded that externally controlled covert orienting is not a necessary condition to produce inhibition. However, the results of the double-cueing experiment reported earlier (Experiment 3), combined with the observation from Experiment 2 that inhibition does not occur if facilitation is absent, argue against this view. It appears that the inhibitory component is *dependent* on externally controlled orienting.

Finally, Posner and Cohen (1984) concluded that the facilitatory (attentional) and inhibitory components “appear to be independent and may cancel each other out. Thus if attention is not drawn away from the cued location, no net inhibition is found. Immediately after a cue there is usually a net facilitation, and no net inhibition appears to occur until attention is summoned away from the cue” [p. 541]. However, it was noted that identical results to those of Experiment 1a were obtained when central cueing (see *Method*) was omitted (Maylor, 1983). Furthermore, if the data from the SOA of 300 msec only are considered, it appears that it is possible for a subject to be slower to respond to a target from one location yet to judge it as occurring earlier than a target from another location (compare Fig. 9.1 and 9.4). Thus, the presence of attention (as inferred from temporal order judgments) is not sufficient to counteract the inhibitory effect. This is consistent with the results from an additional study, in which it was demonstrated that the inhibitory effect is as large at the fovea as it is in the periphery (Maylor & Hockey, in preparation). The complex relationship between the facilitatory and inhibitory components involved in visual orienting clearly requires further exploration. The data presented in Experiments 1 to 4, however, are consistent with Posner and Cohen’s (1984) general conclusions that facilitation is associated with attention and target acquisition within a fixation and is therefore likely to be involved in the direction of the eye-movement system. Inhibition seems to operate between fixations, acting to delay orienting to a location that was sampled

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(either covertly or overtly) within the last second (equivalent to the time for two or three saccades).

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10

Accessing Features and Objects: Is Location Special?

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ABSTRACT

This chapter proposes that the role of localization in the selection of visual information can be understood in terms of the organization of visual processing, in which each of several visual maps represents a different attribute. The experiments reported here tested the following predictions: (a) When information registered within a visual map is adequate for the task, selection by location should hold no special advantage. Results showed that selecting an item by color and reporting its location was as accurate as selecting by location and reporting color. (b) Color and shape information are registered in separate maps. The accuracies of reporting the color and shape of an item cued by its location were shown to be independent. (c) When a task requires information from corresponding locations of separate visual maps, localization is necessary for cross-referencing between maps. Results from such a task, in which subjects reported the shape and location of an item cued by its color, showed that the accuracy of shape judgments depended on and was predicted from the accuracy of locating the cued color. This set of results is consistent with findings by Treisman and Gelade (1980) that focused attention is required in searching for conjunctions but not features.

INTRODUCTION

A good deal of research on selective attention in vision and audition has involved tasks in which subjects are instructed to select information on the basis of its spatial location. We know that selection can be based on physical attributes other than location, such as the pitch or loudness of auditory stimuli or the color or brightness of visual stimuli, but selection by location has been emphasized.