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Perception of Binary Visual Patterns by Pre-School Children and by School Children

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Thesis

PERCEPTION OF BINARY VISUAL PATTERNS BY PRE-SCHOOL CHILDREN AND BY SCHOOL CHILDREN

Submitted by

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Introduction

The basic problem of the research reported in this paper is to discover variables which might interfere with normal progress in reading and which might produce such a phenomenon as "strephosymbolia" (reversal reading). This task is too formidable to attack directly because the number of potential variables is obviously very large. The present approach is to look for basic perceptual mechanisms in a simpler task than reading. It is argued that certain features of perceptual organization which may transfer to, or which may influence the acquisition of, reading skills may be established even before the child begins formal instruction in reading. If this is the case, one would be attempting to understand the development of a skill starting at an unknown position on the learning curve.

Classically some workers in the field have attempted to account for retarded development in reading in terms of structural or structural-functional abnormalities in the visual sensory system. That is, a child has difficulty in learning to read because of some atypical neural organization in the brain. This organization causes him to perceive most clearly those elements in the visual pattern lying to the right of the fixation point, and therefore causes the perceptual organization of the pattern to begin at that point. This reversed perceptual organization may produce a reversed perceived image in reading a language such as English, which proceeds from left to right. The basic question then arises--What factor or factors influence whether the elements in the left visual field or those in the right visual field will be more quickly and accurately perceived?

In an attempt to at least partially answer this question, this study has loaded the testing conditions in favor of finding structural, rather than learned, causal factors. This was done by using a relatively simple perceptual task in which the effects of learning would probably be less than with some more complex task such as reading. It is felt that, if such structural factors are not important in a perceptual task which is simpler than reading, they would not become more important for the more complex perceptual task of reading.

A review of the literature indicates that differences in perception of stimuli appearing in the left and right visual fields have been attributed both to structural factors, such as cerebral and/or eye dominance, and to learning factors, such as a learned sequence of perceptual analysis. The difference between these two explanations is important, since the orientation to the handling of the problem would be considerably different if failures to show superior perception in one visual field as opposed to the other resulted from learning factors rather than from structural factors.

The suggestion that selective perception of stimuli in different areas of the visual field is caused by hemisphere and/or eye dominance will be considered first.

The Concept of Dominance

Cerebral hemisphere dominance, as defined by Hebb (1958), is "the concept that one hemisphere controls the other or is more important to behavior." (p. 85) Perhaps the hemisphere more important to behavior would be the one in which are grouped the motor controls for the dominant side of the body--the dominant side of the body being indicated by handedness. Therefore, a person who is right handed would be left hemisphere dominant, as the right hand is controlled by that hemisphere. Stimulation received at the left hemisphere could therefore be expected to be more accurately perceived than stimuli received at the right hemisphere.

Eye dominance, "preference for the use of one eye over the other" (Hebb 1958, p. 85), cannot be so easily explained. Since each eye is connected to both hemispheres, one eye is not dominant for the same reason that a hand is dominant. The matter is further complicated by the lack of a reliable test of eye dominance. The popular notion, however, is that the eye which shows superior, more persistent, etc. perception of stimulus material is the dominant eye. Since the nasal retina of each eye is more sensitive than the temporal retina, one might expect superior perception of the stimuli which are presented to the nasal retina of the dominant eye.

If the dominant eye and hand are on the same side of the body, a condition which will be referred to as uniform laterality or uniform dominance exists. When they are on opposite sides of the body, however, the condition is called mixed dominance. If these conditions of dominance do cause differential perception of stimuli in the visual field, people with one dominance condition, for example uniform right dominance, would be expected to perceive visual material differently than people with a different dominance condition such as uniform left dominance. Educators have been particularly interested in the possible implications of dominance to reading. As described above, certain kinds of dominance might lead to some students' perceiving more accurately those stimuli on the left of the page and others perceiving more accurately those stimuli on the right on the page. In reading, then, this would mean the difference between superior perception of the beginning and the end of either the word or the sentence. Therefore, according to the notion of dominance, students who have a certain combination of eye and hand dominance tend to perceive certain areas of the visual field before, or more intensely than, other areas. The exact mechanism(s) causing this phenomenon is not specified by proponents of this position. To summarize, superior perception of material appearing to one or the other side of fixation may occur if the material is projected to a dominant hemisphere, if all other things are equal. Similarly, such a difference could be produced by presenting the material to the nasal retina of a dominant eye, if all other things are equal. However, an unambiguous prediction in those cases in which all other things are not equal is difficult, if not impossible, to achieve.

In spite of the obvious difficulties in prediction, considerable writing and research has been devoted to the problem of determining the effects of dominance on perception. The effect of left handedness has been of particular concern. Dearborn (1931) suggests that left handedness may be an important determinant of incorrect viewing sequences. The left-handed person may tend to begin at the wrong end of the word and proceed toward the beginning. Monroe (1932) states that left-handed or left-eyed children may find these movements toward the left easier than movements toward the right. However, in a study designed to investigate this possibility, the percentage of right and left handedness among the reading defect cases and the control cases was approximately equal. Smith (1950) obtained similar results. In studying the laterality characteristics of retarded readers and reading achievers, no significant difference in hand preference between the two groups was found. According to Hildreth (1950), it is not the child who is left handed, but the child who was left handed, and was forced to change, who experiences the reversal errors. In light of this evidence, it would appear that left handedness *per se* does not importantly affect the perception of stimuli in the left and right visual fields.

However, there are suggestions in the literature that mixed dominance may lead to incorrect viewing sequences. In testing over 700 school children, Levell (1954) found that more retarded readers than reading achievers had mixed dominance. Retardation was attributed to the lack of unilateral coordination of a controlling hand and eye. Monroe (1932) also speaks of opposite hand and eye dominance as an impediment in the coordination of directional responses. Experimentation found a significantly greater number of pupils with left-eye-right-hand preferences among the reading-defect cases than among the control (i.e. uniform laterality) cases. Contrary to this, Smith (1950) found that approximately an equal number of reading achievers and retarded readers had mixed dominance. According to Hildreth (1949) this condition is found in only 20 to 40 percent of the population depending upon the age group considered. Since many of these people never experience confusion in reading and writing, she feels that this factor is exaggerated.

Knehr (1941) compared the acuity of 16 observers for Landolt C stimuli presented to the left and right of fixation.

under the two monocular viewing conditions. Although his over-all results suggest an effect of viewing eye, the effect was produced by the data of only three observers—none of whom exhibited a complete reversal of the results from one viewing eye to the other. Considered in this manner his data suggest no effect of viewing eye on relative acuity left and right of fixation. This is the reverse of his conclusion which was based on the over-all results.

A study by Harcum and Rabe (1958c) using binary-pattern targets, found no appreciable effect of viewing eye on left-right field difference in accuracy for college-student observers. This conclusion, however, must be modified slightly as a result of a recent study by Dyer and Harcum (1960). Their data suggested that there is a non-structural, and, therefore, presumably learned, tendency favoring, for most observers, the left-hand elements of a complex pattern such as the one used in this study. This tendency, they concluded, supersedes all effects of eye and/or hemisphere dominance, which may, however, be important if the learned prepotent direction for the operation of an effect of directional perceptual organization has not been strongly established. The reason for this conclusion was that an effect of viewing eye was not exhibited unless the observer had no appreciable difference in reproduction accuracy between left- and right-hand elements under the binocular viewing condition.

<u>Learning Left-to-Right Sequences</u>

In view of the above evidence it would appear that something in addition to cerebral hemisphere dominance and/or eye dominance affects the perceptual processes involved in reading. Since the English language proceeds from the left to the right, readers must learn this sequence of viewing. Betts (1953) states that acquainting the child with the left-to-right progression of symbols across the page is an essential part of developing reading readiness. He sees no reason to assume that the child has previously acquired these left-to-right habits. Bond and Wagner (1950) refer to the learning of these habits as the acquiring of an orientation to the printed page. This involves learning that lines of printed material are read from the left to the right and cannot be viewed in the random manner in which pictures and objects may be viewed.

Betts (1953) believes that beginners should develop this left-to-right mindedness in both the reading of sentences and in word attack skills. Evidence indicating that left-to-right word attack skills are acquired is provided by Teegarden (1933). By administering tests of reversal tendencies to 262 first-graders at the beginning and at the end of the school year, he found that reading achievement was positively related to a decrease in reversal tendencies. Kennedy (1954) in testing kindergarten, first-grade, and second-grade subjects found a decrease in reversal difficulties with an increase in educational level. Although maturation was considered as a possible cause of the decrease, she maintained that the learning of the left-to-right sequence was of primary importance. The results of Smith's (1950) study with more advanced readers, showed that eighty-six percent of the retarded readers tested made reversal errors. This tendency appeared in only twenty-two percent of the reading achievers. These findings may be interpreted as indicating that superior readers favor stimuli in the left visual field. Crosland (1939) supplied evidence in favor of this explanation. He found that the superior readers whom he tested made fewer errors identifying letters to the left of fixation, while the inferior readers made fewer errors identifying letters to the right of fixation.

According to Potter (1949) the learning of the direction of a language leads to the development of a "sidedness." She indicates that in our culture a "sidedness" is learned which favors information appearing in the left visual field. If this is true it would be reasonable to expect that different "sidedness" would develop in cultures in which visual material is presented in sequences different from that of English. For example, it would be predicted that readers of the Hebrew language, which proceeds from right to left, would develop a set favoring information appearing in the right visual field. However, readers familiar with both the English and the Hebrew languages may reveal different results, since they have been exposed to conflicting training in the direction of reading. A study by Mishkin and Forgays (1952) investigates the relative accuracy with which bilingual observers perceive stimuli in the left and right visual fields. Using bilingual, English and Hebrew, observers, they presented English and Hebrew words successively to the left and right of fixation. English words were more accurately perceived when they appeared to the right of fixation than when they appeared to the left of fixation. The reverse was true for Hebrew words. Although these results appear to be contrary to the prediction made in the present study, two differences in apparatus and procedures are relevant. Later evidence to be cited suggests that the use of meaningful verbal material and conditions of successive presentation of the stimuli are critical to their results. (Successive presentation of the stimuli means presenting the entire stimulus on one side of fixation in one exposure and on successive exposures presenting the entire stimulus on the same or opposite sides of fixation. This is distinguished from simultaneous exposure, as used in the present study, in which stimulus elements appear simultaneously on opposite sides of fixation during the same exposure.)

In an experiment similar to that of Mishkin and Forgays, Orbach (1952) found that only when Hebrew had been learned first were Hebrew letters better recognized in the left visual field.

Regardless of the order in which the languages were learned, English letters appearing on the right of fixation were more accurately reproduced. When Anderson (1946) randomly presented nonsense English and Hebrew words which were bisected by fixation, the results were completely reversed. More English letters were recognized to the left of fixation and more Hebrew letters were recognized to the right of fixation. This may have been caused by the simultaneous presentation of the stimuli and/or the use of nonsense words rather than meaningful words.

Heron (1957) also found that the conditions of successive and simultaneous presentation of stimuli in the left and right visual fields yielded different results. Using groups of English letters he found that fewer errors were made in perceiving letters in the right visual field when letter groups were successively presented to the left and right of fixation. The reverse was true when letter groups appeared simultaneously in the left and right visual fields. Heron explains his results in terms of an attentional process developed during reading training. Two tendencies contribute to this attentional proccess--the tendency for eye movements to proceed from left to right and the tendency for eye movements to be made toward the beginning of the line. Therefore under conditions of successive presentation, material in the right visual field would be more easily recognized as both tendencies are working together. When stimulation occurs only on the left of fixation, however, the two tendencies are in opposition—resulting in poor perception of the material. In contrast, simultaneous presentation of letters on both sides of fixation more closely resembles the reading situation. The dominant tendency is, therefore, to move to the beginning of the line and then proceed from left to right. This results in fewer errors in reproducing material appearing in the left visual field.

Similar results were not obtained, however, when simple non-alphabetical material was used. Heron found that the recognition of tachistoscopically presented single nonsense and familiar forms was not significantly different on the two sides of fixation. Studies by Harcum (1958a, b) however supply somewhat conflicting evidence. Using target patterns composed of blackened in and unfilled circles which were bisected by fixation he found superior reproduction of the horizontally-presented elements in the left visual field. The differences in the results of Heron's and Harcum's studies may be due to differences in the target material. Heron's forms were discrete single elements, whereas Harcum's forms were elements which comprised parts of a total complex pattern. The stimuli used in the present investigation are similar to those used by Harcum. In contrast, Aulhorn (1948) presented meaningful stimuli at various orientations in the visual field. German text was rotated clockwise from the horizontal on the frontal plane with the result that zero degrees of rotation (i.e., the normal left-right orientation) was the most favorable for rapid reading. The right-to-left direction, Aulhorn found to be especially difficult for reading. Both Harcum and Aulhorn attribute these results to the influence of a learned attentional process developed through experience in reading.

The suggestion that a learned attentional process may facilitate the perception of stimuli appearing in certain areas of the visual field is supported by two studies in which exposure durations were of sufficient length to allow eye movements. Anderson and Ross (1955) presented miscellaneous items in a five-cell square matrix for a duration of one minute. Items in the upper-left cells were more often correctly reproduced. Anderson and Ross suggest that this may be due to their observers' experience in reading English. In the second study in point, Brandt (1941) exposed a card with nonsense line figures arranged in the four quadrants. Eye movement recorded during the ten-second exposure indicated that the observers devoted the greatest proportion of the total viewing time to the upper-left figures. Progressively less time was spent observing figures in the upper-right, lower-left, and lower-right quadrants. Again it appears that the upper-left portion of the visual field was favored by an attentional factor.

If, as these studies suggest, training in reading English, which is horizontally presented from left to right, is the determinant of superior perception of material presented at the left of the visual field, readers of languages with vertical directionality might better perceive stimuli in different areas of the visual field. Such observers would be expected to more easily perceive stimuli arranged vertically. Chen and Carr (1926) found vertical arrangements of Chinese characters more easily read by bilingual observers. English letters and Arabic numerals, however, were more easily reproduced when presented along the horizontal. Using English-speaking observers, Tinker (1955) recorded reading speed of text presented vertically and horizontally. Material presented horizontally was more quickly read. Following a training period, however, reading speed along the vertical was significantly increased.

These results indicate that the dominant sequence of viewing visual stimuli is learned. Through training observers can change their direction of scanning the visual field (i.e., they may alter the order of attending to the stimuli). The usual viewing sequence, however, seems to be largely dependent upon the directionality of the language used. Observers appear to learn to perceive the tachistoscopically presented stimuli in a sequence. This sequence is the same as the sequence of normally perceiving written material when one is reading across the printed page.

If this order of viewing is indeed a learned or developmental process, different results would be expected from observers who have had little or no experience with the directionality of a language. Experienced readers and beginning readers might, therefore, show differential viewing sequences. Forgays (1953) in presenting three- and four-letter English words to school children found that observers in grades two through seven did not show differential accuracy of word recognition to the left and right of fixation. From the eighth grade level through the junior year in college, however, the superiority of recognition of words presented to the right of fixation is an increasing function of the educational grade level. Although this is the type of developmental process that would be expected, the results of Heron (1957) and Harcum (1958a, b) would indicate an increasing accuracy in perceiving stimuli in the left rather than the right visual field. This apparent contradiction may be reconciled, however, since superior recognition by Forgay's observers of material in the right visual field may again be due to the successive rather than simultaneous presentation of stimuli in the two hemi-fields as well as to his use of meaningful material.

<u>Present Theoretical Approach</u>

The present theoretical orientation proposes that the recognition capability measured by this visual task reflects the functional excellence of some time-space perceptual organizations of visual stimuli compared to other organizations. These favored analysis sequences presumably are established by visual experience with, particularly, printed verbal material. This scanning sequence might refer psychologically to a sweep of attention even when the eyes are fixed. The areas in the visual field covered first in the sequence will produce fewer errors in target reproduction. In other words, there will be a primacy effect. That is, fewer errors on one side of fixation are assumed to result from the effects of primacy.

While previous research using a visual task that was similar to the present one has found that primacy apparently most often favors the elements left of fixation, some observers exhibit the reverse result. The present study might also provide some evidence concerning the cause of these individual differences.

Purpose of Study

The purpose of the present study is to investigate further the development, in an English-speaking culture, of a pattern of perceptual organization for complex, but meaningless, visual stimulus configurations. Observers from nursery school, kindergarten, first grade, and second grade will be tested in an effort to infer the nature of the temporal sequences in the perceptual processes prior to and following basic training in reading.

Complex stimulus patterns will be simultaneously presented to the left and right of fixation. These stimuli, because of the observers' low educational level, will be non-alphabetical and non-meaningful. It is predicted that observers with no formal reading training, i.e. nursery school and kindergarten observers, will show little or no differential recognition of stimuli in the left and right visual fields. Following reading training, however, an increased tendency toward superior recognition of stimuli in the left visual field is expected. On the psychological level, this might mean that the children have learned to attend first to the left-hand stimulus elements, because in reading training they have learned to attend first to the left-hand words or letters. Such training is necessary because the normal sequence in reading English is from left to right. Therefore, it was hypothesized that the tendency to more accurately reproduce elements to the left of fixation will increase as a function of the educational level of these observers.

In addition, information about the eyedness, handedness, and reading proficiency of each observer will be obtained. An attempt will be made to discover any relationships existing between these observer attributes and performance on this perceptual task.

Method

Observers

Sixty-six children with normal vision served as subjects. They were selected from nursery-school, kindergarten, first-grade, and second-grade populations. All nursery school and kindergarten observers were enrolled in the same private school.[1] All first and second grade observers had previously attended that same private school and were pupils at a public elementary school.[2]

Each child attending school during a selected week was given a printed form describing the experiment generally, and requesting the parent's permission for the child to participate. Only those children returning the signed permission slip before the collecting of data was completed were used as observers. These selection criteria defined the observer population. All children returning the slips were tested except those in the kindergarten group in which only the first 18 were tested. The order of testing within a group was determined by a table of random numbers, within the limits of the school attendence of the children. The final numbers of observers in each group were as follows: Nursery: N = 13; Kindergarten: N = 18; First grade: N = 18; and Second grade: N = 17.

[1] Happy Hours School, Williamsburg, Virginia.

[2] Matthew Whaley Elementary School, Williamsburg, Virginia.

<u>Apparatus</u>

The apparatus was a Dodge-type tachistoscope set to expose the target material for about .15 second. The illumination on the target field and the fixation field, which was produced by two incandescent light sources, was sufficient for each observer to detect each target element.

Each target consisted of six elements arranged horizontally. The elements were "circles" 7 mm. by 9 mm. and were placed 1 cm. apart. The target material, therefore, was about 9 cm. in length. The fixation cross on the fixation field registered with a point at the center of the target, i.e. half way between the third and fourth elements. Target patterns were made by filling in (i.e. blackening) two of the six elements on each target. One filled element on each target appeared to the left of the fixation point and one filled element appeared to the right of the fixation point. Each element position was filled equally often. (The individual target patterns are reproduced in Appendix A.) Nine different target patterns resulted. Three sets of these nine target patterns were randomly arranged, and one set used for each of the three viewing conditions: binocular, monocular with the left eye, and monocular with the right eye. Each subject, therefore, viewed 27 targets.

Duplicates of three targets randomly chosen from the nine test targets were utilized to acquaint the observers with the viewing procedure and target reproduction task.

Dittoed score sheets, one for each target exposed, were supplied for each observer.

The type of stimulus used in this study was chosen because, since each stimulus element was circular, there was no inherent directionality in the total pattern. Therefore, investigation of the basic perceptual mechanism was not contaminated by the meaningfulness, dependencies, or other discriminatory characteristics associated with verbal stimuli. However, these stimulus patterns did extend across the visual field and, therefore, involve the perception of spatial relationships.

Procedure

At the beginning of the testing session each observer binocularly viewed and reproduced the three practice target patterns. The nine targets were then observed once under each of the three viewing conditions (binocular, left eye, and right eye). The order of these viewing conditions for an individual observer was determined by which of the six possible viewing orders he had been assigned, i.e. binocular, left eye, and right eye; binocular, right eye, and left eye; etc. An attempt was made to insure fixation by requiring the observer to report the color of the fixation cross prior to target exposure. The color of the cross was periodically changed to red, blue, green, orange, and black.

Immediately after the .15-second exposure of each target the observer was asked to reproduce the pattern. This was done by having the observer point to the elements on a blank template that corresponded with the ones he had observed as filled in on the target. The experimenter marked the elements which he indicated. The intertrial interval was determined by the pace at which the observer chose to work. Testing time for each observer was usually 15-20 minutes.

An error was recorded when an observer indicated that an open element was filled or when he indicated that a filled circle was unfilled.

The Snellen Chart was used to determine the visual acuity of the observer, and a manoptoscope was used to check handedness and eyedness. Reading readiness of the kindergarten observers was indicated by performance on sections 1-4 of the Metropolitan Readiness Tests. Teachers' ratings were obtained to estimate the reading proficiency of the first and second grade observers. Unforeseen circumstances prevented giving the Metropolitan Reading Test to the nursery-school children.

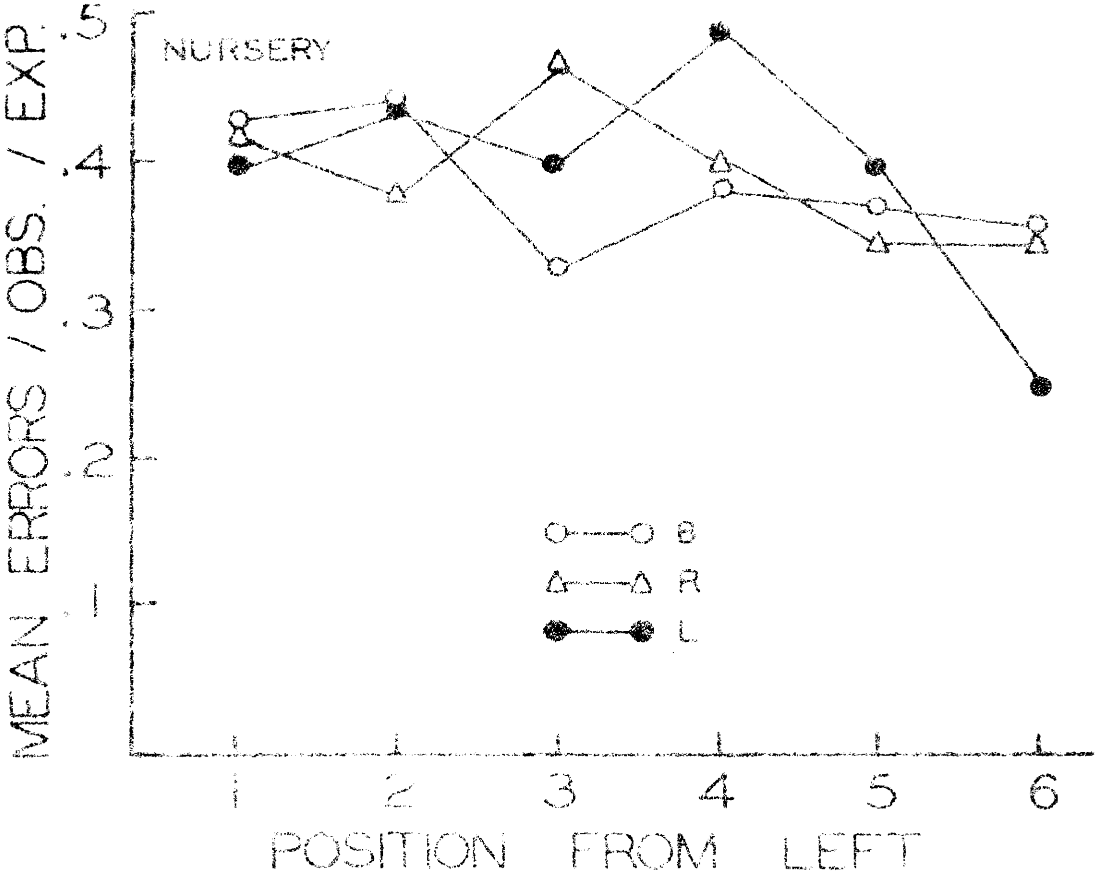
Results

Appendix B contains summarized raw data tables for all observers. The entries represent the total number of errors at each element position. There is a maximum of nine possible errors at each of the six element positions.

Nursery School

The performance of the nursery school group under the three viewing conditions can be seen in Fig. 1, in which the means of errors per observer per exposure are plotted as a function of the position of the element from the left. The curves do not reveal any systematic increase or decrease in errors for any of the three viewing conditions. The left eye condition produces a decrease at the sixth position. Generally, however, the curves are similar with approximately an equal number of errors occuring in the left and right visual fields. There are, however, slightly fewer errors to the right of fixation. This relationship was tested by computing chi-squares for the frequency of observers who show fewer errors at the sixth element than the first element, at the fifth element compared to the second element, and at the fourth element compared to the third element. These chi-squares were then summed to obtain an added chi-square with three degrees of freedom. The result was not significant ($X^2 = 4.68$; $p > .20$).

Figure 1 Mean number of errors per element position for the nursery school observers under the three viewing conditions.


NURSERY
MEAN ERRORS / OBS. / EXP.
.5
.4
.3
.2
.1
B
R
L
1
2
3
4
5
6
POSITION FROM LEFT

It is interesting to note that there are approximately equal numbers of errors under each viewing condition. This would imply that the eyes can take in more information than can be used by the central nervous system.

Kindergarten

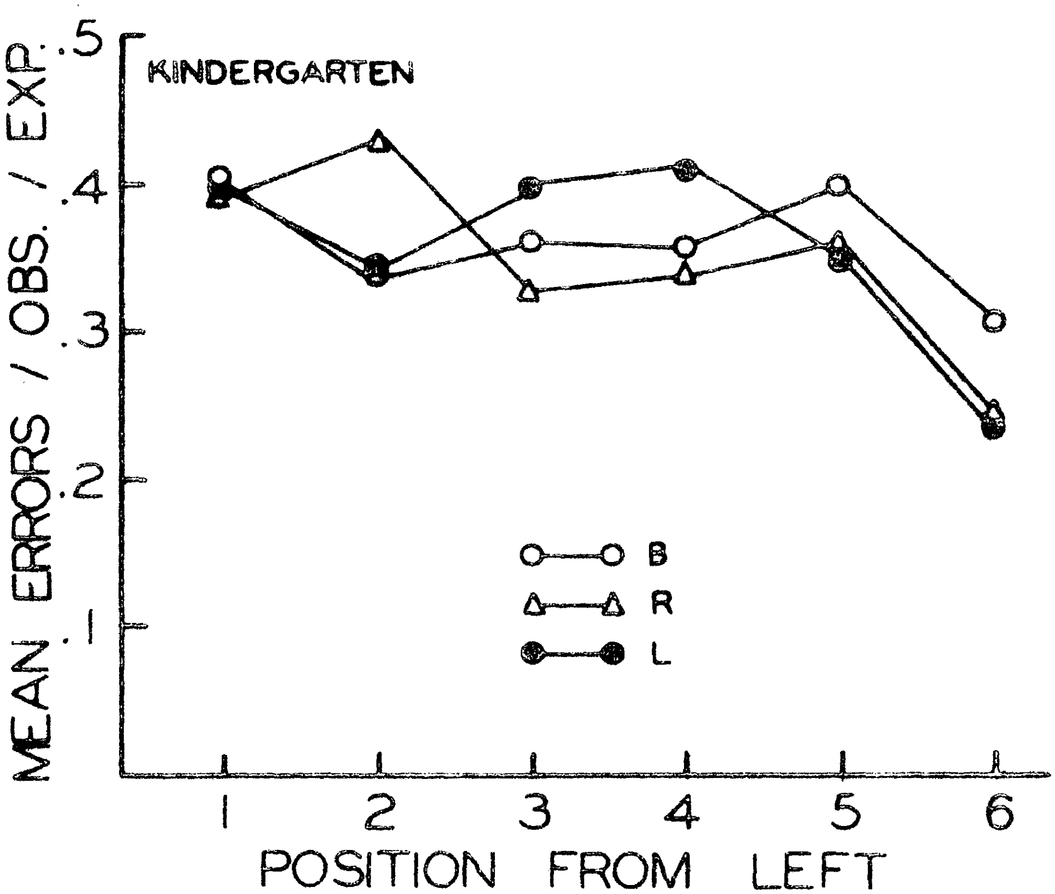
The curves of errors made by the kindergarten observers are shown in Fig. 2. The results for the three viewing conditions are even more consistent than those of the nursery school observers. The curves are virtually flat except that again there are slightly fewer errors on the right of fixation. In addition, the sixth position, which showed a decrease in errors only under the left-eye viewing condition for the nursery school group, now exhibits a decrease under all three viewing conditions. The relative number of errors left and right of fixation was compared by the chi-square method. The result was not significant ($X^2 = 3.67$; $p > .30$).

The total number of errors under each viewing condition is approximately the same.

Summary of Data for Pre-School Observers

The results for these two pre-school groups are about as predicted. First, there is no apparent effect of viewing eye, and, second, the error curves are virtually flat, showing no decrease in errors at the left of fixation compared to those at the right. On the contrary, if there is any difference between the groups

Figure 2 Mean number of errors per element position for the kindergarten observers under the three viewing conditions.



MEAN ERRORS / OBS. / EXP.
.5
.4
.3
.2
.1
KINDERGARTEN
B
R
L
1
2
3
4
5
6
POSITION FROM LEFT

the kindergarten observers show a trend toward a relative decrease in the number of errors to the right of fixation.

Because of the similarity of the data obtained from the nursery school and the kindergarten groups, the results for the two groups were combined for purposes of statistical analysis. The chi-squares for each group and their degrees of freedom were summed yielding a single value for the pre-school group. The differences in performance in the left and right visual fields was not significant for this pre-school group. ($X^2 = 8.35$; $p > .30$).

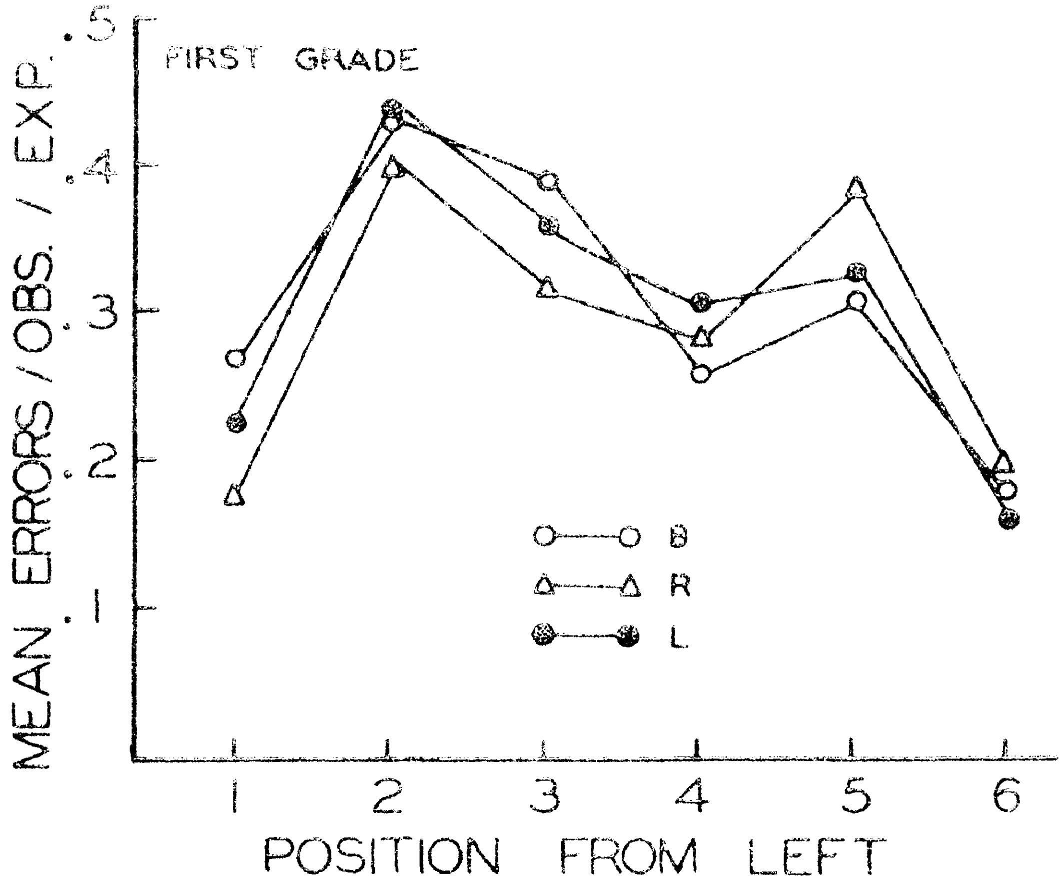
As would be expected, the kindergarten children make somewhat fewer errors than the nursery school children.

First Grade

Fig. 3, containing the data of the first grade observers, also reveals little difference between the curves for the three viewing conditions. All three curves show the same rise at the second element and low at the sixth element. The decrease[s] in errors at the extreme positions and at the elements near fixation are frequently seen in the data of adult observers. Therefore, the curves might be described as being more articulated than those of the pre-school observers. Also the degree of correspondence among the curves for the three viewing conditions suggest that these articulations are similar to the components of a function produced with the data of adult observers.

The data of Fig. 3 deviate, however, in one important way

Figure 3 Mean number of errors per element position for the first grade observers under the three viewing conditions.



FIRST GRADE
MEAN ERRORS / OBS. / EXP.
.5
.4
.3
.2
.1
1
2
3
4
5
6
POSITION FROM LEFT
B
R
L

from the data of adult observers on a similar task. There are consistently fewer errors in reproducing elements to the right of fixation than to the left of fixation. Therefore, the hypothesis of a progressive decrease in errors on the left of fixation relative to those on the right is not verified. As predicted, however, there is a change in the relative number of errors left and right of fixation with increased educational level, but the direction of this change is the opposite of that predicted. The difference between the errors at the right and left of fixation was tested for significance in the same manner as the pre-school observer data. The resultant value of chi-square was significant ($X^2 = 15.84$; $p < .01$).

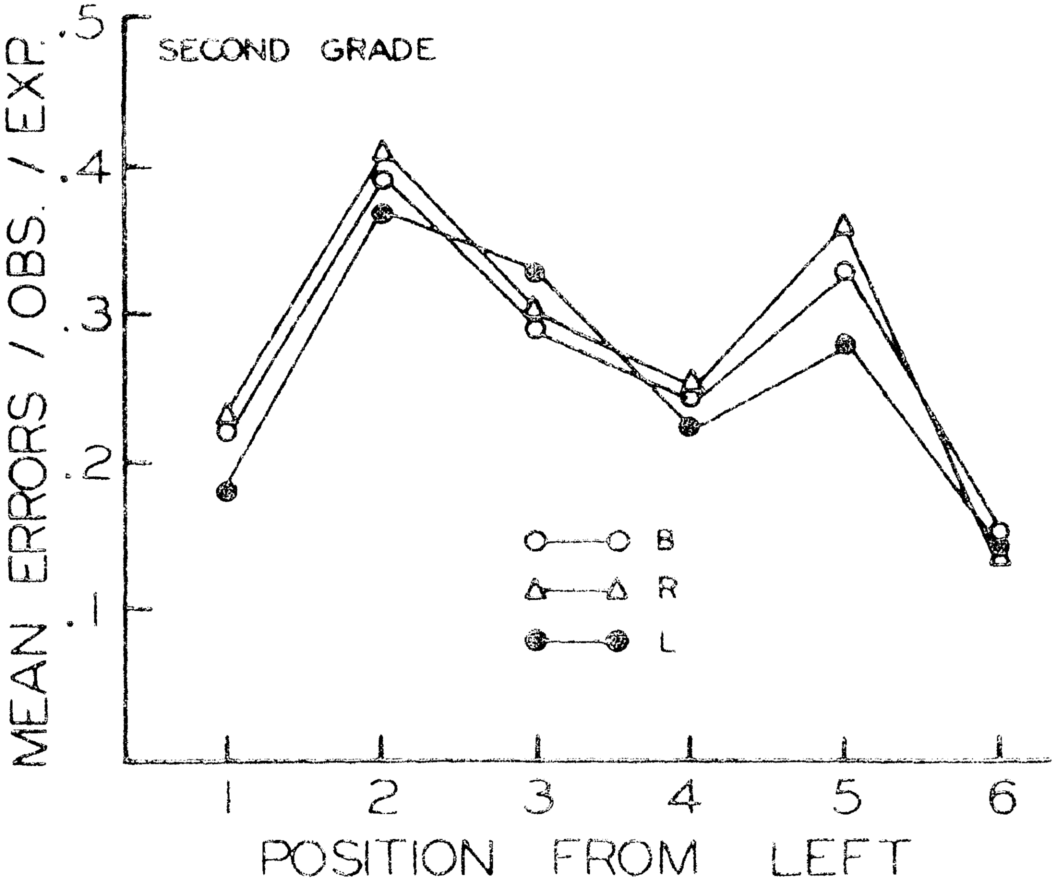
Again the numbers of errors for each viewing condition are virtually equal. There are, of course, fewer total errors for the first grade observers than for the kindergarten observers.

<u>Second Grade</u>

The means of errors per exposure at each element position are illustrated for the second grade observers in Fig. 4. The data of these observers is similar to that of the first grade students in every important respect. The close correspondence of the two sets of curves is quite remarkable. The left-right differences tested by the chi-square technique is not significant ($X^2 = 5.71$; $p > .20$).

The second grade observers made fewer total errors than the first grade observers.

Figure 4 Mean number of errors per element position for the second grade observers under the three viewing conditions.


SECOND GRADE
MEAN ERRORS / OBS. / EXP.
.5
.4
.3
.2
.1
B
R
L
1
2
3
4
5
6
POSITION FROM LEFT

Summary of Data for School Children

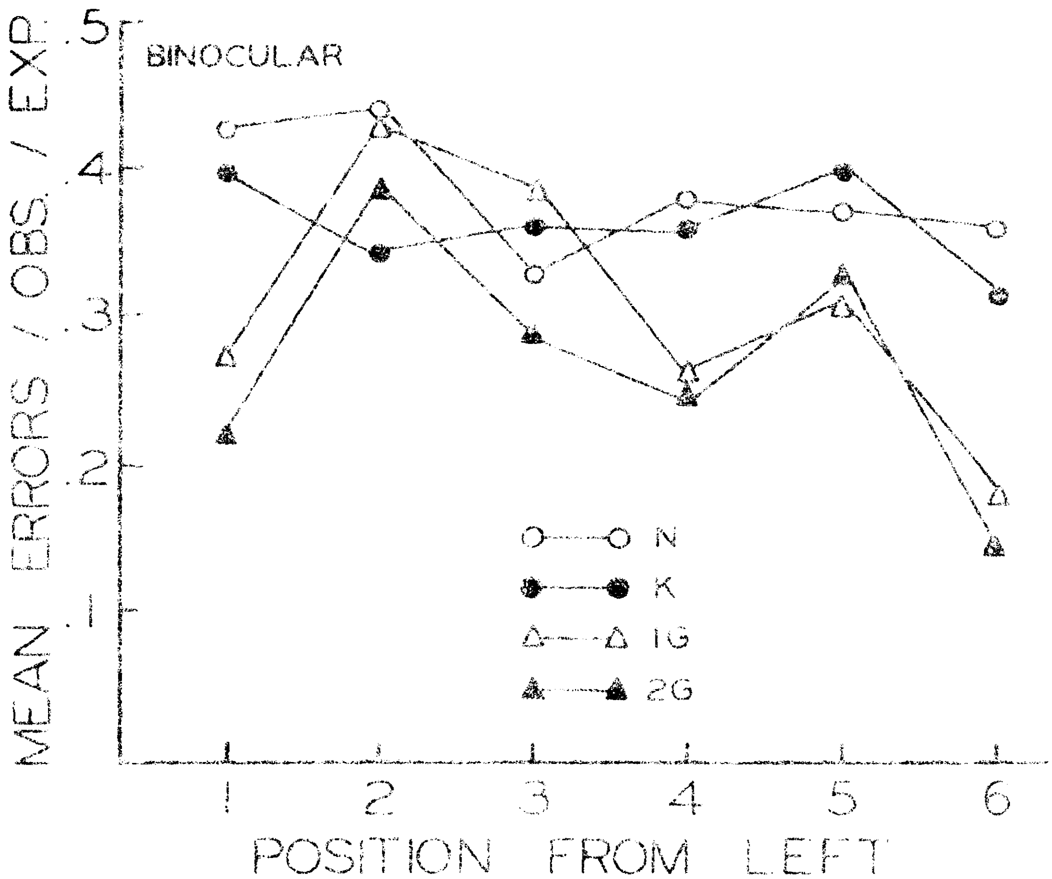
Since the results of the first and second graders are so nearly identical, they were combined for purposes of statistical analysis. The differences between errors left and right of fixation were tested in the same manner as were these differences for the pre-school group. The differences were significant ($X^2 = 21.55$; $p < .01$).

General Trend of Results

In Fig. 5 the data for the binocular viewing condition of all four groups of observers are plotted for purposes of direct comparison. The previous conclusions show up clearly in this graph. That is, the function relating errors and element position is about the same for nursery and kindergarten children and for first grade and second grade children. But the function differs markedly for pre-school and school groups. This change is in the opposite direction from the predicted change.

The conclusion drawn from Fig. 5 is supported by the data presented in Table 1. This table presents the means of errors per exposure for each element position averaged across the three viewing conditions. As mentioned previously, the means of errors averaged across the element positions show a progressive decrease in errors as a function of educational level.

Figure 5 Mean number of errors per element position with binocular viewing for each educational level.



MEAN ERRORS / OBS. / EXP.
.5
.4
.3
.2
.1
BINOCULAR
N
K
1G
2G
1
2
3
4
5
6
POSITION FROM LEFT

Table 1 — Mean errors for the four groups at each element position per exposure for all three viewing conditions.

	Element Position						
Group	1	2	3	4	5	6	Mean
Nursery	.411	.419	.401	.424	.370	.319	.391
Kinder-garten	.399	.371	.362	.371	.369	.269	.357
Grade 1	.235	.422	.356	.288	.343	.179	.304
Grade 2	.209	.388	.305	.255	.325	.144	.271

Individual Differences

The consistent and relatively regular curves for the various figures shown above represent the averaging out of individual differences within each observer group. An analysis of the raw data in Appendix B will reveal that some observers, even nursery school children, exhibited left-right field differences. However, the differences in opposite directions came closer to cancelling each other out for the pre-school children than for the school children. Information about the eyedness and handedness of the observers is presented in Appendix C. Table 2 shows this data summarized for the observers in each of the four educational levels. The total numbers of errors made by each observer to the left and right of fixation is indicated. In addition the number of errors to the left is expressed as a percentage of the total errors. The N of each cell indicates the number of children on which the results of that cell are based. Regardless of the eye and hand dominance of the observers, the mean number of errors to the left of fixation is consistently greater than the mean number of errors to the right. This would indicate that dominance conditions did not effect accuracy of perception of the stimuli presented. There does not appear to be a relation between the total number of errors made by an observer and his characteristic uniform or mixed laterality.

Table 3 summarizes the data of Table 2. The percentage of

Table 2 — Mean errors left and right of fixation for observers at each educational level as a function of eyedness and handedness.

Educational Level	Handedness		Eyedness: Left	Eyedness: Right
Nursery	Left	L	29.0	44.0
		R	33.0	44.0
		Tot.	62.0	88.0
		% L	.47	.50
		N	1	1
	Right	L	36.3	31.0
		R	25.7	29.5
		Tot.	62.0	60.5
		% L	.59	.51
		N	3	8
Kinder-garten	Left	L	36.0	32.0
		R	33.0	28.0
		Tot.	69.0	60.0
		% L	.52	.53
		N	1	3
	Right	L	32.4	27.2
		R	28.2	24.9
		Tot.	60.6	52.1
		% L	.53	.52
		N	7	7
Grade 1	Left	L	26.0	—
		R	15.5	—
		Tot.	41.5	—
		% L	.63	—
		N	2	—
	Right	L	23.8	29.2
		R	19.8	24.1
		Tot.	43.6	53.3
		% L	.55	.55
		N	5	11
Grade 2	Left	L	24.5	14.0
		R	20.0	11.0
		Tot.	44.5	25.0
		% L	.55	.56
		N	4	1
	Right	L	27.8	23.3
		R	17.4	22.1
		Tot.	45.2	45.4
		% L	.62	.51
		N	5	7

Table 3 — Relation of eyedness and handedness of all 66 observers to percentage errors left of fixation and to total errors per observer.

Handedness		Eyedness: Left	Eyedness: Right
Left	Tot.	49.0	58.6
	% L	55	53
	N	8	5
Right	Tot.	52.8	53.2
	% L	55	53
	N	20	33

errors to the left of fixation and the total errors for the eyedness and handedness conditions are presented for all observers, ignoring differences in educational level. As in Table 2 no effect of eyedness, handedness, or mixed laterality is seen.

Relation of Laterality to Reading Proficiency

Table 4 presents the frequency distributions of ratings in reading proficiency for the observers having various laterality characteristics. The ratings for the kindergarten observers were determined by scores on sections one through four of the Metropolitan Readiness Tests. The ratings for first grade and second grade observers were made by the class room teachers. These ratings are of questionable validity because they were made by seven different teachers. In addition the teachers may have allowed knowledge of the student's laterality characteristics to influence the rating. (For example, a teacher might believe that all left handed children have reading difficulties.) If there is any relationship in the data between laterality and frequency of reading proficiency ratings it is not obvious.

Relation of Left-Right Differences to Reading Proficiency

Table 5 shows the relation of the differences in errors left and right of fixation to reading proficiency for the first and second grade observers. It presents the frequency of observers in a two-way classification of higher vs. lower reading profi-

Table 4 — Relation of eyedness and handedness of observers at each educational level to frequency of reading proficiency scores in each category.

Educational Level	Handedness	Reading Proficiency Scores	Eyedness	
			Left	Right
Kindergarten	Left	Superior	0	1
		High Normal	1	2
		Average	0	0
		Low Normal	0	0
		N	1	3
	Right	Superior	2	2
		High Normal	3	3
		Average	1	2
		Low Normal	0	0
		N	6	7
Grade 1	Left	Superior	1	0
		High Normal	1	0
		Average	0	0
		Low Normal	0	0
		N	2	0
	Right	Superior	1	4
		High Normal	2	1
		Average	2	6
		Low Normal	0	0
		N	5	11
Grade 2	Left	Superior	0	0
		High Normal	1	0
		Average	2	1
		Low Normal	1	0
		N	4	1
	Right	Superior	0	5
		High Normal	3	1
		Average	2	0
		Low Normal	0	1
		N	5	7

Table 5 -- Relation of reading ratings to the percentage errors to the left of fixation for first-grade and second-grade observers.

% to Left	Reading Rating: Average or below	Reading Rating: Above Average
Above 50%	9	13
50% and below	6	7

ciency ratings and higher vs lower relative number of errors to the left of fixation. These two classifications are not significantly related ($X^2 = 2.40$; $p > .05$), although the difference is in the direction of a positive relation between more errors left of fixation and teachers' ratings of above average reading proficiency.

Discussion

The results of the present study indicate that pre-school children who have had little or no reading experience tend to perform differently than do children who have had basic instruction in reading. Both groups of pre-school observers (i.e. the nursery school and kindergarten groups) reproduced patterns of target elements appearing in the two hemi-fields almost equally well. The two school groups (first- and second-grade observers), however, more accurately reproduced stimuli appearing in the right visual field. This is contrary to the primary prediction in this study--that the relative tendency to more accurately reproduce elements to the left of fixation will increase as a result of training in reading. Even though the primary prediction was not confirmed, the results may be analyzed to see what new information can be extracted from them, and what hypotheses can be formulated. However, such hypotheses and speculations would have to be verified by further experimentation.

Nature of Task

The fact that there was no difference between binocular and monocular viewing in terms of over-all accuracy implies that the present visual task is not basically a detection, sensitivity threshold, or acuity task. If the detectability of the pattern elements were a limitation on the performance of the observer, then the use of two eyes should improve performance. The task for the observer, then, is apparently to analyze and to interpret the pattern of stimulation that his peripheral nervous system has received.

Differences from Adult Observers

The curves for the first and second grade observers are different from those found by both Heron (1956) and Harcum and Rabe (1958a, b) using similar stimulus material. As indicated previously, Heron found that non-meaningful forms presented simultaneously in both hemi-fields were perceived equally well. The attentional process developed by reading, which he suggested as the determinant of superior perception of meaningful stimuli appearing to the left of fixation, apparently did not similarly affect the viewing of the non-meaningful forms. Harcum and Rabe, however, found superior reproduction of such nonsense-stimulus material when it appeared in the left visual field under conditions of simultaneous presentation. They have explained these results in terms of a "primacy effect" favoring left-hand items. The concept of primacy, well known in serial learning data, means that stimuli appearing first in a series will be more accurately recalled than stimuli presented later in the sequence. Harcum and Rabe (1958) proposed that primacy would favor elements appearing to the left of fixation in a visual task such as the one used in the present experiment. This effect was found in college-student observers and was attributed to training in reading the English language which proceeds from the left to the right. In other words, there is a left-to-right sequence in the perceptual organization even though the stimulus exposure is tachistoscopic and simultaneous.

Although the two groups of school observers in the present experiment had been given initial instruction in reading, they did not show a primacy effect similar to that of Harcum's college students. In fact, the present error curves are essentially the mirror images of those reported by Harcum in another study (1958b). As in this study, Harcum's observers showed a marked decrease in errors at the two extreme elements and a less marked dip in errors near fixation. Only the position of the maximum errors was different. It would appear then, that the same type of discrimination of elements is occurring with these school children as occurred with Harcum's adult observers.

There is, however, no necessity to assume that the mechanisms in pattern recognition for these young observers are exactly like those for adult observers, whose data provided the basis for prediction in the present study. The data of the present study has shown that in similar perceptual tasks two samples of school children (first grade and second grade) both differ in performance from several samples of college students. Apparently, at some time during the interval between the second grade and college, a change occurs from superior perception of stimuli appearing in the right visual field to superior perception of stimuli appearing in the left visual field. This change may be gradual or abrupt.

Possibly the differences between the performance of young school children and college students represents sampling error. Since in both first-grade and second-grade groups and in college groups there are individual observers whose data run counter to the general trends, it is possible that the present school samples included unusually high percentages of individuals showing superior perception of the stimuli presented to the right of fixation. Additional groups of observers must be tested to determine if sampling error is a major determinant of these results.

As discussed previously, Forgays (1953) found that observers in grades two through seven showed no differential accuracy of recognition for words to the left and right of fixation. Starting at the eighth grade level, however, superior recognition of words presented in the right visual field was an increasing function of the grade level of the observers. Because stimuli in the present experiment appeared simultaneously in the two hemi-fields rather than successively as in Forgays' study, favoring of the left visual field was predicted. Also in contrast to Forgays' investigation, effects of favoring the left visual field were looked for at the first and second grade levels. If observers from higher grades had been included, a change over in the predicted direction may have been found. The observers in the present study may have had too little reading training to develop a viewing sequence similar to that evidenced by adult observers.

A consideration of superior and inferior readers may throw some light on the problem. There is a slight indication that the better readers in the present study made fewer errors in reproducing stimuli in the right visual field. Crosland (1939), however, found that the superior readers whom he tested made fewer errors in perceiving stimuli to the left of fixation. Since Crosland's observers were 10.5 years old, his results do not necessarily contradict those found here. His observers may have perceived the targets in a more adult-like manner than did the children in the present investigation.

One other factor could conceivably have produced the difference in relative left-right performance between the present child observers and the college-student observers. This factor is the difference in the number of elements in the task. The present study employed only six-element templates because pilot observations indicated that patterns with eight or more elements would be too difficult for the children. However, previous research with college students by Harcum (1958b) showed that the difference favoring the left-hand elements was more marked for ten-element patterns than for eight-element patterns. If this trend were to continue, college students viewing difficult six-element targets might show superior perception of stimuli in the right visual field.

Possible Maturation Effects

In the present study the educational level of the observers is confounded with their chronological age. Therefore, the conclusions stated for different educational levels might be attributed to maturation rather than training. Inferential evidence against this possibility is the rather marked change in the function of errors per element position coincident with the start of instruction in reading. The groups representing the two years previous to the start of instruction in reading produced nearly identical results. The results were also nearly identical for the first and second grade groups, representing the two years after initiation of formal instruction in reading. The two school groups, however, produce results that are markedly different from those derived from the pre-school observers. This rather abrupt change would, therefore, seem more reasonably due to reading instruction than to maturation. The change is especially noteworthy when one considers the wide range of developmental stages represented within each educational level. For example, one child in kindergarten was highly proficient in reading. Interestingly enough, his errors-per-element curve was quite similar to the second-grade's curve.

Effect of Fixation

The possibility exists that the observers, particularly those in the pre-school groups, did not follow the directions concerning fixation. They may have been looking at different areas of the visual field rather than at the fixation cross when the target was exposed. This failure to fixate properly may account to some extent for the relatively equal number of errors made to the left and right of fixation. The first- and second-grade observers, on the other hand, probably fixated correctly and thus showed more variability (i.e. discriminability) in reproducing the target elements. Unfortunately there was no way of accurately determining whether or not the observer was fixated prior to the target exposure. However, Terrace (1959) reports that the observers do not lose fixation with form stimuli and with verbal stimuli the deviation is to the left. Such effect would operate against the present results.

Alternative Explanations of Results

The fact that more errors were made to the left of fixation does not necessarily negate the existence of a left-to-right viewing sequence. Recalling stimuli viewed at the beginning of a sequence may be too difficult a task for observers of this grade level. This would lead to more errors in perceiving material in the left visual field. In contrast, stimuli appearing to the right of fixation are viewed last or most recently and therefore might be more easily recalled. Thus a recency effect many cause superior reproduction of material presented in the right hemi-field.

However, the possibility that the first and second grade observers viewed the stimuli in a right-to-left sequence must be considered. In that case, the obtained data may be explained in terms of a primacy effect favoring the elements appearing in the right visual field. Considering the original hypothesis, this possible explanation is, at least, equally as likely as the recency hypothesis. If the viewing sequence did proceed from the right to the left, the limited reading experience of the observers may have been a causal factor. However, why this right-to-left sequence would develop during the first stage of learning to read would be a difficult question to answer. Perhaps the directionality of the English language had not been sufficiently learned to allow its transference to the perceiving of non-directional stimuli. Such an argument would assume that the obtained change with school children is coincidental, or that somehow transference worked to reverse the effect.

As is the case when reversals occur, the child observer may revert to a previously learned right-to-left sequence of viewing, or to a sequence which is more natural. The possibility that the child may revert to a more natural sequence of viewing suggests the possible importance of cerebral hemisphere and/or eye dominance. The evidence from the present study does not appear to show an effect of dominance. The mean number of errors occuring to the left of fixation was greater than that occurring to fixation under all combinations of hemisphere and eye dominance. Since the number of cases was not equal for all these combinations, the effect of dominance could not be adequately tested.

The high degree of similarity between performance under all viewing conditions, supplies additional evidence that no effect of viewing eye occurred. This is in agreement with Smith's (1950) and Hildreth's (1949) conclusions concerning the effect of dominance on the perception of reading material. They stated that the dominant hand and/or eye of an observer does not necessarily lead to differential perception of visual stimuli.

Summary

Binary target patterns were observed by nursery-school, kindergarten, first-grade, and second-grade school children under conditions of left eye, right eye, and binocular viewing. It was hypothesized that the tendency to perceive more accurately the pattern of elements to the left of fixation would increase as a function of the educational level of the observers because the observers at the higher educational levels had more experience with the appropriate left-to-right viewing sequence in reading English. This prediction was based on the results of previous experiments using adult English-reading observers which indicated that stimuli appearing in the left hemi-field were more correctly reproduced.

The obtained results did not support the experimental hypothesis. On the contrary, the two pre-school groups showed a non-significant difference favoring the perception of stimuli in the right hemi-field, and the two school groups showed a significant difference favoring the stimulus material in the right rather than the left visual field. The failure of the data to support the present hypothesis may be due to the fact that this hypothesis was derived from the data of adult observers. Apparently, performance of pre-school and primary-school observers does not follow in any simple way the same laws governing adult behavior.

No effect of viewing condition, eyedness, handedness, or "conflicting" eyedness-handedness of the observers was found. In addition, no significant relationship was found between the percentage of total errors to the left of fixation and reading proficiency rating.

APPENDICES

APPENDIX A

TARGET PATTERNS FOR THE THREE VIEWING CONDITIONS

Left Eye

1.	Ø	0	0	Ø	0	0
2.	0	0	Ø	0	0	Ø
3.	0	Ø	0	0	0	Ø
4.	0	Ø	0	Ø	0	0
5.	0	0	Ø	0	Ø	0
6.	Ø	0	0	0	Ø	0
7.	Ø	0	0	0	0	Ø
8.	0	Ø	0	0	Ø	0
9.	0	0	Ø	Ø	0	0

Right Eye

1.	0	Ø	0	0	0	Ø
2.	0	0	Ø	0	0	Ø
3.	0	0	Ø	Ø	0	0
4.	Ø	0	0	0	Ø	0
5.	0	0	Ø	0	Ø	0
6.	Ø	0	0	0	0	Ø
7.	0	Ø	0	Ø	0	0
8.	Ø	0	0	Ø	0	0
9.	0	Ø	0	0	Ø	0

Binocular

1.	0	0	Ø	0	Ø	0
2.	Ø	0	0	0	Ø	0
3.	0	0	Ø	Ø	0	0
4.	0	0	Ø	0	0	Ø
5.	Ø	0	0	Ø	0	0
6.	0	Ø	0	0	0	Ø
7.	0	Ø	0	0	Ø	0
8.	0	Ø	0	Ø	0	0
9.	Ø	0	0	0	0	Ø

APPENDIX B

TOTAL ERRORS PER ELEMENT POSITION PER OBSERVER FOR ALL THREE VIEWING CONDITIONS

NURSERY SCHOOL

Left Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	3	3	3	5	4	2
2.	5	5	1	3	2	3
3.	3	4	3	5	2	0
4.	6	4	4	4	3	0
5.	3	6	4	4	3	0
6.	3	2	3	4	4	2
7.	5	3	3	4	5	2
8.	2	6	5	5	2	3
9.	4	4	6	5	3	2
10.	3	3	3	3	6	6
11.	4	3	3	4	4	5
12.	3	4	4	5	4	0
13.	4	4	6	6	4	4
Σ	48	51	48	57	46	29

Right Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	3	2	3	5	3	3
2.	4	3	7	3	2	3
3.	4	2	3	3	2	2
4.	3	0	2	3	4	3
5.	3	6	3	0	3	3
6.	4	6	2	3	4	5
7.	6	3	4	5	6	4
8.	3	5	4	3	3	0
9.	4	4	6	6	2	2
10.	3	2	4	2	5	6
11.	4	2	5	5	1	3
12.	6	4	5	2	2	3
13.	2	6	7	7	4	4
Σ	49	45	55	47	41	41

Both

Errors per Position

Subj.	1	2	3	4	5	6
1.	2	3	3	4	3	6
2.	4	4	4	3	2	1
3.	4	2	5	5	3	5
4.	5	5	4	3	7	3
5.	1	3	3	2	1	2
6.	2	6	1	4	5	2
7.	5	6	2	1	1	1
8.	3	4	1	3	4	4
9.	5	3	4	4	2	4
10.	3	3	3	3	6	6
11.	3	4	0	4	3	3
12.	4	3	2	3	1	1
13.	3	5	7	6	5	4
Σ	44	51	39	45	43	42

Total Errors Per Element

Subj.	1	2	3	4	5	6
1.	8	8	9	14	10	11
2.	13	12	12	9	6	7
3.	11	8	11	13	7	7
4.	14	9	10	10	14	6
5.	7	15	10	6	7	5
6.	9	14	6	11	13	9
7.	16	12	9	10	12	7
8.	8	15	10	11	9	7
9.	13	11	16	15	7	8
10.	9	8	10	8	17	18
11.	11	9	8	13	8	11
12.	13	11	11	10	7	4
13.	9	15	20	19	13	12
Σ	141	147	142	149	130	112

KINDERGARTEN

Left Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	2	3	3	2	1	0
2.	2	2	1	2	2	3
3.	4	3	4	4	4	1
4.	0	2	1	4	5	2
5.	3	4	6	6	4	3
6.	4	1	4	7	4	3
7.	4	4	5	3	4	1
8.	2	2	2	2	2	0
9.	5	4	4	4	2	2
10.	6	3	3	2	2	3
11.	5	5	5	3	1	2
12.	3	1	5	5	4	4
13.	5	3	3	4	4	1
14.	1	4	3	2	2	3
15.	3	4	4	5	5	3
16.	5	4	4	5	3	5
17.	6	3	3	5	5	2
18.	4	3	5	2	2	1
Σ	64	55	65	67	56	39

Right Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	3	3	3	3	3	1
2.	1	4	4	4	1	1
3.	2	2	0	2	3	1
4.	1	3	3	3	3	1
5.	2	1	2	2	4	3
6.	5	5	6	4	3	3
7.	5	4	7	2	0	2
8.	2	4	3	4	3	1
9.	5	5	2	0	2	0
10.	6	5	4	3	7	5
11.	5	3	3	3	3	1
12.	6	5	4	5	3	4
13.	5	6	3	4	3	2
14.	3	5	1	1	6	2
15.	2	5	3	3	3	3
16.	3	5	1	2	3	5
17.	8	2	2	5	7	3
18.	1	3	2	4	2	3
Σ	65	70	53	54	59	41

Both

Errors per Position

Subj.	1	2	3	4	5	6
1.	2	4	3	4	2	2
2.	5	4	4	2	2	5
3.	1	2	2	2	5	2
4.	1	1	0	4	3	3
5.	3	4	3	3	3	3
6.	6	2	3	3	3	3
7.	6	3	3	5	4	4
8.	4	3	5	3	3	0
9.	2	3	7	3	4	5
10.	3	3	3	5	5	4
11.	4	4	3	1	5	2
12.	2	2	3	2	4	1
13.	7	3	1	3	4	2
14.	2	4	1	2	2	3
15.	3	4	5	4	4	4
16.	6	2	5	4	3	4
17.	6	4	2	3	4	2
18.	2	3	5	6	4	2
Σ	65	55	58	59	64	51

Total Errors Per Position

Subj.	1	2	3	4	5	6
1.	7	10	9	9	6	3
2.	8	10	9	8	5	9
3.	7	7	6	8	12	4
4.	2	6	4	11	11	6
5.	8	9	11	11	11	9
6.	15	8	13	14	10	9
7.	15	11	15	10	8	7
8.	8	9	10	9	8	1
9.	12	12	13	7	8	7
10.	15	11	10	10	14	12
11.	14	12	11	7	9	5
12.	11	8	12	12	11	9
13.	17	12	7	11	11	5
14.	6	13	5	5	10	8
15.	8	13	12	12	12	10
16.	14	11	10	11	9	14
17.	20	9	7	13	16	7
18.	7	9	12	12	8	6
Σ	196 (194)	180	176	180	179	131

GRADE 1

Left Eye

Errors per Element

Subj.	1	2	3	4	5	6
1.	0	4	4	0	2	1
2.	3	4	3	3	3	0
3.	3	5	2	1	3	2
4.	5	4	5	5	4	3
5.	2	4	2	2	3	1
6.	2	4	2	5	5	0
7.	3	4	6	4	4	3
8.	1	3	2	1	2	1
9.	2	1	5	4	4	0
10.	0	2	2	4	4	0
11.	3	7	4	1	0	1
12.	3	3	6	3	1	2
13.	2	3	2	4	4	3
14.	3	6	1	2	2	2
15.	1	3	3	1	3	1
16.	2	3	3	1	2	1
17.	3	6	4	4	4	2
18.	4	6	2	6	3	3
Σ	42	72	58	51	53	26

Right Eye

Errors per Element

Subj.	1	2	3	4	5	6
1.	1	2	0	3	4	2
2.	0	3	3	4	3	0
3.	3	5	4	2	5	2
4.	2	5	3	6	6	2
5.	2	4	3	3	4	2
6.	1	1	3	3	3	1
7.	3	4	3	4	5	3
8.	1	2	1	1	1	0
9.	1	2	3	4	4	2
10.	0	3	3	0	3	3
11.	2	5	3	2	2	2
12.	1	2	4	3	3	1
13.	4	5	1	2	3	1
14.	0	3	3	2	2	1
15.	2	5	4	0	4	3
16.	2	6	4	2	5	3
17.	2	4	3	1	2	0
18.	2	3	4	5	4	4
Σ	29	64	52	47	63	32

Both

Errors per Element

Subj.	1	2	3	4	5	6
1.	1	6	4	3	3	2
2.	3	4	5	1	5	4
3.	2	4	4	3	5	3
4.	2	4	3	5	3	3
5.	4	4	4	2	3	2
6.	4	5	4	1	1	0
7.	3	4	4	1	3	2
8.	1	2	1	3	4	1
9.	3	4	5	2	5	5
10.	1	2	1	2	3	1
11.	3	5	4	2	4	2
12.	4	4	4	2	2	0
13.	3	5	3	4	3	2
14.	2	3	5	2	2	0
15.	2	4	2	2	2	0
16.	2	1	1	2	1	0
17.	1	3	4	3	1	2
18.	2	5	5	2	1	1
Σ	43	69	63	42	51	29

Total Errors Per Position

Subj.	1	2	3	4	5	6
1.	2	12	8	6	9	5
2.	6	11	11	8	11	4
3.	8	14	10	6	13	7
4.	9	13	11	16	13	8
5.	8	12	9	7	10	5
6.	7	10	9	9	9	1
7.	9	12	13	9	12	8
8.	3	7	4	5	7	2
9.	6	7	13	10	13	7
10.	1	7	6	6	10	4
11.	8	17	11	5	6	5
12.	8	9	14	8	6	3
13.	9	13	6	10	10	6
14.	5	12	9	6	6	3
15.	5	12	9	3	9	4
16.	6	10	8	5	8	4
17.	6	13	11	8	7	4
18.	8	14	11	13	8	8
Σ	114	205	173	140	167	88

GRADE II

Left Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	1	2	3	3	0	1
2.	2	4	5	3	2	2
3.	0	0	1	1	0	0
4.	3	4	1	1	2	1
5.	1	2	3	4	2	2
6.	1	4	4	3	5	0
7.	4	5	5	2	2	0
8.	3	5	4	0	2	2
9.	2	7	4	3	4	0
10.	3	4	2	1	1	1
11.	1	2	1	2	2	0
12.	1	3	3	4	4	1
13.	0	2	2	1	3	2
14.	3	3	2	4	3	1
15.	1	2	3	4	4	2
16.	2	4	4	1	3	2
17.	0	3	3	3	4	4
Σ	28	56	50	40	43	21

Right Eye

Errors per Position

Subj.	1	2	3	4	5	6
1.	4	5	4	3	2	0
2.	2	4	3	4	6	1
3.	0	3	4	3	3	0
4.	3	5	3	3	5	2
5.	1	3	2	3	2	1
6.	2	4	4	3	4	0
7.	3	2	1	0	0	0
8.	2	5	3	1	5	4
9.	4	6	4	2	1	1
10.	1	3	2	4	4	1
11.	0	2	1	1	3	1
12.	3	3	3	2	2	1
13.	0	2	2	3	4	1
14.	3	2	1	1	4	3
15.	1	3	2	2	3	1
16.	4	8	4	2	5	3
17.	2	3	3	2	2	2
Σ	35	63	46	39	55	22

Both

Errors per Position

Subj.	1	2	3	4	5	6
1.	3	4	3	2	2	0
2.	2	4	1	3	3	1
3.	1	2	3	2	2	0
4.	3	3	2	1	2	2
5.	0	3	4	2	3	1
6.	1	5	4	3	6	1
7.	2	2	4	2	3	2
8.	3	4	1	4	4	3
9.	3	4	3	1	1	0
10.	2	5	3	6	4	3
11.	2	4	2	1	2	1
12.	2	4	4	2	4	0
13.	1	1	0	0	1	1
14.	3	3	4	2	4	2
15.	2	3	1	1	3	2
16.	1	5	4	2	4	2
17.	2	3	1	4	3	3
Σ	33	59	44	38	51	23

Total Errors per Position

Subj.	1	2	3	4	5	6
1.	8	11	10	8	4	1
2.	6	12	9	10	11	4
3.	1	5	8	6	5	0
4.	9	12	6	5	9	5
5.	2	8	9	9	7	4
6.	4	13	12	9	15	1
7.	9	9	10	4	5	2
8.	8	14	8	5	11	9
9.	9	17	11	6	6	1
10.	6	12	7	11	9	5
11.	3	8	4	4	7	2
12.	6	10	10	8	10	2
13.	1	5	4	4	8	4
14.	9	8	7	7	11	6
15.	4	8	6	7	10	5
16.	7	17	12	5	12	7
17.	4	9	7	9	9	9
Σ	96	178	140	117	149	67

APPENDIX C

HANDEDNESS, EYEDNESS, AND READING PROFICIENCY SCORE OF EACH OBSERVER

NURSERY SCHOOL

Observer	Handedness	Eyedness	Reading Proficiency
1	Right	Right	Note: Reading scores were not obtained for this group.
2	Right	Right	
3	Right	Right	
4	Right	Right	
5	Right	Left	
6	Left	Left	
7	Right	Left	
8	Right	Right	
9	Right	Left	
10	Right	Right	
11	Right	Right	
12	Right	Right	
13	Left	Right	

KINDERGARTEN

Observer	Handedness	Eyedness	Reading Proficiency
1	Right	Left	Average
2	Right	Right	High Normal
3	Right	Left	Superior
4	Right	Right	High Normal
5	Left	Right	High Normal
6	Left	Left	High Normal
7	Right	Left	High Normal
8	Right	Right	Superior
9	Left	Right	Superior
10	Right	Right	Superior
11	Right	Right	Average
12	Left	Right	High Normal
13	Right	Left	High Normal
14	Right	Right	High Normal
15	Right	Left	High Normal
16	Right	Left	Average
17	Right	Left	Superior
18	Right	Right	Average

GRADE ONE

Observers	Handedness	Eyedness	Reading Proficiency
1	Right	Left	Average
2	Right	Right	Superior
3	Right	Right	Average
4	Right	Right	Superior
5	Right	Right	Average
6	Right	Right	Superior
7	Right	Right	Average
8	Right	Left	Average
9	Right	Right	Average
10	Right	Left	High Normal
11	Right	Left	High Normal
12	Right	Right	Superior
13	Right	Right	High Normal
14	Left	Left	High Normal
15	Left	Left	Superior
16	Right	Right	Average
17	Right	Right	Average
18	Right	Left	Superior

GRADE TWO

Observers	Handedness	Eyedness	Reading Proficiency
1	Left	Left	Average
2	Right	Right	Low Normal
3	Left	Right	Average
4	Right	Right	Superior
5	Right	Right	Superior
6	Right	Left	High Normal
7	Right	Left	Average
8	Right	Left	Average
9	Right	Left	High Normal
10	Left	Left	High Normal
11	Right	Left	High Normal
12	Left	Left	Average
13	Right	Right	Superior
14	Right	Right	High Normal
15	Left	Left	Low Normal
16	Right	Right	Superior
17	Right	Right	Superior

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