Recognition of tachistoscopically exposed letters by normals and retardates¹

JOHN J. WINTERS, JR.² AND IRMA R. GERJUOY³
EDWARD R. JOHNSTONE TRAINING AND RESEARCH CENTER

Thirty adolescent educable retardates, 30 equal-MA normals, and 30 equal-CA normals were tachistoscopically presented a square array of four letters at two exposures (.01 sec and .3 sec). The groups did not differ significantly in correct recognitions at the shorter exposure and the two older groups had significantly better recognitions in the right visual field than the left. Under the longer exposure the groups ordered from poorest to best performance: retardates, equal-MA normals, and equal-CA normals; and no group recognized significantly more letters on one side than the other. Results were discussed in terms of consistency of reporting patterns which aided recognition.

A number of investigators have been concerned with the differential recognition of tachistoscopically exposed stimuli in the left and right visual fields. Early pioneers in this area (Mishkin & Forgays, 1952) found that there is a lower threshold for recognition of words in the right visual field than the left visual field when the words are presented successively (.15-sec exposure rate) in the four quadrants. They attributed this difference to the selective training of limited regions of the left hemiretinas. They suggested, further, that this selective training occurred during reading experiences.

The results of this study were replicated by Forgays (1953), who again used a .15-sec exposure rate; Terrace (1959), who used a .1-sec exposure rate; and Overton and Wiener (1966), who used a .0098-sec exposure rate. In these studies recognition of alphabetic material (words or several letters) was better in the right visual field than the left as long as the material was presented in only one field at a time, i.e., successively. Heron (1957), utilizing a .1-sec exposure rate, also found that his Ss had better recognition of the stimuli in the right visual field when they were presented successively. However, when his Ss were informed about the next location of the stimuli, the right field superiority decreased. When letters were then presented in both fields simultaneously, recognition was superior in the *left* visual field. Although Heron, as well as the other investigators, had his Ss use a fixation point, the results that he obtained suggest that his Ss were moving their eyes. There was decremental superiority of the right visual field when Ss had knowledge of the side of presentation under successive presentation and left field superiority under simultaneous presentation. In fact, it is possible that, despite fixation instructions, many Ss in the cited studies did move their eyes.

Rather than presenting a fixation point and instructing Ss to fixate in order to eliminate their eye movements, restricting eye movements can be accomplished by using an extremely short exposure time. Overton and Wiener (1966), using successive presentation, found the average recognition threshold of their Ss to be .0098 sec. Ss are unable to move their eyes within this short exposure (Woodworth, 1937, p. 688).

Forgays (1953), also using successive presentation, found that children in Grades 2 through 7 had no lateral superiority, but that a right-side superiority emerged at Grade 8 and then increased with increasing age. Total recognition scores for the younger Ss were lower than those for the older Ss. Solomon and Howes (1951) and Gibson and Gibson (1955) found that

more familiar words are better recognized than less familiar words. It is clearly important that familiarity of material be controlled in this, and other, developmental studies.

Problem

In order to determine whether differential sensitization of the left and right hemiretinas, or whether eye movements is the more important variable in producing left field superiority under simultaneous exposure, it was necessary to employ two exposure times: one under which eye movements could *not* occur, and a second under which limited eye movements *could* occur. No fixation point was used in order to permit eye movements under the longer exposure rate. An exposure time of .01 sec was chosen in the first instance since this was close to the mean recognition threshold found by Overton and Wiener (1966). Pilot work suggested that .3 sec would allow a complete scanning of the stimuli. Simultaneous presentation of stimuli should maximize the differences between the two exposure times, i.e., under the shorter exposure the lower sensitivity of the left hemiretinas and the restricted eye movements should cause the material in the right visual field to be better recognized than that in the left, but under longer exposure the reverse should be true since Ss have time to scan the material, looking first to the left.

If reading experience is the predominant factor in tachistoscopic recognition, as Mishkin and Forgays (1952) claim, then Ss with less reading experience (i.e., lower MA Ss) should have less lateral preference and should recognize less material than Ss with more reading experience. In order to test this hypothesis Ss were chosen from three populations: adolescent educable retardates, equal-CA normals, and equal-MA normals. Since these groups might have differential familiarity with written words, letters were used as the stimuli.

METHOD

Subjects

Ss were 30 high-grade educable retardates from the Johnstone Training and Research Center ($\bar{CA}$ = 15.8 years, σ = 1.1 year; $\bar{IQ}$ = 64.2, σ = 8.2; $\bar{MA}$ = 10.06 years), 30 equal MAs from an elementary school in Trenton, New Jersey ($\bar{CA}$ = 10.3 years, σ = 1.1 year; $\bar{IQ}$ = 104, σ = 9.8) and 30 equal CAs from Bordentown Regional High School ($\bar{CA}$ = 15.9 years, σ = 0.8 year; $\bar{IQ}$ = 104.2, σ = 10.2). Fifteen males and 15 females were in each of the two normal groups; 19 males and 11 females were in the retarded group.

Apparatus and Stimulus Materials

A Gerbrands tachistoscope was used to present the stimuli. The stimulus materials consisted of two training cards and 10 test cards (25 cm x 27 cm). The 10 test cards were prepared in two separate series, five in each. In the first series a different upper case letter was placed in each corner of each card. The letters (all consonants except Q, which was not used) were randomly selected and assigned to each corner. The letters were again randomly selected for the second series with the restrictions that they appear diagonally to their position in the first series, and that no two letters appear together on the same card in both series. Each training card consisted of four vowels, A, E, O, and U, randomly assigned on one card and

diagonally placed on the second card. The letters, which were 2 cm square, were printed in black ink and displaced laterally 6.0 cm and vertically 2.5 cm from the center of the card; the distance from the letters on the left to the letters on the right subtended a visual angle of 9 deg.

Procedure

The Ss were shown a 3-in. x 5-in. plain white card on which the 20 consonants were typed in capital letters in a random order. The S's task was to read the letters aloud to be sure that he was familiar with them. Three retardates who were unable to read all the letters were dropped from the experiment and replaced.

The S was seated in a chair, which was adjusted to his height, and his head was placed against the eyepiece of the tachistoscope where he looked into the unlit field. He was then dark adapted for 5 min. The E gave the following instructions: "I am going to show you something in this box. Tell me what you see as soon as you can." The E then briefly exposed a black outline of a rectangle whose corners coincided with the positions of the letters. When S reported seeing a rectangle or four lines, it was established that his head was in the correct position so that the stimuli could be seen. If S did not see the four sides, he was instructed to move his head appropriately, up or down, and the rectangle was presented until the proper position of the head was established. The S was then instructed to *keep his head in that position* until the experiment was over. He was finally instructed: "Now we are going to show you some letters in there. Each card will have four letters on it. You will see them for only a *very* short time. Try to remember as many of them as you can. Here is one for practice." A verbal "ready" signal was given prior to the exposure of each stimulus card. The S then saw the first training card, with the vowels, exposed at .01 sec. This card was exposed at 20-sec intervals until S reached a criterion of recognizing at least one of the four vowels. Then the first series of five test cards was exposed at .01 sec. The second training card and the second series of five test cards were then presented at .3-sec exposure. An intertrial interval of 20 sec was maintained throughout. The order of exposure was kept constant, .01 sec first, then .3 sec, because the criterion for the shorter exposure was more difficult to achieve. One half of the Ss in each group viewed each series first to control for any differential ease of recognizing any letter in a particular spatial position. S's task was to report the letters he saw after each exposure.

If it was noticed during the experiment that S was reporting only the upper or lower half of the stimuli in the longer exposure time, the last test card was shown again at an unlimited exposure, and S was asked to read all the letters on the card. This procedure was used to determine if S *had* moved his head during the experiment. Three equal-MA Ss were dropped and replaced as a result of moving their heads.

RESULTS

A comparison of males and females in each population under both exposure times revealed no differences. Therefore, the data were collapsed across sex.

For each population, the total number and per cent of correct responses to the left and right under each of the two exposure times are presented in Table 1.

An analysis of variance revealed a significant Population main effect ($F = 9.10$, $df = 2,87$), a significant Exposure Time main effect ($F = 701.00$, $df = 1,261$) and three significant double interactions; Exposure Time by Side of Response ($F = 13.60$, $df = 1,261$), Exposure Time by Population ($F = 19.93$, $df = 2,261$) and Population by Side of Response ($F = 8.06$, $df = 2,261$). All were significant beyond the .001 level. The main effect of Side of Response and the triple interaction were not significant. There was a nonsignificant heterogeneity of variance among Populations by Exposure Time by Side of Response cells ($F_{\max} = 3.2$, $k = 12$, $n_{\max} = 30$; $p > .05$).

There were more correct responses under long exposure than there were for short exposure for all three populations. Over all, the three populations differed significantly from each other in number of correct responses (Duncan multiple range test, $p < .001$). They ordered from fewest to most: retardates, equal-MA normals, and equal-CA normals. These differences among populations were due entirely to their differences under long exposure. Under the short exposure none of the groups differed significantly from any other on total correct responses. There were significantly more correct responses on the right side than on the left under the short exposure for retardates ($\chi^2 = 16.28$, $p < .001$) and equal-CA normals ($\chi^2 = 9.04$, $p < .01$). Under the long exposure the number of correct responses to each side did not differ significantly (see Table 1).

It was also found that letters in the upper half of the visual field were perceived correctly by all groups under both exposures significantly more often than letters in the lower half of the field ($\chi^2 = 68.5$, $p < .001$).

Since the letters on one side were not recognized more often than letters on the other side under the longer exposure, an analysis of the sequence of recall was performed in order to determine what scanning patterns were used. Scanning pattern can be inferred from recall sequence since it has been found previously that eye movements are significantly correlated with order of verbal report in tachistoscopic recognition tasks with these populations (Winters & Gerjuoy, 1967). The order of correct responses by quadrant was recorded for each S on each trial. The most common pattern given was the horizontal scanning pattern: upper left, upper right, lower left, lower right. Median tests of number of correct responses reported in the horizontal reading scanning order showed that equal MAs reported in this order significantly more often than retardates ($\chi^2 = 10.8$, $p < .001$) and significantly more often than equal

Table 1
Number and Per Cent of Correct Responses on the Left and on the Right Under Two Exposure Times for Three Experimental Groups

Exposure Time (sec)	Population	Left	%	Right	%	Total	%
.01	Retardates	46	15.33	100	33.33	146	24.33
	Equal MA	71	23.67	71	23.67	142	23.67
	Equal CA	46	15.33	81	27.00	127	21.16
	Total	163	18.11	252	28.00	415	23.05
.30	Retardates	156	52.00	179	59.67	335	55.83
	Equal MA	241	80.33	208	69.33	449	74.83
	Equal CA	266	88.67	241	80.33	507	84.50
	Total	663	73.66	628	69.78	1291	71.72

CAs ($\chi^2 = 5.7$, $p < .05$). The retardate and equal-CA groups did not differ. The only group that used the vertical reading scanning order with any consistency was the equal-CA group, i.e., upper left, lower left, upper right, lower right.

In order to determine whether the consistency of order of report was related to recognition of the letters, the responses of Ss who reported the stimuli in the same order on at least four of the five trials were recorded. It was found that 23 of the 30 equal CAs were consistent, 12 reporting the horizontal pattern and 11 reporting the vertical pattern; 20 of the 30 equal MAs were consistent, 18 reporting the horizontal pattern and two reporting the vertical pattern; 10 of the 30 retardates were consistent, eight reporting the horizontal pattern and two reporting the vertical pattern. Thus, the order of consistency paralleled the order of correct response.

The possibility existed that some Ss contributed more correct responses under both exposure rates than other Ss, thereby differentially affecting the results. Inspection of the data indicated that the correct responses were evenly distributed throughout each group. Under the short exposure rate 29/30 retardates, 29/30 equal-MA normals, and 27/30 equal-CA normals gave at least one correct response; under the long exposure rate all Ss gave at least one correct response. There were 12 retardates, 13 equal-MA normals, and nine equal-CA normals who gave six or more correct responses (which is the median of the correct responses under the short exposure rate). There were 23 retardates, 30 equal-MA normals, and 28 equal-CA normals who gave 10 or more correct responses (the median correct responses under the long exposure rate). These results suggest that the distributions of correct responses among the three groups were similar. Comparison of correct responses for each S under each exposure rate produced an r of $-.05$ indicating that the Ss uniformly contributed to the pool of correct responses.

DISCUSSION

The hypothesis that material in the right visual field would be better recognized than material in the left visual field under short exposure conditions was confirmed only for the two older groups. Even though the stimuli were presented in both fields simultaneously, right-field recognition was superior. Since eye movements could not be made within so short an exposure time, differential reading experience cannot account for these results. Any influence of reading experience within this short exposure time (.01 sec) seems even more unlikely since the retardates, who had an average reading grade of only 3.6, had equally good recognition and performed similarly to the equal-CA normals, who were high school sophomores and undoubtedly had more reading experience. These older groups differed from the younger fifth-grade normals, who were also probably better readers than the retardates for whom reading scores were not available. This suggests that experiential or developmental differences other than that proposed in the studies cited may account for the data.

When the exposure time is as long as .3 sec there is no evidence of a differential threshold between the left and right hemiretinas. Here it is likely that reading experience did play a part in Ss' responses. Although most Ss recognized an equal number of letters in each field, there was a strong tendency to start responding with the letter in the upper left quadrant. The most common pattern of responding was upper left, upper right, lower left, lower right. Even retardates, who were less consistent in their patterns of responses than the normal groups, adopted this pattern more frequently than any other. The equal-CA normals were more adaptable. Although most of them adopted some consistent pattern, this pattern was as often vertical as horizontal. In other words, for this group, academic skills other than reading may have determined their pattern of responding, e.g., arithmetic skills. It should also be noted that within this group the Ss who gave consistent

patterns made significantly more correct responses ($t = 2.59$, $p < .02$).

The present results are in agreement with those previously cited if it is assumed that Ss tend to make eye movements in tachistoscopic recognition tasks even when they are instructed to fixate. At a very short exposure time (.01 sec), when eye movements cannot be made, there is usually a differential sensitivity in favor of the right visual field whether the material is presented successively or simultaneously to both visual fields. At longer exposure rates (.10-.15 sec used in the above studies) differential scanning units would account for the differences under successive and simultaneous presentation. With successive presentation, when several letters or words are presented in each half of the field, S scans from center to right (one scanning unit) to see stimuli on the right. If the stimuli are on the left he must scan from center to left and back again (two scanning units) to see all of the stimuli. This would explain the better recognition in the right visual field reported in the literature. With simultaneous presentation S should tend to scan first to the left and then back to center and on to the right, a total of three scanning units. In this case left side superiority should be expected, and it has been found. If the exposure time is extended (.3 sec), S should have sufficient time to scan all the material, and there should be no superiority in either visual field, as was found here.

Although the three S groups did not differ significantly in correct left and right responses, they did differ in overall correct responses under the long exposure. These results cannot be accounted for by differences in the familiarity of the stimuli since all populations did equally well under the short exposure. If there had been differential recognition of letters, the two lower MA groups should have performed dissimilarly to the higher MA group. It is possible that the poorer performance of the two lower MA groups under the longer exposure resulted because their rate of scanning had not developed to the same proficiency as that of the equal-CA normals. However, there must be some additional explanation for the large gap in performance between the retardates and the equal-MA normals.

In a previous study by the present authors (Winters & Gerjuoy, 1967), Ss from these same three populations were shown pairs of letters for 1 sec. The Ss' task was to recall the letters after the exposure of each pair. It was found that the normal groups recalled more letters than the retarded group, their eye movements were more consistent with their order of report, i.e., the direction of eye movements and order of verbal reports were in agreement, and those retardates whose eye movements were consistent with their verbal reports recalled more letters. It was concluded that consistency between eye movements and order of report facilitates recall. By the same token, it has been found in the present study that the more consistent the Ss are in the order of reporting a certain pattern, the better the recall.

The possibility remains that the retardates' inferior performance in this and the above-mentioned study was due to their inability to manage the amount of information within each presentation of the stimuli. If this were true, the retardates should have had a greater recall decrement compared with the normals in the present study than did retardates when compared to similar normal groups in the previous study, where less information was presented at a slower rate (four stimuli/.3 sec vs two stimuli/1 sec). An analysis of variance, comparing these two studies, indicates that there is no significant interaction between the experiments and populations. This comparison demonstrates that, though the populations differed in amount recalled and the more difficult experimental condition increased errors, the retardates were not differentially affected by the more difficult condition, i.e., the three groups had the same

decrement in recall. If the retardates could not handle the amount of information, they should have exhibited a greater decrement in recall in this experiment. It is more likely that inconsistent organization (Spitz, 1966; Winters & Gerjuoy, 1967) and scanning resulted in poorer recall.

In summary, there were several concomitant findings in this study. First, the assumption by Mishkin and Forgays (1952) that reading experience lowers the threshold for stimuli in the left hemiretinas was unsubstantiated since retardates with less reading experience saw significantly more letters in the right visual field than fifth-grade normals. Second, the conflict between the simultaneous condition in Heron's (1957) study (left field superiority at .1-sec exposure) and the results here with the older groups (right field superiority at .01-sec exposure) may be explained by the inability of Ss to make eye movements in the present study. Finally, poorer recall by the retardates under .3-sec exposure was probably due to their inconsistent scanning behavior.

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NOTES

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2. Address: Edward R. Johnstone Center, Bordentown, N. J. 08505.
3. Deceased.

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