WORD RECOGNITION AS A FUNCTION OF RETINAL LOCUS

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CHAPTER I

INTRODUCTION

No contemporary psychologist would deny that the problems of learning and perception are intimately related. But how they are related and the degree to which they are interdependent has never been considered systematically. Hilgard (6, p. 181) has pointed to what is in all probability the major stumbling block. Leading theorists have been too long preoccupied with either one or the other of the two fields of investigation, and it can be fairly said that they have neglected the relationship between them.

Kohler (9, p. 192), for example, would have us believe that if past experience does exert an influence upon perceptual organization, "it must be restricted to particular situations". Furthermore, those who believe otherwise "will have to support their theory by experiments of their own". Certainly the evidence gathered in support of the Gestalt view (8), (10), (18) is voluminous and persuasive.

However, there _is_ evidence which is incompatible with the generalization that the Gestaltists have drawn and introduces concepts with which they have not dealt adequately. Leeper (13), in a paper emphasizing the Gestalt failure to study factors of experience in the determination of the Gestalt, reports an experiment demonstrating that stimulus organization can be changed by learning. Other investigators (3), (4), (20), have shown that learned sets and attitudes may determine what is perceived. Unfortunately, as Woodworth (19) has indicated, many learning theorists, (presumably satisfied by such findings as these), have assumed an opposite position and have made little attempt to incorporate the laws of dynamic patterning into their systems.

The author believes that results from the present study provide additional evidence for the influence of learning upon perception, but he wishes to make clear at the start that this does not contradict the hypothesis that a considerable degree of visual structuring is determined by essentially unlearned processes. The evidence for both viewpoints must be recognized and reconciled.

Turning to the 'neurologizing' in contemporary psychology, we find once again that a preoccupation with a particular point of view has resulted in a restriction upon the type of problem subjected to investigation. The hypothesis that behavior, and learning in particular, will someday be explicable in terms of the characteristics of individual neurons and their interconnections, what Morgan (16, p. 519) has called theory at the "molecular" level, has been criticized vigorously by a number of writers (7, pp. 235-236), (9, pp. 96-99), (12, p. 306). Hilgard (6, p. 308) holds that part of this concerted attack originated from the finding that animals respond to relational rather than absolute qualities of the stimulating situation. Thus the pattern, not the element, is important. Consequently, it has been concluded by these critics that there must be a corresponding brain field effect, which has been alternatively conceived of as an electrochemical conduction of neural processes through a continuous medium, or as radiating waves of excitation through equipotential tissue. Lashley (12, p. 306), major exponent of the equipotentiality theory, states that "all behavior seems to be determined by masses of excitation" without regard to particular nerve cells. Many psychologists have accepted his "molar" interpretation as the only alternative to the ill-treated "molecular" hypothesis.

In support of the equipotentiality theory an impressive number of studies has been reported. For example, Lashley (11) has demonstrated that a rat wich has learned pattern discrimination when its visual cortex is intact will continue to discriminate successfully after large amounts of this tissue have been removed. The remaining part of the visual area is thus said to be inherently equivalent to or equipotential with the whole, and the behavioral phenomenon is explained in terms of a transfer of learning throughout the equipotential zone.

However, there is recent evidence that would lead us to question the tenability of a theory of equipotentiality even as it is applied to a particular function subserved by the comparatively restricted area of the visual cortex. Levine (14), in confirming the earlier finding of Beritov and Chichinadze (1), demonstrated that interocular transfer of discrimination learning did <u>not</u> occur in pigeons. When in a subsequent study Levine (15) did produce an interocular transfer, he concluded that its presence or absence could be accounted for in terms of the particular retinal area stimulated. That is, with stimulation of the upper temporal retina transfer occurred, whereas there was no such effect with stimulation of the lower temporal retina. Although Levine's and Lashley's results appear to be contradictory, Levine's experiment is not crucial to the equipotentiality position because it is conceivable that differences in mammalian and avian cortical structures explain the varied results.

The present investigation provides a new and perhaps a less equivocal test of the equipotentiality hypothesis. If it can be shown that subjects achieve higher recognition scores in one visual field than in another when they are presented tachistoscopically with words displaced an equal distance in different directions from the point of their fix - ation, it would follow that no complete cortical transfer of learning is operating. This finding would be inconsistent with a theory of general equipotentiality in vision. However, it would be unreasonable to con- clude that no field effects are present in the brain.

CHAPTER II

TACHISTOSCOPIC STUDIES OF WORD RECOGNITION

A. Preliminary Study

This investigation had its origin in a seminar directed by Dr. Hebb at McGill University in 1947. A tachistoscopic demonstration conducted for the course indicated that errors in the beginning and middle of a word were discerned considerably more frequently than errors at the end. No particular fixation point had been suggested to our subjects, and the results led to the conclusion that in this study they had favored the left half of the visual field.

That hypothesis, and certain considerations suggested by Dr. Hebb's theorizing, (to appear in a forthcoming publication), led to further research on the problem. The purpose of the second study was to discover the effect of varied fixation on word recognition. Twenty-five 8-letter words were presented tachistoscopically to each of twenty-five college students. Five fixation points were selected: one, directly on the center of the word, a second and third immediately in front of and following the word, and a fourth and fifth slightly above and below it. A statistically reliable difference was found between recognition scores at second and third fixation points, as well as between scores at points four and five. These results suggested that cues obtained by fixating beneath and especially to the right of a word did not provide the subject with sufficient data for accurate recognition.

It was considered desirable to verify these preliminary findings using improved techniques. This subsequent experimentation, parts of which were carried out jointly by Mr. D. G. Forgays and the author,[1] are reported in greater detail.

B. Experiment 1a

Subjects, Apparatus and Procedure.

A tachistoscope mechanically calculated to have an exposure time of 150 milliseconds was used throughout the study. (It has been determined experimentally that subjects are ordinarily unable to make two fixations within this time interval (18, p. 688).) Sixteen males and females, predominantly college students, acted as subjects. Each was seated comfortably so that his eyes were approximately twenty-four inches from the exposed words. A fixed chin-rest assured a uniform visual distance for all subjects.

Twenty-four 8-letter words were presented. Each was in lower case hand print, two inches long and a quarter-inch high. It was found in the preliminary investigation that words containing common prefixes or suffixes were frequently confused with similar words not included in the list. Therefore, six words were carefully selected for each of four categories: 1. Words with common prefixes only; 2. Words with common suffixes only; 3. Words with both common prefixes and suffixes; 4. Words with both unique initial and final syllables. This arrangement eliminated one potential source of bias. If, for example, the selected

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[1]Experiments 1a, 1b and 2 were conducted in collaboration with Mr. Forgays.

material had contained a disproportionate number of words with common suffixes, fixation to the right of these words might have produced confusion and lowered recognition scores. Such a biased sample would operate to produce recognition differences in the direction of our hypothesis.

The words were exposed in a random order one and one-third inches above and below, and two inches to the right and to the left of a central fixation point. (Measurements were taken from fixation point to the center of the word.) The possibility of a subject's anticipating the position of a word either by eye movement or by directing attention was thus excluded. Taking the entire sample of twenty-four words and sixteen subjects into account, every word was exposed four times at each position enabling the investigators to determine recognition as a function of word position, without regard to either subject or specific word used. Observers were instructed to fixate the intersection of diagonally-crossed threads, a point in the center and immediately in front of the exposure field. Each subject was then given a short practice session and upon reaching the criterion of word recognition without eye movements immediately before and during exposure, he was presented with the twenty-four word test.

Results.

Scoring consisted of giving full credit for correct responses and one-half credit for those responses of the subjects which contained at least one-half of the correct letters in sequence. Out of a total of 96 words at each position, it was found that 53 words were recognized to the right of fixation point as compared with 25.5 words to the left; 63.5 words were reported correctly below fixation, whereas 31.5 were recognized above. As shown in Table 1, right-left and below-above differences were both significant at the one per cent level of confidence.

TABLE 1

Comparison of Recognition Scores for the Method of Central Fixation and Varied Word Position

Word Position in Relation to Fixation	Subjects	Words Presented to Each Subject	Mean Words Recognized	*t*
Right	16	6	3.31	4.20
Left	16	6	1.59	
Below	16	6	3.97	4.00
Above	16	6	1.97	

With fourteen degrees of freedom a *t* of 2.98 is significant at the one per cent level.

C. Experiment 1b

Subjects, Apparatus and Procedure.

The same tachistoscope, subjects and general procedure were used here as in Experiment 1a. As a variation of fixation, however, the words were always presented in the center of the exposure field, and the subject's fixation was directed by red dots to four different positions peripheral to the word. These positions were such that the distances from the center of the word to the points of fixation were equivalent to the distances reported in Experiment 1a. Since the subject knew where the word was to be exposed, the present method allowed for anticipatory eye movements and directing attention. (The procedure duplicated the preliminary study and provided a check on those results.) A different series of twenty-four 8-letter words was presented and was subdivided into the same four categories outlined in the previous experiment.

Results.

The same method of scoring was followed here as in Experiment la. Out of a possible 96 words at each position, 55.5 words were accurately perceived to the right of fixation and 15 to the left; 66 words were recognized below fixation and 33.5 above. As shown in Table 2, the differences in both cases are significant at the one per cent level of confidence.

TABLE 2

Comparison of Recognition Scores for the Method of Varied Fixation and Central Word Position

Word Position in Relation to Fixation	Subjects	Words Presented to Each Subject	Mean Words Recognized	t
Right	16	6	3.47	6.33
Left	16	6	.94	
Below	16	6	4.13	3.77
Above	16	6	2.09	

With fourteen degrees of freedom a t of 2.98 is significant at the one per cent level.

A comparison of results from Experiments la and lb indicates that the testing procedure employed in the latter did not result in significantly increased scores as might have been anticipated from the fact that subjects knew where the word was to appear. This demonstrates that the exposure time and the testing procedure were adequate for the investigation. Furthermore, since no significant differences were found between recognition scores for words in the same position in the two methods, the results of these two experiments may be considered as confirming one another.

Contrary to expectations there were no recognition differences among the four word-types selected for the test. Moreover, following through with the example cited on page 6, words with common suffixes caused no more confusion when they appeared in the left visual field than when they appeared in the right. The precaution taken against a biased word selection thus proved unnecessary.

A further question arose concerning the relationship between the familiarity of a word and the frequency with which it was recognized. Thorndike's (17) word-frequency list was consulted to obtain a rough measure of each word's familiarity. A Spearman rank-order correlation between this measure and each word's recognition rating yielded a rho of $+.31$, significantly different from zero at the five per cent level. It may be argued from the correlation that learning results in a better perceptual organization. Of course, an alternative and equally tenable hypothesis is that familiar words are more quickly recognized by virtue of a certain simplicity inherent in their organization.

<u>Conclusion</u>.

The results of Experiments 1a and 1b demonstrate that accuracy of word perception depends in large part upon which retinal area is stimulated. Since word recognition is specific to the retinal projection area there can be no complete transfer of the learning involved, and it is suggested that a differential visual learning modifies to a significant degree the organization of the perceptual field.

D. Experiment 2

Problem.

English words only were used in Experiments 1a and 1b. Thus the subjects were prepared to recognize patterns which were meaningful in a left to right sequence, and a process of attention, related to the expectancy, may have been acting selectively upon the right perceptual field. To test whether this factor (as well as variables of eye domiance and differential visual acuity) could have facilitated right field recognition the following modifications were introduced in a second experiment.

Subjects, Apparatus and Procedure.

Twenty-four English and twenty-four Jewish words were presented tachistoscopically to eighteen subjects each of whom was presumed to have an adequate reading facility in both languages. (Results indicating that such was not the case will be discussed shortly.) For nine of the subjects the Jewish words used were from three to five letters long and were cut out of an elementary reader. For the remaining nine subjects all Jewish words were five letters in length and were hand printed. English words were five letters long and were hand printed for all subjects. Crossed threads aided central fixation and the words were exposed in a random order two inches to the right and to the left, so that a subject did not know on which side of his fixation the stimulus would appear, nor whether it would be an English or a Jewish word.

If the aforementioned variables (selective attention, eye dominance, or differential visual acuity) are operative, any differences in word recognition clearly should be in the same direction for both languages.

The same apparatus and general experimental procedure were employed here as in the preceding experiments.

Results.

Recognition was 25 per cent greater for Jewish words to the left than for Jewish words to the right, and 40 per cent greater for English words to the right than for English words to the left of the fixation point.

TABLE 3

Comparing Recognition Scores of Jewish and English Words in the Right Visual Field with the Same Words in the Left

Word Position in Relation to Fixation		Subjects	Words Presented to Each Subject	Mean Words Recognized	*t*
Right	English	18	6	5.76	3.54
Left		18	6	4.13	
Left	Jewish	18	6	3.58	1.78
Right		18	6	2.87	

With sixteen degrees of freedom a *t* of 2.92 is significant at the one per cent level, and a *t* of 2.12 at the five per cent level.

Table 3 shows that the English differences are significant at the one per cent level of confidence. Despite the lower level of significance of the Jewish differences, (*P* = .08) they are, nevertheless, in the direction opposite to the English differences. It is clear that whatever factors facilitated recognition of English to the right of fixation did not affect similarly the recognition of Jewish.

Conclusion.

It may be concluded that unidirectional factors can not be invoked in explanation of the results.

E. Experiment 3

Problem.

One further difficulty remains. It was reported earlier that a low but significant correlation was found between word recognition and word familiarity as measured by Thorndike's word-frequency list. Perhaps a similar factor makes the beginning of a word more important than the ending for word perception. Thus, in Experiment 2, for example, when an English word is placed in the right visual field, the beginning of the word is closer to fixation than when the same word is placed in the left. In the case of a Jewish word the converse would be true. The combined effects of a greater importance of the initial letters and a greater visual acuity as fixation point is approached would result in higher recognition scores for English to the right and Jewish to the left of fixation. The argument is a plausible one and Experiment 3 was designed to test it.

Subjects, Apparatus and Procedure.

A representative sample of twelve words was selected from the lists used in Experiments 1a and 1b. One series of these words, in which the initial four letters of six words and the final four letters of the remaining six had been blurred by pencilling, was presented tachistoscopically to each of seven subjects. Seven other subjects were presented with a second series of the same list in which the blurred letters were the opposite of those in series one. This precaution was taken to eliminate individual word bias.

All subjects were college students. Fixation was directed to the intersection of diagonally-crossed threads, a point which marked the center of the word to be exposed.

If scores were found to be significantly lower for cases in which the first or left half of the word was darkened, it would follow that that part was more important for recognition. If, on the other hand, there were little or no differences between scores for the two types of disfiguration, it could be maintained that both halves of the word were equally important.

Results.

Full credit was given only for a complete word. Out of a total of 84 of each type (fourteen subjects presented with six words of each kind), a score of 53 was made in response to words which were blurred on the left, and a score of 50 to words blurred on the right.

Conclusion.

Since these differences are non-significant, the results are incompatible with the criticism that the beginning of a word is more important than the ending for word perception.

F. Experiment 4

Problem.

One possible objection to Experiment 3 is that a response made to a partly blurred word is not representative of word recognition in general and, therefore, it does not provide a sufficiently critical test. In the experiment the blurred half of the word may have been so heavily darkened that no cues were received from it, (although the majority report contradicts this assumption); whereas ordinarily, cues are received from all parts of the word (with beginning cues of greatest importance) and the completion more nearly resembles the kind which takes place in reconstructing an abbreviated term such as 'std.' or 'bldg.'

However, if the criticism does not apply, and the test is adequate, the question immediately arises as to why scores were not considerably better when the left half of the word was blurred. This after all, would have been the prediction on the basis of a learning factor which facilitates recognition in the right visual field. Thus, when the left half of a word is darkened, a clear perception of the word ending should still remain; whereas, when the right half is disfigured, the initial letters should be seen only imperfectly for according to our hypothesis recognition would be significantly lower in that field.

Experiment 4 was designed to overcome the first criticism, and to provide an answer for the second.

Subjects, Apparatus and Procedure.

The material chosen for the test consisted of twenty-four 4-letter words. Each was in lower case hand print, one inch long and a quarter-inch high. The words were presented tachistoscopically immediately behind a specially constructed aperture which provided an exposure field six inches in length and one inch in height.

A number of word positions were selected: one in the middle of the field, and five on either side. The latter, as measured from fixation (mid-point in the field) to the center of the word, were displaced by graduated one-half inch steps. These positions will be designated by 'C' for center, and 'L1' to 'L5' and 'R1' to 'R5' for places in the left and right visual fields, respectively. Fixation was marked as before by diagonally-crossed threads.

Six observers were tested with the words at L1, C and R1 positions; ten were tested at L3, L2, R2 and R3; an additional ten at L4, L2, R2 and R4; and a final ten at L5, L3, R3 and R5.

The total of twenty-four words was equally divided among the three or four positions at which each subject was tested, and within each observer group a given word appeared as many times in a left field place as it did in the corresponding place on the right. The number of subjects tested at each position is reported in Figure 1.

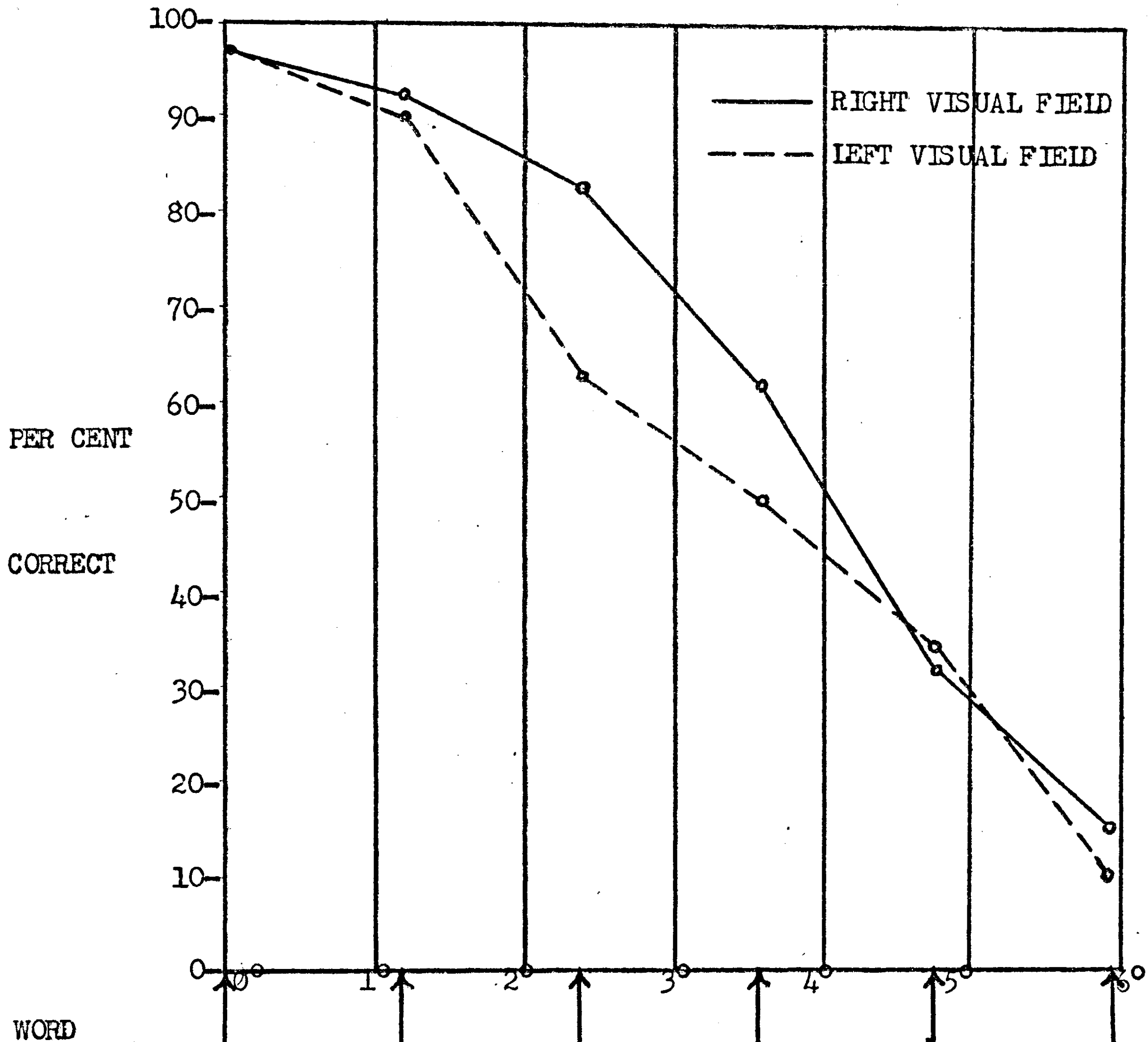
Results.

The number of words exposed was different for each position. (The reason should be apparent from the preceding discussion.) Therefore percentage recognition score will be reported as a more meaningful figure for purposes of comparison.

Full credit was given only for a complete word. A score of 98 per cent was achieved for words placed at C. The drop in recognition on either side of the center is illustrated in Figure 1. Percentage scores are as follows:

Position	Right	Left
1	92	90
2	82.5	63.5
3	62.5	49.2
4	31.7	35
5	15	10

As shown in Table 4, differences between scores at R2 and L2, and R3 and L3, are significant at the one per cent and five per cent level of confidence, respectively. All other right-left differences may be attributed to random errors of sampling.



WORD POSITION:	C	1	2	3	4	5
CENTER OF WORD FROM FIXATION IN DEGREES:	0°	1°11'	2°23'	3°35'	4°46'	5°57'
IN INCHES:	0	.5	1.0	1.5	2.0	2.5
SUBJECTS:	6	6	20	20	10	10

FIGURE 1. RECOGNITION CURVES FOR FOUR-LETTER WORDS PLACED AT SEVERAL POSITIONS IN THE RIGHT AND LEFT VISUAL FIELDS.

TABLE 4

Comparing Recognition Scores of Words Placed at R2 and R3 with the Same Words Placed at L2 and L3

Word Position in Relation to Fixation	Subjects	Words Presented to Each Subject	Mean Words Recognized	*t*
Right 2	20	6	4.95	3.71
Left 2	20	6	3.80	
Right 3	20	6	3.75	2.16
Left 3	20	6	2.95	

With eighteen degrees of freedom a *t* of 2.88 is significant at the one per cent level, and a *t* of 2.10 at the five per cent level.

The results indicate that a facilitation factor favoring right field recognition over left is effective only within certain narrowly defined limits. In terms of the distances and materials used *in the present experiment* these limits are set by points one-half and two inches from fixation, (closing of the curves in Figure 1). It is evident that the finding provides us with an explanation of the difficulty raised in the discussion of Experiment 3. That is, the unblurred right half of a word would be perceived no more accurately than the unblurred left half, because stimuli extending only one inch out from fixation on either side do not excite retinal loci which are differentially affected by the learning factor proposed earlier.

With respect to the criticism that the beginning of a word is more important for recognition than the end, the present experiment offers a more critical test than did Experiment 3, if we accept as valid the first objection raised against it.

It is difficult to maintain that the initial two letters of a four-letter word are more important for its perception than the remainder, yet recognition was significantly better for such words at certain positions on the right than for corresponding positions on the left. However, should this single hypothesis still be maintained, it would then be impossible to explain why a word placed one and one-half inches to the right of fixation (R3) was perceived as accurately as a word placed only one inch to the left (L2), a fact which the results of Experiment 4 demonstrate. That is, greater visual acuity alone should result in better recognition of a stimulus that is closer to fixation. Therefore the 'beginning of the word' criticism cannot by itself explain the phenomenon. Only some variable which facilitates right field word perception could offset the effects of greater acuity.

Figure 1 reports the visual angles (computed from trigonometric functions) for all positions covered by the words. For the material in our test, differential learning has been demonstrated to be effective within the retinal angle subtended by points at $1^{\circ}11'$ and $4^{\circ}46'$ from fixation in the visual field. However, the finding would not preclude a more widespread effect for single letters or even for words of more than four letters. Note the significant difference in recognition scores in Experiment 1a between an 8-letter word placed with its center two inches to the right of the fixation and the same word similarly displaced to the left. There the effect was seen to extend as far out as $7^{\circ}12'$ from fixation, since the word began three inches from center when exposed on the left and ended three inches from center when exposed on the right.

Conclusion.

The results indicate that differential recognition is demonstrable only within certain narrowly defined retinal limits, which are determined in part by the length of the words exposed.

G. Incidental Observations

Throughout the study, subjects volunteered the information that the right visual field appeared clearer than the left. Some of their impressions recorded during the test period follow: "I seem unable to get the words on the left"; "I feel that if I fixated a little above and possibly to the left of the crossed threads I could cover all points better"; "Words at the bottom and on the right are easiest of all".

These and similar reports suggested the following informal demonstrations. In one, a number of 8-letter words were printed on a large card and exposed tachistoscopically two feet from the observer, who was instructed to fixate the center. Results from two subjects confirmed the hypothesis that more words would be reported from the lower right quadrant than from any other part of the card. In a second miniature study, a subject was presented with lists used in Experiments 1a and 1b. He was instructed to fixate anywhere he desired for the purpose of maximizing his recognition score. Upon completion of the test the subject confirmed our expectations by indicating that fixation was most advantageous at a point above and to the left of center.

These observations, reaffirming an hypothesis of differential learning, lend credence as well to the earlier conclusion that subjects discerned more errors in the beginning and middle of a word than in the ending because they favored a fixation point to the left of center.

Further evidence on the topic is contained in a study reported by Brandt (2, pp. 33-39). Photographs of subjects' eye-movements and fixation tendencies were taken while they viewed rectangular advertisement copy. That investigator found a consistent and statistically significant preference for the upper left quadrant of the visual field. The relative time spent in each of the four quarters was 41 per cent in the upper left, 25 per cent in the lower left, 20 per cent in the upper right, and 14 per cent in the lower right.

Brandt concluded that habits of reading and a type of brain dominance were the determining factors. The writer does not agree with either of the explanations. The habit proposed by Brandt is the movement to the left preparatory to reading. But that would not account for the greater period of time spent fixating the upper left corner. A mere movement to the left, were it not perceptually advantageous, would soon be overcome by shifts to other areas. If the narrow field of tachistoscopic vision and the wide visual field in reading are at all comparable, the fact that Brandt's subjects continue to fixate in the upper left quadrant for a relatively large part of the total time is understandable if we postulate that in his experiment, as in the present study, the lower right field of vision is more clearly perceived than the rest. Thus a fixation slightly above and to the left of center would tend to equalize the clarity of the perceptual field.

CHAPTER III

DISCUSSION

A. Conclusions

Experiments 1a and 1b suggest that a differential visual learning results in a modified perceptual organization. Other possible explanatory factors such as differences in visual acuity, eye dominance, anticipatory attention, and the disproportionate significance of word beginnings are ruled out in the other investigations.

It is proposed that the long process of learning to read a language has resulted in a particular structuring of the reading material in the perceptual field. And since it has been demonstrated that the best recognition of English words is in the right and the lower perceptual fields, it is argued that the underlying memory trace organization developed in the reading situation must be more effective in the parts of the visual systems that mediate those areas. Further, since English and Jewish are better recognized in different visual fields, the development of the more effective organization of memory traces in the corresponding cerebral hemispheres (left for English words, right for Jewish words) must be the result of the learning tasks specific to those languages. In neither case can the learning be subject to complete transfer. A theory of general equipotentiality in vision is therefore untenable.

The conclusion that processes within the visual systems of the two cerebral hemispheres are not as intimately related as the equipotentiality theory suggests, finds support in a study by Gengerelli (5). From the results of an investigation of apparent movement he similarly concludes that two excitations existing in the same cerebral hemisphere are more strongly interrelated than two excitations existing in different hemispheres.

One mechanism that could set up a more effective organization of memory traces in some parts of the visual system than in the others is suggested by the results of a tachistoscopic investigation conducted by Mr. Woodburn-Heron at McGill University in 1947 (unpublished). In that study it was demonstrated that with central fixation the distribution of a subject's attention, varied in accordance with the experimenter's instructions, determined in large part which letters of a nonsense word were most accurately perceived. It is reasonable to suppose that in reading, attention is consistently directed to the right (to the left when reading Jewish) and below in anticipation of the material ahead. Conceivably there is an accompanying central inhibitory effect which may prevent perceptual interference from the reading material that has gone before. Many years of such persistent, selective attention might well lead to the differential visual learning which results in an altered perceptual organization. Neither anticipatory attention nor inhibition need be operative in the test situation, and results from Experiment 2 appear to have excluded that possibility.

A familiar example of a developmental sequence similar to the one proposed will serve to illustrate how selective attention may determine perceptual response. It is well known that in drawing the human face, children often fail to include features such as eyebrows and teeth, although these have been present in their visual field just as frequently as the eyes which they normally do include. It is only after a certain level of sophistication has been reached, or the child's attention has been drawn to these features, that teeth and eyebrows are portrayed, and then all too prominently.

Quite a different explanation of the word recognition differences would probably be offered by the Gestalt writers. Koffka (8, pp. 275-280) treats at length the concept of the anisotropy of behavioral space, a concept expressing his belief that space has different properties in different directions. Should such an anisotropy exist (and it is "not to be interpreted empiristically") it might provide greater clarity to the lower right visual field, and hence provide an explanation for the results obtained with English subjects. However, unless the Jewish subjects behave in different kinds of space depending upon whether Jewish or English words are exposed it would seem that the results from Experiment 2 contradict an explanation in terms of anisotropy.

Although results from Experiment 2 add weight to the hypothesis of differential visual learning, less equivocal support will depend upon the finding of a more significant Jewish difference between scores for left and right presentations. This might be obtained by using subjects who have a truly comparable reading facility in both languages, a requirement which our subjects apparently lacked. This is readily understandable in view of the fact that English was their native language. It should prove interesting to test a group of observers who have a greater reading facility in Jewish than in English to determine whether they would give results opposite to those obtained in Experiment 2: That is, significant Jewish left-right differences and tendencies in the direction of better recognition of English to the right than to the left.

B. Suggestions for Research

Theoretical refinement must await the study of at least three aspects of the problem revealed by the present investigation.

1. A study of the tachistoscopic recognition of non-alphabetical material:

It is maintained that differences in recognition are a function of the type of perceptual training involved. The development of many kinds of pattern perception should not be affected by the intervening process of directional attention discussed in the thesis. This proposal could be tested by repeating the present study using non-alphabetical material such as geometrical patterns, primary forms and simple drawings. Should recognition differences be found that are significant at a lower level than those obtained here, they may be attributable to the effects of a transfer of training from the reading situation.

2. Experimental inducement of differential learning with special training techniques:

In a forthcoming publication, Dr. Hebb has theorized on the possibility that transfer of learning between one cortical area and another occurs only after a correspondence or equivalence has been established by learning between the two.

A modification of Levine's experiments, by rearing pigeons in darkness, or blindfolding one or both eyes at birth, would eliminate such preestablished equivalence. These animals could then be trained at maturity in monocular pattern discrimination with stimulation of the upper temporal retina to determine if binocular transfer would then occur.

3. A development study of visual recognition:

There are many significant questions to be answered by such a study. Relevant to the thesis developed in this paper it would be important to determine whether or not the differences in recognition between right and left visual fields increase gradually with age until maturity, corresponding to the steady increase in reading experience. An investigation of the recognition abilities of adult semi-illiterates would provide an essential control of maturational factors.

SUMMARY

The purpose of the present investigation was to determine the manner in which the stimulation of various retinal loci would affect word recognition.

Tachistoscopic presentation of English words peripheral to the observer's fixation point indicated that recognition is significantly better in the right visual field than in the left, and better in the lower visual field than in the upper. It is further demonstrated that such factors as visual acuity, eye dominance, anticipatory attention, and the disproportionate significance of parts of a word cannot account for the results.

It is argued that these findings are inconsistent with the theory of a general equipotentiality in vision since there is no complete transfer of learning among the parts of the visual system that mediate different visual fields.

An hypothesis is proposed which attributes the phenomenon to a differential visual learning which is itself a result of a process of selective attention persistent throughout many years of reading experience.

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