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SELECTIVE ATTENTION AND VERY SHORT-TERM RECOGNITION MEMORY FOR NONSENSE FORMS[1]

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In 2 experiments Ss received displays containing 2 or 4 nonsense forms presented for 125 msec. and followed by a single test form at delays of 0–1,000 msec. S judged whether the test form was or was not included among the forms in the display. 4 form displays were presented under 2 conditions, 1 where directional bar markers directed Ss to the top or bottom pair of forms and another condition where no indicators were present. In the latter condition an indicator occurring at the time of the test form directed S to make his decision on the basis of the top or bottom pair of preceding display forms. Recognition was superior at all delay intervals for 2-form displays, and 4-form displays with the simultaneous indicator were superior to 4-form displays where the indicator was delayed until the test form. The results were interpreted in terms of a selective process in visual attention and a masking effect apparent in the data was interpreted in terms of saccadic eye movement.

The concept of attention arises primarily from the need to account for the selective capacity of humans and lower animals as well to respond to certain stimuli and effectively ignore others that appear equally potent on physical and time dimensions. The present study is addressed to three questions about the operation of visual attention. (*a*) To what extent do the effects of attention depend upon foveal fixation, i.e., can selective attentional effects be found when both attended and nonattended stimuli are on equally sensitive foveal areas? (*b*) Is the differential memory for attended and nonattended stimuli attributable to events or processes occurring at or shortly after the stimulation event or to differential rehearsal or processing following the stimulation? (*c*) A somewhat related question has to do with how long it takes for the selective attentional process to act upon stimulations.

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Results from a previous experiment (Steffy & Eriksen, 1965) suggested a procedure for an initial attack upon these questions. In that study recognition memory over short durations of 700 msec. or less was impaired when the form to be recognized was presented briefly together with two other nonsense forms as opposed to the condition where the form was presented alone. The result was interpreted in terms of an interference process among the three forms similar to interference effects over longer memory periods. The question arises as to whether the selective capacity of attention can be used to eliminate or reduce the interfering effect of the extraneous forms. For example, can the interference be eliminated or reduced if an indicator is present in the display directing *S*'s attention to a subset of the forms?

In the present studies *S*s were shown displays containing two or four nonsense forms presented for 125 msec. and followed by the occurrence of a single test form at delays of 0–1,000 msec. The *S* was required to judge whether the test form was or was not included among the forms in the display. The displays of four forms were presented under two conditions, one where the display contained directional bar markers directing *S*s to the top or the bottom pair of the forms and another condition where no indicators were present. In this latter condition an indicator occurred at the time of the test form directing *S* to make his decision on the basis of the top or the bottom pair of forms that had been presented in the preceding display.

In addition to providing information on the selective attentional process these experiments also provided further information on interference effects in recognition memory over very short time intervals.

Experiment I

Method

Subjects.—Twenty-four students at the University of Illinois served as paid volunteers. They were assigned randomly to two groups of 12 each, each group containing eight females.

Apparatus and stimuli.—A three-field Scientific Prototype Model GB tachistoscope was used for stimulus presentation. The stimuli were 9–16 sided nonsense forms constructed according to the method of Attneave (1957). The forms were drawn on black paper, cut out and placed on a white field where they were photographed. The photographs were then mounted on cards to be inserted in the fields of the tachistoscope. A total of 24 nonsense forms were used to construct four different sets of 24 stimulus cards. Three of the sets were displays, one set consisting of two-form displays, another set of four-form displays with indicators, and the third set, four-form displays without indicators. The two sets of four-form displays contained four different nonsense forms on the corners of an imaginary square around the fixation point. Both sets of four-form displays were identical except that one set had small horizontal lines (indicators) at each side of either the top or bottom row of two forms. The set of two-form displays consisted of the two forms designated by the indicator lines in the four-form display set. To maintain control for perceptual complexity, these displays also had the indicator lines. The set of test forms had a small vertical line above or below the nonsense form.

In constructing the sets each of the 24 nonsense forms appeared once in each corner of the four-form display and the form in the display matched by the test stimulus appeared equally often in each position. When viewed through the tachistoscope the nonsense forms subtended approximately 20 min. of visual angle and were positioned 50 min. of angle from the fixation point, a small cross of two fine black lines subtending 7 min. of angle. The test form always contained a black indicator line either above or below the form which when it appeared was centered on the fixation point. The indicator on the test form was used for the condition of the four-form display without indicators. The position of the indicator on the test form directed *S* to make his choice either from the top or the bottom pair of the four stimuli previously presented in the display. The same indicator line occurred on the trials when the display with indicator had also appeared and in this case was congruent with the position of the display indicators. To control for stimulus complexity the same test-form indicator occurred with the two-item displays, although here, as with the four-form displays with indicator, the indicator appearing with the test form had no meaning for *S*.

The luminance in the adapting and two stimulus fields was 5 ftl. The adapting field was on continuously except during presentation of the display and test forms. The adapting field luminance also filled the delay intervals.

Procedure.—Prior to undertaking the experimental sessions each *S* engaged in two practice sessions during which he made same-different judgments of two nonsense forms (not identical to any used in the experimental sessions) simultaneously presented at brief duration. For the experimental sessions *S*s were assigned randomly to either one of two conditions. In the indicator with display (*ID*) condition *S*s were given two kinds of trials during each experimental session. In random ordering they were presented with either the two-form display or the four-form display *with indicators* which upon termination was then followed by the test form at one of four delay times, 0, 50, 200, and 600 msec. between offset of the display and onset of the test form. The *S* was required to make a judgment as to whether the test form was the same or different from the forms that had appeared in the two-form display or the indicated two forms in the four-form display. The *S*s assigned to the indicator with test-form group (IT) were treated identically to the ID group except that no indicators occurred with their four-form displays. Instead they were instructed to use the indicator occurring with the test form to narrow down their decision as to whether the test form was the same or different from the designated two forms in the four-form display. Thus *S*s in the ID group possibly were able to direct their attention to the two relevant forms in the four-form display simultaneously with the display occurrence whereas *S*s in the IT group were unable to selectively attend to a subset of the two forms until the indicator appeared simultaneously with the test form.

Each *S* was run for four sessions. During a session there were four blocks of 24 trials, one for each of the delay intervals. Within a session the delay interval was constant within trial blocks but the order of the delay interval within sessions was counterbalanced across sessions and across *S*s. Each trial block contained 12 trials of the two-form displays and 12 with four-form displays in random ordering. Half of the trials for both the two- and the four-form displays had the test form the same as one of the designated two forms and in the other half the test form was different from all of the display forms. For all *S*s the display and test forms were each presented for 125 msec.

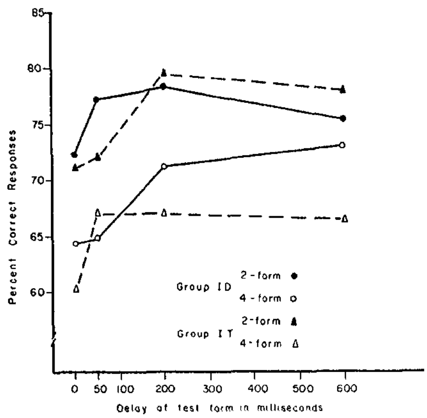

FIG. 1. Percentage of correct same-different recognitions as a function of the number of alternative forms in the display, and delay of the test form for the ID and IT groups.

Results

The number of correct same-different discriminations were analyzed by a modified four-way analysis of variance (ID and IT groups, *S*s, test-form delay, and two- and four-form displays). Significant beyond the .01 level were the effects due to *S*s, F (22, 66) = 4.25, the difference between two- and four-form displays, F (1, 22) = 157.23, and the effects of delay of the test form, F (3, 66) = 9.54. Also the interaction of groups, two- and four-form displays, and delays was significant beyond the .05 level, F (3, 66) = 3.74.

Figure 1 shows recognition accuracy as a function of delay of the test form for the two groups and for the two- and four-form displays. There is a clear and consistent superiority in recognition memory when the display contained two as opposed to four forms. There is close agreement between the performance of the ID and IT groups on the two-form displays except when the test form occurred 50 msec. following termination of the display. Since the stimulation conditions were identical for the two form displays in both groups, this difference would appear attributable to sampling fluctuation.

Of major interest is the effect of the indicator on the four-form displays. The ID group which received the indicator simultaneously with the display is superior in performance to the IT group except at the delay interval of 50 msec. The overall trend of the data is for performance to continue to improve for the ID group with increasing delay of the test form with a suggestion of an asymptote in common with the two-form display data. Performance for the IT group is maximum at 50-msec. delay of the test form and remains essentially constant throughout the 600-msec. delay interval.

The effect of delay of the test form is somewhat surprising. There is no indication of a forgetting function over the 600-msec. interval for either the two- or four-form displays. Instead recognition performance is improved when the test form is delayed 200 msec. rather than presented immediately upon display termination or even 50 msec. later. This result suggests a visual masking effect which could be a masking of the test form by the preceding display (forward masking), a masking of the display by the test form (backward masking), or a mutual masking.

Experiment II

Since the difference between the ID and IT groups on the four-form displays was of borderline significance in the preceding experiment, Exp. II was carried out to see if the obtained recognition memory differences would hold up on a new sample. Also the failure to obtain forgetting effects as a function of the delay of the test form raises the question as to what would happen if the delay interval range was extended to 1,000 msec.

Method

Subjects.—Eight students at the University of Illinois, three female, served as paid volunteers in this experiment.

Procedure.—Apparatus, stimuli, and procedure were identical to those employed in Exp. I with the following exceptions. Only one experimental group was constituted and only four-form displays were used. On alternate experimental sessions the indicators occurred with the displays (ID condition) and on the other sessions the indicator occurred with the test form (IT condition). The order in which ID and IT condition sessions were given was counterbalanced across *S*s. In addition to the delay intervals for the test form that were employed in the preceding experiment a 1,000-msec. delay interval was added to the present study. Thus *S*s were given five blocks of 24 trials each for the five delay intervals during a given experimental session. The *S*s had a total of 48 trials at each of the five delay intervals and under each of the two display conditions.

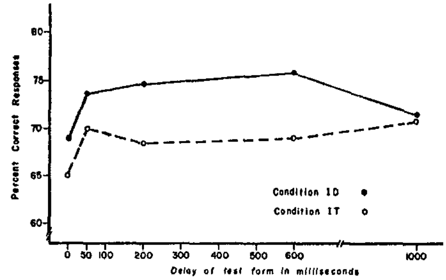

FIG. 2. Percentage of correct same-different recognitions as a function of the delay of the test form and whether the indicators appeared with the display (ID) or the test form (IT).

Results

Number of correct same-different recognitions were analyzed in a three-way classification analysis of variance (ID and IT conditions, *S*s, and delay intervals). The main effects for conditions, $F\ (1, 7) = 33.4$, and for *S*s, $F\ (7, 28) = 5.9$, were significant beyond the .01 level. The effect of delay intervals was not significant, $F\ (94, 28) = 1.5$, and none of the interactions approached significance ($F < 1$).

Figure 2 shows recognition accuracy as a function of indicator conditions and delay interval of the test form. While overall accuracy is slightly higher, the shape of the functions for the ID and IT conditions is essentially the same as was obtained in Exp. I. The only discrepancy occurs at 50-msec. delay. In the previous experiment this was the only delay where performance was poorer when the indicators occurred simultaneously with the display. In the present study performance under this condition is consistently superior to the IT condition where the indicator occurs with the test form. This suggests that the previous discrepancy was a chance fluctuation.

Although the effect of delay intervals was not significant in the A-V, this second experiment replicates quite closely the impairment in performance previously found when the test form occurred immediately following termination of the display.

Extending the range of delay intervals to 1,000 msec. has not produced unequivocal evidence of a forgetting function. There is a decrease in performance for the ID condition at 1,000 msec. suggesting a forgetting effect but this interpretation is clouded by a slight increase for the IT condition at this delay.

Discussion

The results of these two experiments taken together are quite convincing that a selective attentional process in visual perception is operative within a time interval of 125 msec. If *S*s are given an indication of which pair of nonsense forms is relevant at the time the two pairs are presented, they are more accurate in their judgments of whether a subsequent nonsense form was or was not a member of the pair. Delaying the designation of the relevant pair until the time the test form occurs results in poorer performance. This superiority in recognition accuracy with simultaneous indicators is apparent even when compared with the case where the indicator occurs immediately following termination of the display and in fact may become slightly greater as the indicator is delayed out to an interval of 600 msec.

This finding would suggest that whatever is involved in the selective attentional process is occurring within the first 125 msec. The *S*s in both the simultaneous and delayed indicator groups have only two forms to compare with the test form. If both groups had perceived and/or stored the total input of the four forms in the display in the same manner, then selection of the relevant pair of forms at the time of the test form's occurrence should reveal no difference in performance for the two groups. There are also several indications that selectivity is not occurring after the input since the difference between simultaneous and delayed indicators is present even when the delayed indicator occurs immediately upon termination of the display. For the delay group there is no advantage in having the indicator delayed only by 50 msec. as opposed to 1,000 msec. Performance for both the 50- and 1,000-msec delays is almost identical, a result that would argue against the generality of a short-term perceptual storage process as has been advanced by Averbach and Coriell (1961) and Sperling (1963). In the present experiments, at least, the occurrence of the indicators must be simultaneous with the display for an advantage to occur in subsequent recognition memory.

It is of interest to look at the present results from the point of view of serial vs. parallel processing of information. Sperling (1963) and Averbach and Coriell (1961) have presented models of visual perception in which it is assumed that items are processed serially. If we assume that *S* serially processed each of the items in the four-form display, then the advantage of the simultaneous indicators would have been to tell him which two forms to process first. If the total duration of the stimulation and resultant perceptual event were too short to process all four items before the perception decayed, then the advantage of the simultaneous indicators can be understood. With delayed indicator *S*s would have to guess whether to begin processing the top or the bottom two forms with only a 50% chance of guessing correctly.

If we apply these assumptions to the data from the IT group in Exp. I where we have appropriate observations, it turns out that the data for the four-form displays in this group are approximately what would be expected from these assumptions. Average recognition accuracy for the two-form data for this group at the 200- and 600-msec. delay was 78.7%. Chance is 50% and if the assumption is made that *S*s guessed correctly the same number of times they guessed incorrectly, we are left with an estimate of 57.4% as the time that *S*s were responding correctly to a real memory of the stimulus. If 57.4% is then taken as an indication of the times *S* can process or partially process two items, we can extrapolate to the data for the four forms with delayed indicator. Half of the time *S* chooses the correct two forms to process with a recognition accuracy of 57.4%. Thus on 28.7% of the trials he will be correct on the basis of having processed or encoded the relevant forms. On the remaining 71.3% of the trials, he either processed the irrelevant forms or failed to complete the processing of the relevant pair and is thus forced to guess. By chance he would be expected to be correct half of this 71.3% of the trials for an overall accuracy of 64.3%. As will be observed from the data in Fig. 1 this is quite close to the percentage accuracy (66%) obtained for the four-form displays by the IT group at 200- and 600-msec. delay.

It is quite tempting to adopt this model of the underlying processes in the present experiments but a major difficulty arises when one considers that four-form displays with simultaneous indicators are appreciably less effective than if only two forms are presented in the display. A model such as is described above would seem to require little or no difference between two-form displays and four-form displays with simultaneous indicators. In both cases *S* should be able to process the correct two forms.

Whatever the basis of a selective process, it is not completely effective in eliminating the effects of extraneous stimuli. Even when the indicator occurs simultaneously with the two pairs of nonsense forms, *S* is not as accurate in his decisions as when only a single pair of nonsense forms is presented. In other words, extraneous input is not completely ignored since it apparently provides interfering effects even for such short memory intervals as are involved in the present experimental arrangements. In this respect the present results confirm the previous findings of Steffy and Eriksen (1965).

The results do indicate that whatever is involved in selective visual attention does not depend primarily upon fineness of foveal fixation. In the present experimental arrangement all forms were presented equidistant from the center of foveal fixation and the duration of stimulus presentation was too short for eye movements to have occurred even under the condition where the cue occurred concurrently with the displays.

The apparent masking effect when the test form follows immediately the termination of the display appears to be a real phenomenon. Experiment I shows the effect quite clearly for both the two- and four-form displays under both indicator conditions. Although the main effect of delay intervals was not significant in Exp. II when the 1,000-msec. delay was included in the analysis, the consistency of the finding for 0 delay is certainly confirmatory. This impairment is also verified by introspective reports of *S*s who quite uniformly reported that when the test form followed the display at 0 delay they tended not to see the test form (forward masking). Typical comments were to the effect that the test form occurred while they were still busy "looking" at the display.

This masking effect is quite similar to previously found effects resulting from luminance summation–contrast reduction (Eriksen, 1966; Eriksen & Hoffman, 1963; Thompson, 1966). However in the present experiment other processes must be involved since the experimental procedure was designed in terms of adapting and delay field luminances to control luminance summation–contrast reduction effects.

It is possible that this "masking effect" is attributable to saccadic eye movement. The problem of "blanking out" of vision during eye movements has a long history in experimental psychology (Dodge, 1900; Holt, 1903; Woodworth, 1906). Recently Volkmann (1962) has presented convincing evidence that thresholds are markedly raised during saccadic eye movements and Latour (1962) has further indicated that suppression occurs approximately 40 msec. before the eye begins to move. When these observations are combined with the findings that latency of eye movement varies from 125 to approximately 230 msec., depending upon individual *S*s (Diefendorf & Dodge, 1908), an explanation for the "masking effect" is obtained.

The impairment in performance found when the test form occurred immediately following termination of the display could be due to an eye movement that is just beginning or occurs shortly after the test form occurs. Since the display form was on for 125 msec. followed by 125 msec. of the test form, an eye movement would occur during the time the test form was being presented to *S*. If we consider the approximately 40 msec. of visual suppression occurring before an eye movement, as reported by Latour (1962), and add another 20 msec. for the time for the eye to travel approximately 1° from the fixation point to one of the forms presented in the display, we end up with an interval of about 60 msec. of visual impairment that occurs during the time the test form is being presented. This could well account for *S*s' phenomenal reports that at 0 delay they did not seem to see the test form.

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