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# The effects of concentrated and distributed attention on peripheral acuity*

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Two experiments studied the peripheral discriminability of a target differing in its line slope (a tilted T) and in its line arrangement (an L) when presented in briefly flashed displays of upright Ts. The results showed that: (a) an L and a tilted T were equal in discriminability when attention was focused or concentrated on one display position, (b) the discriminability of an L decreased while the discriminability of a tilted T was not statistically significantly affected as the number of display positions that attention needed to be paid to increased, and (c) the reaction time to find a disparate tilted T was less than that to find a disparate L. The results are interpreted as supporting the hypothesis that, under distributed attention in peripheral vision, the visual system is more sensitive to differences in line slope than to differences in line arrangement. The results are discussed in connection with hypotheses of how selective attention affects the discriminability of a target.

Recently, Beck and Ambler (1972) have reported that a masking flash that controlled the time available to attend selectively to individual letters in a display increased the discriminability of a target differing in its line slopes relative to that of a target differing in its line arrangement. They hypothesized that in peripheral vision differences in line slope are more discriminable than are differences in line arrangement when attention is distributed and not concentrated or focused. This paper presents two experiments designed to compare further the peripheral discriminability of targets differing in their line slopes and in their line arrangements when presented in briefly flashed displays. Experiment I studied how discriminability was affected by prior information regarding the position of a target in a display. Experiment II investigated the reaction time differences to targets differing in their line slopes and in their line arrangements. Hypotheses of how selective attention affects the discriminability of a target will be considered in the discussion section.

## EXPERIMENT I

The displays consisted of a circular arrangement of eight letters flashed for 50 msec. An S was given the task of discriminating whether a display contained all upright Ts or a disparate letter. The disparate letter could be either an L or a tilted T. The lines of an L have the same slopes as the lines of an upright T but differ in their arrangement. The lines of a tilted T have the same arrangement as the lines of an upright T but differ in their slopes. The letters in the display were covered by masks 50 msec after the offset of the display. A within-Ss design involving five experimental conditions was used. The distribution of attention was controlled by varying the number of dot indicators. The dot indicators were presented 150 msec before a display was flashed. In Condition 1, a single dot indicator appeared over the position of a letter. A single indicator allowed an S to concentrate or focus his attention. The effects of distributed attention on discrimination can be determined by comparing an S's performance on the other conditions with that of Condition 1. In two conditions, two dot indicators were presented. In Condition 2, the two indicators were adjacent, and in Condition 3, the two indicators were separated by the diameter of the circle. Performance with the two indicator conditions shows how the relative discriminability of a tilted T and of an L changed when attention was distributed between two letter positions. The two indicators that were adjacent (Condition 2) compared to those which were separated (Condition 3) provide information relevant to the difficulty of attending to display positions as a function of their spacing. In Condition 4, eight dot indicators were presented, one over each letter position. The eight indicators required the maximum distribution of attention. An S's performance with eight indicators indicates how the relative discrimination of an L and of a tilted T was affected by requiring an S to attend to the entire display. In Condition 5, eight dot indicators were also presented, but the mask delay was changed from 50 to 320 msec. Condition 5 was included to provide information about the relative discriminability of an L and of a tilted T when an S is given time to attend selectively to individual letters of the stimulus display in the fading visual trace. A 320-msec delay should allow sufficient time for an S to inspect the fading visual trace and on the basis of prior research (Beck & Ambler, 1972) the discriminability of an L and of a tilted T from an upright T should be similar to each other.

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## Method

*Subjects*

Five volunteers with normal vision without correction served as paid Ss. They were naive as to the purpose of the experiment.

*Apparatus and Stimuli*

The experiment was programmed on a PDP-15 computer, and the stimuli displayed on a Hewlett-Packard 1300A oscilloscope with a P11 phosphor. The face of the oscilloscope was masked to present a circular field 8 in. in diam. The stimulus displays consisted of eight equally spaced letters arranged around the circumference of an imaginary circle 6.25 in. (36.4 deg) in diam at 0, 45, 90, 135, 180, 225, 270, and 315 deg. The letters were separated by approximately 2.5 in. Seven of the letters were upright Ts. The position of the eighth letter, which was determined randomly, was a disparate letter and was either an L or a T tilted 33 deg from the vertical. Each of the two lines making up a figure was composed of seven dots. Since, at the conjunction of the two lines, there was a common dot, each figure contained 13 dots. The lengths of the lines of dots making up an upright T, an L, and a tilted T were about .38 in. (approximately 2.1 deg). The indicators were placed 3.5 in. (20.2 deg) from the fixation point along radial lines from the fixation point and consisted of .08-in. squares. The dot indicators remained on until the offset of a display. The average distance from the indicators to the nearest point on a letter was .34 in. (approximately 1.8 deg).

The masking field consisted of eight masks and eight dot indicators. The letter masks consisted of 12 by 12 matrices of dots in the areas that the letters had occupied. Each mask completely covered a letter and was approximately .5 in. square. The masking field continued until an S pressed a response key or 2 sec elapsed from the time a stimulus display was presented. The Ss were informed after each response whether they were "correct" or "wrong" (feedback) by writing a Y or an N on the scope. The feedback continued until 2 sec elapsed from the time the letters were presented. If an S did not respond within 2 sec, the masks were terminated and an error was recorded. After the offset of the feedback or masks (if an S failed to respond), the computer waited 50 msec before presenting the next trial. The individual dots making up the letters and masks were not discriminable in peripheral vision and appeared as lines and surfaces of fine texture. The masks were equally effective with an L and with a tilted T. When a single letter was presented in an otherwise empty visual field, the mask delay at which an L and a tilted T could be detected 75% of the time (50% corrected for chance) was the same (Beck & Ambler, 1972). The letters and mask were presented at a low level of brightness. The luminances of the letters were approximately .01 fL and those of the masks .05 fL.[1]

*Procedure*

Each S was dark adapted for 10 min in a dimly illuminated room before beginning the experiment. A 100-W bulb shielded by a reflector run at 35 V was placed in the corner of the room 6 ft from an S and directed at the ceiling. The oscilloscope was completely enclosed in a compartment. A chinrest, which assured a constant binocular viewing distance, was approximately 9.5 in. from the scope and was placed within the compartment. The compartment in which the oscilloscope and chinrest were located was completely dark except for the illumination supplied by the display. The stimulus displays were viewed binocularly at eye level. The Ss were instructed to fixate a central dot, .08 in. square, that was always visible. The stimuli in the circle were presented at 18.2 deg of arc from the central fixation point. On a table in front of the S were two keys. An S responded by pressing one of the two keys with the fingers of his right hand to indicate whether a stimulus display consisted of all upright Ts or contained a disparate letter.

Each S was run for 5 days. Four experimental days followed a practice day which familiarized an S with the experimental conditions. Practice trials were also given at the beginning of each of the experimental days. On each of the 4 experimental days, each S was presented with 180 trials, with a tilted T as the disparate letter and with an L as the disparate letter. Five blocks of 36 trials (one block for each of the five experimental conditions) were presented with a tilted T as the disparate letter and five blocks of 36 trials with an L as the disparate letter. In a block of 36 trials, 18 stimulus displays having only upright Ts were mixed randomly with 18 stimulus displays having a disparate figure. The disparate letter and dot indicators were presented with equal probabilities in all eight positions and varied randomly from trial to trial so that an S never knew where the disparate letter would be presented. The 36 trials in a block were broken into subblocks of 18. The Ss were given a 20-sec rest between each subblock and a 1-min rest between blocks of 36 trials.

A different irregular order for each of the five experimental conditions was prepared for each S. This order was used on the first 2 experimental days. On the 3rd and 4th days, a different irregular order was prepared in which the experimental conditions that were presented at the beginning of the experimental session on Days 1 and 2 were presented toward the end of the experimental session on Days 3 and 4. The order presenting a tilted T or an L as a disparate figure was alternated within each of the five experimental conditions over days.

## Results

Table 1 presents the mean errors and standard deviations for each of the five experimental conditions. The number of errors for each S is based on 144 trials per S. The overall significance of the differences in mean errors was evaluated by a three-way analysis of variance (target type, experimental conditions, and Ss). An analysis of variance, excluding eight indicators with a 320-msec mask delay (Condition 5), showed a significant variation between letters (whether the disparate letter was an L or a tilted T) [$F(1,4) = 20.0$, $p < .05$], between experimental conditions [$F(3,12) = 18.9$, $p < .01$], as well as a Letter by Experimental Condition interaction [$F(3,12) = 9.1$, $p < .01$]. The interaction indicates that increasing the number of indicators adversely affected the discriminability of an L but not of a tilted T. Table 1 shows that when one position was indicated, the mean error for a tilted T, 19.2, was greater than with an L, 15.0. In contrast, when more than one position was indicated, more errors were made with a tilted T than with an L. For example, the mean error for a tilted T when eight indicators were presented, 19.4, is approximately the same as when one indicator was presented, while the mean error for an L when eight indicators were presented, 40.6, is 2.7 times greater than when one indicator was presented. Beck and Ambler (1972) also found that an L was discriminated better from an upright T than was a tilted T when a single letter was presented with a mask delay of 50 msec. Thus, the results show that an L is discriminated equal to or better than a tilted T with focal attention but is discriminated worse than a tilted T with distributed

**Table 1**
**Mean Errors and Standard Deviations for the Five Conditions in Experiment I**

| | Conditions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | |
| Indicators | One | | Two Adjacent | | Two Separated | | Eight | | Eight | |
| Mask Delay | 50 msec | | 50 msec | | 50 msec | | 50 msec | | 320 msec | |
| | L | Tilted T | L | Tilted T | L | Tilted T | L | Tilted T | L | Tilted T |
| Mean | 15.0 | 19.2 | 33.2 | 22.8 | 27.8 | 21.6 | 40.6 | 19.4 | 27.2 | 9.8 |
| SD | 6.1 | 7.6 | 6.8 | 13.2 | 10.1 | 6.5 | 5.4 | 7.0 | 13.2 | 6.8 |

attention. The equal or better discriminability of an L than of a tilted T when one indicator was presented shows that the much poorer discriminability of an L than of a tilted T when eight indicators were presented is not to be ascribed to an inherent discriminability difference that is augmented when the discrimination is made difficult.

To further analyze the data, multiple comparison analyses of the mean error scores were carried out separately for an L and for a tilted T in Conditions 1, 2, 3, and 4. For an L, a Tukey analysis showed that the mean error in Condition 1 differed from the mean errors in Conditions 2, 3, and 4 ($p < .01$); the mean error in Condition 3 differed from the mean error in Condition 4 ($p < .01$); and the mean error in Condition 2 just missed differing significantly from the mean error in Condition 4 ($p > .05$). For a tilted T, the Tukey analysis showed that none of the four experimental conditions differed significantly from each other.

Table 1 shows that the errors the Ss made with an L when the two indicators were adjacent and when the two indicators were separated by the diameter of a circle were similar. The results show that in the present experimental conditions the discriminability of an L varied with the number of locations that need to be processed simultaneously and not their spatial proximity. Eriksen and Hoffman (1972) have proposed that the focus of attention subtends about 1 deg of visual angle. If we assume that the discrimination of an L from an upright T required the full focus of an S's attention, adjacent display locations would be outside this focus of attention and would have to be attended to sequentially, as would display locations separated by the diameter of the circle. In Condition 5, with a mask delay of 320 msec, the increased time available to an S to inspect the fading visual image reduced the errors for both an L and a tilted T. The relative discriminability of an L and of a tilted T, however, is similar to that of Condition 4 with a 50-msec delay. In both conditions, a tilted T was more discriminable than an L [$t(4) = 6.52$, $p < .01$, in Condition 4; $t(4) = 3.51$, $p < .05$, in Condition 5]. A recent study by Beck and Ambler (1972) indicated that, though on the average a tilted T and an L were discriminated equally well when a mask did not limit the time available to process the information in the visual trace, the discriminability of a tilted T was better than that of an L for some Ss. One explanation is that, although a 320-msec mask delay would allow an S to inspect the visual trace, the Ss did not concentrate attention but used distributed attention on a significant proportion of the trials. In the present experiment, the Ss ran in experimental sessions in which the 320-msec mask delay condition was intermixed with blocks of trials from the other conditions. If we assume that due to the preponderance of their experience, they developed the habit of concentrating attention only when a single indicator was presented, their performance with eight indicators and a 320-msec mask delay would be expected to be similar to that with eight indicators and a 50-msec mask delay.[2]

A comment should be made about the possibility of eye movements. The total duration of the dot indicator plus the stimulus display was 200 msec. Saslow (1967) reported mean latencies of about 200 msec for saccades of up to 10 deg to either side of a fixation point. It is, therefore, just possible that an S might move his eyes to an indicated stimulus position. It is relevant to mention, however, that following experimental sessions Ss reported that they had complied with instructions and had kept their gaze directed at the fixation point. Moreover, eye movements may be expected to have occurred equally with a tilted T and with an L as the disparate figure. Thus, there is no reason to suppose that the difference in results for an L and a tilted T, when multiple positions were indicated, are to be ascribed to eye movements.

## EXPERIMENT II

Experiment I has clearly demonstrated that, when attention is distributed over a field, accuracy is greater for discriminating a difference in line slope than it is for discriminating a difference in line arrangement. Experiment II investigated whether, in briefly flashed displays, the reaction time for discriminating a difference in line slope would be less than the reaction time for discriminating a difference in line arrangement.

### Method

*Subjects*

Six volunteers with normal vision without correction served as

**Table 2**
**Mean Reaction Times and Errors in Experiment II**

| | | Displays With Disparate Letter | | Displays Without Disparate Letter | |
|---|---|---|---|---|---|
| | | RTs | Errors* | RTs | Errors† |
| | | High Luminance | | | |
| L | Mean | 648.8 | 3.7 | 743.2 | 5.8 |
| | SD | 89.3 | 1.1 | 82.2 | 2.9 |
| Tilted T | Mean | 605.0 | 2.5 | 641.7 | 1.8 |
| | SD | 74.2 | 1.6 | 65.3 | 1.4 |
| | | Low Luminance | | | |
| L | Mean | 694.3 | 6.3 | 781.2 | 6.3 |
| | SD | 55.4 | 2.9 | 84.2 | 2.0 |
| Tilted T | Mean | 679.3 | 6.5 | 705.2 | 2.8 |
| | SD | 88.4 | 2.6 | 44.0 | 2.1 |

**Incorrect rejections* †*False alarms*

paid Ss. They were naive as to the purpose of the experiment.

*Apparatus and Procedure*

The apparatus, experimental arrangement, and stimulus displays were similar to that in Experiment I. A fixation point was presented in the center of two imaginary concentric circles with diameters of 4.75 and 6.25 in. Six equally spaced letters were presented in the inner circle and eight in the outer circle. The letters in the inner circle were 14.1 deg and the letters in the outer circle 18.2 deg from the fixation point. Thirteen letters were always upright Ts. The 14th letter was either an L or a tilted T for half the trials and an upright T for the rest.

The displays were presented at two luminance levels. The higher luminance was the same as in Experiment I. The luminances of the letters were approximately .01 fL, and of the masks .05 fL. The luminances of the letters and masks at the lower luminance level were .0006 and .0015 fL, respectively, for five Ss and .0012 and .004 fL, respectively, for one S. Unlike Experiments I and II, the fixation point was not present continuously, but appeared at the beginning of each trial. An S was instructed to start a trial by fixating a central dot, .08 in. square. Two seconds after the fixation point appeared a stimulus display was flashed. The exposure duration was 100 msec with masks presented 320 msec after the offset of the stimulus display. The masks covered the 14 letter positions and continued until an S pressed a response key or 2 sec had elapsed from the onset of the stimulus display. Responses that took longer than 2 sec were not counted. After an S responded, he was given feedback on the correctness of his response by writing "yes" or "no" on the oscilloscope face. The feedback continued until 2.5 sec had elapsed from the onset of a stimulus display. After the feedback was terminated, the computer waited 1 sec before the next trial was presented.

The procedure was similar to that in Experiment I. Each S was run for 3 days. Two experimental days followed a practice day. The training session on the practice day was divided into two parts. During the first part, an S was presented with displays with an L and a tilted T as the disparate letters at both the high and low luminances. After an S had attained an error level of less than 10%, the second part of the training session began. During the second part, reaction time instructions were given. An S was instructed to respond as fast as he could, but cautioned to keep his error rate low. If he found he was making many errors, he was to respond more slowly and be more careful. If he was not making any errors, he was to try to respond more quickly. An S was told that if he made more than three errors in a block of 18 trials, his data would be discarded and the block would be run over. During the experiment, three blocks had to be rerun with an L at the high luminance, four blocks with the L at the low luminance, and one block with a tilted T at the low luminance.

Each S was dark adapted for 10 min before beginning the experiment. On each experimental day, an S was given practice trials on the first condition to be run that day. On each experimental day, four blocks of 18 trials were presented with an L as the disparate letter at the high and low luminance levels, and four blocks of 18 trials were presented with a tilted T as the disparate letter at the high and low luminance levels. In a block of 18 trials, nine stimulus displays having only upright Ts were mixed randomly with nine stimulus displays having a disparate letter. The position of the disparate letter varied randomly from trial to trial. The Ss were given a 30-sec rest between blocks of 18 trials with the same disparate letter and a 2-min rest period between blocks with different disparate letters.

An S was presented with 36 trials (two blocks of 18 trials) with an L or a tilted T at the high luminance level, and then with 36 trials with the same disparate letter at the low luminance level. This sequence was then repeated. An S was then presented with the other disparate letter with the high and low luminance levels presented in the same order. An S who was presented with an L first on Day 1 was presented with a tilted T first on Day 2. The order of presenting the high and low luminance levels was the same as on Day 1. That is, if an S was run with the high luminance level first with an L, he was run with the high luminance level first with the tilted T. The order of presenting the two luminance levels was counterbalanced over Ss.

## Results

Table 2 presents the mean reaction times in milliseconds for the L and for the tilted T presented at a high and at a low luminance level. The means are for the reaction times in which Ss made correct responses. For each experimental condition, a mean reaction time was determined for the nine presentations in which a disparate letter was presented and for the nine presentations in which no disparate letter was presented for each block of 18 trials. For each S, eight separate means were determined for each experimental condition, one for each of the four blocks of trials presented per experimental condition on each experimental day. The means in Table 2 are the means of these eight reaction time means averaged over Ss. The mean reaction times in Table 2 are consistent with the error scores obtained in Experiment I. The Ss were able to more quickly find a disparate tilted T in a field of upright Ts than a disparate L. Decreasing the luminance of the stimulus increased the magnitude of the difference in reaction time for an L and for a tilted T. An analysis of variance revealed a significant effect due to whether the disparate letter was an L or a tilted T [$F(1,5) = 11.7$, $p < .05$], the luminance level [$F(1,5) = 121.0$, $p < .01$], and whether a disparate letter was presented [$F(1,5) = 12.9$, $p < .05$].

Table 2 also presents the mean errors made by the Ss. The error rates for the entries in Table 2 ranged from 2.5% to 9.2%, with a mean of 6%. Table 2 shows that for both the high and low luminance levels there was a tendency to make more errors with an L than with a tilted T. An analysis of variance of the errors showed a significant effect due to whether the disparate letter was an L or a tilted T [$F(1,5) = 18.1$, $p < .01$], the luminance level [$F(1,5) = 9.2$, $p < .05$], and Target

Type (whether an L or a tilted T was presented) by Error Type interaction (whether an error was an incorrect rejection or false alarm) [$F(1,5) = 14.5$, $p < .05$]. Table 2 shows that errors due to false alarms occurred more frequently in blocks in which an L was the disparate letter than in blocks in which a tilted T was the disparate letter. The results of Experiment II are consistent with those of Experiment I and show that differences in line slope are more discriminable than differences in line arrangement when stimuli are presented to peripheral vision in a patterned visual field in which an S does not know where to direct his attention.

## DISCUSSION

The principal finding of this study was that in peripheral vision, when attention was distributed and not focused, a tilted T that differed in the slopes of its lines from an upright T was more discriminable than an L that differed in the arrangement of its lines. When attention was focused or concentrated, the discriminability of an L and of a tilted T from an upright T was the same. How does selective attention affect peripheral acuity?

A plausible interpretation of the present findings can be given by assuming that the extraction of information from a visual information store (VIS) varies with the magnitude and type of stimulus information to be read out and the properties of the elements in a display. When a display is presented, the elements in the display activate feature detectors and the results of this processing are registered in a VIS that decays rapidly with time. We assume that visual detections are the result of the readout and subsequent processing of the contents of the VIS. This is presumed to occur almost simultaneously for distinctive stimulus information, such as highly discriminable differences in brightness, color, or the slopes of lines. von Wright (1970) has reported that when the selection criterion is brightness, color, size, or location, performance in a delayed partial-report task improves. What is suggested is that information about discriminable simple properties may be read out in parallel or, if sequentially, more quickly than information about less discriminable or relational properties. It is worth noting that these properties are also those that are effective in producing strong similarity grouping (Beck, 1972).

We further assume that in a display in which confusable features are present, or when the distinctive features to be taken into account are weakly signaled, the information in the VIS will not be transferred almost simultaneously for subsequent processing. The presence of confusable vertical and horizontal lines interferes with a parallel or "quick" readout of the arrangement of the lines of an L and of an upright T. Peripheral receptive fields, because they are large, also do not provide precise information about the location of the lines and would therefore signal their arrangement weakly. We suppose that, under these conditions, a central attentional mechanism can examine the content of the VIS and facilitate the processing of the stimulus information.

The present results may be interpreted by assuming that, in the periphery, the discrimination of the difference in the arrangement of the lines of an L from that of an upright T can occur only within the focus of attention, while the discrimination of the difference in the slopes of the lines of a tilted T from those of an upright T does not require focal attention. What is supposed is that, when attention is distributed, a tilted T is discriminated from an upright T on the basis of a parallel or "quick" readout of the differences in their line slopes. The relatively better discrimination of a tilted T than of an L when multiple positions were indicated in Experiment I would be based on the greater number of letters which could be read out before the display decayed beyond intelligibility. The increase in errors with an L in Experiment I as a function of the number of display locations to which an S had to attend would be the result of the attentional mechanism having to examine the representations of the letters in the VIS in a slower sequential manner. Similarly, in Experiment II, since the detection of an L requires the focal examination of the stimuli in a display, the reaction time to find an L is longer than it is to find a tilted T.

The present results, together with those reported by Beck and Ambler (1972), demonstrate that focal attention increases the sensitivity of the visual system to peripherally presented differences in line arrangement. The discriminability of an L from an upright T became equal to or better than that of a tilted T with focal attention. The hypothesis proposed assumes that selective attention facilitates the readout and encoding of information from the VIS rather than facilitating the processing of information up to the point of readout. Though we do not know how attention affects the processing of information, it is not difficult to suggest how this might occur. First, attention to one position in a briefly flashed display would certainly allow a stimulus to be more fully analyzed. Second, attention may also increase the extraction of information by increasing the sensitivity of the visual system to weakly signaled stimulus differences, that is, there is a lowering of the threshold for the transfer of information that is attended to. Third, the attentional mechanism may also affect the encoding of the information by bringing to bear interpretive processes which select one of several interpretations that may be possible if the information in the VIS is unclear.

It has been argued that attention has no effect on perception but is to be explained in terms of its effect on short-term memory or other postperceptual processes. In a recent article, Shiffrin and Gardner (1972) have shown that accuracy of discrimination is the same when four figures in a display were presented simultaneously (not allowing for the operation of attention) and sequentially (allowing for the operation of attention). However, the failure to obtain effects due to the focusing of attention may be the result of Shiffrin and Gardner's particular experimental conditions.

There are two explanations that can be given for the findings of Shiffrin and Gardner. First, their displays were presented in the foveal area. It is possible that attention facilitates detections primarily outside of the fovea. In the fovea, where the visual system processes a stimulus in detail, it may not be possible for attention to increase sensitivity to stimulus properties. The addition of confusable stimuli may also interfere more with the readout of a target in the periphery than in the fovea. Mackworth (1965) found that the addition of irrelevant stimuli decreased foveal discriminability but that there was much more interference when the irrelevant stimuli were presented peripherally. A second possibility is that the experimental procedure of Shiffrin and Gardner did not allow selective attention to operate. In their first experiment, the presentation rate was approximately 40 msec per stimulus, and, as noted by Shiffrin and Gardner, this may be too fast for attentional switching to take place. In their third experiment, the Ss were given 500 msec after the offset of a stimulus before the next stimulus was presented. However, in this experiment, two of the four figures in a display were presented as a pair in the sequential condition. Thus, the experiment compared the ability of an S to attend to two and to four stimulus positions. The failure to find a difference between the simultaneous and the sequential displays may reflect the fact that under their experimental conditions an S is able to process two spatial positions with the same efficiency that he can process four spatial locations.

Whatever the reason for the failure of Shiffrin and Gardner (1972) to find an effect due to selective attention, the accuracy of detections of peripheral stimuli has been previously shown to decrease when an S was required to perform an attention demanding task (Leibowitz & Appelle, 1969). The present results provide further information on the kinds of perceptual discriminations that require focal attention.

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## NOTES

1. The luminance measures were taken with a Spectra-Pritchard photometer and refer to the average luminance of a matrix of dots that filled the aperture field of the photometer. Two dot spaces were left vacant between neighboring dots in the matrix. Two dot spaces were also left vacant between neighboring dots of the masks and of the indicators. In the lines making up a tilted T, 2.6 dot spaces were left vacant between neighboring dots. In the lines making up an upright T and an L, 3 dot spaces were left vacant between neighboring dots. A single dot was about 1/64 in. (approximately 5.0 min) in diam.

2. The hypothesis is supported by the fact that, with an L as a disparate letter, the errors made by three Ss with eight indicators and a 50-msec mask delay were similar to errors made with eight indicators and a 320-msec mask delay. For eight indicators with a 50-msec mask delay, their errors were 46, 48, and 35; and for eight indicators with a 320-msec mask delay, their errors were 40, 42, and 30. Their errors for one indicator with a 50-msec mask delay were 7, 25, and 12. For two Ss, the errors with eight indicators and a 320-msec mask delay were similar to their errors with one indicator and a 50-msec mask delay. For one indicator with a 50-msec mask delay, their errors were 13 and 18, and for eight indicators with a 320-msec mask delay, their errors were 9 and 15. Their errors for eight indicators with a 50-msec mask delay were 36 and 38.

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