A STUDY OF THE RELATION BETWEEN READING ABILITY AND LATERALIZATION

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By

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ABSTRACT

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by Alexis A. Johnson

This study was undertaken to determine the possible relationships between cerebral dominance and reading ability. Cerebral dominance was assumed to be measured by 1) the Palmer Dowel test for handedness, 2) various sighting tasks for monocular sighting and 3) the McKinney fragmentation test for perceptual breakdown. A possible relationship between body image as measured by the Benton Left-Right test and reading ability was also predicted.

The four predictions were:

1) Good readers and poor readers will exhibit about the same amount of laterality as measured by motor tasks for dominance.

2) Good readers and poor readers will exhibit about the same amount of mixed laterality as exhibited by crossed dominance on motor tasks.

3) Good and poor readers will exhibit about the same amount of mixed laterality when the fragmentation measure of ocular dominance is compared with the other measures of dominance, both hand and eye.

4) Good and poor readers will exhibit about the same amount of knowledge of body schema, i.e., knowing left from right parts of the body.

Alexis Johnson

To test these predictions 39 2nd graders (IQ's between 100 and 110) were picked by their scores on the Gates Primary Reading test. They were divided by reading scores into good and poor readers and by sex thus giving three groups of ten each and one group of nine.

After the lateralization tests had been administered the results were analyzed by a 2 x 2 ANOVA. None of the predictions could be fully supported although the girls only were significant on the tests concerning the first hypothesis. Socio-cultural as well as maturational explanations were offered for this unexpected finding.

It was the author's conclusion that if there is a relation between reading and lateralization, better tests must be devised to find it. Also the concept of lateralization or cerebral dominance itself bears much further investigation.

Approved: [signature]

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To Gregor

who made it possible

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INTRODUCTION

The role of lateral dominance in reading disability is a controversial issue. The literature on the subject would support many different and conflicting views. The concept of lateral dominance refers to the consistent preferences for using, and using more skillfully, the muscles on one side of the body. Anatomically it can be demonstrated that the nerves from the right side of the body remain primarily separate from the nerves of the left. There is a minimum crossover to permit feedback and matching, but these nerve systems are essentially separate. From one side of the body they pass up through the spinal cord, cross at the brain stem, and enter the opposite side of the brain. This is true for the motor nerves innervating the limbs, etc., of the body.

In the human brain there are many functions that do not seem to be equally represented at a cortical level even though the two cerebral hemispheres look like mirror images of each other. Meyers (1956) states that impulses from receptors on each side of the body seem to project nearly equally, though largely contralaterally, to symmetrical cortical areas, and certain information received in the cortex of one hemisphere can be transferred to the other via interhemispheric commissures (Sperry, 1962). In most of the higher cortical functions there seems to be a dominant hemisphere, one which leads the activity. Zangwill (1960) states that cerebral dominance is one of degree, while most neurologists assert that cerebral dominance is probably most nearly complete in relation to the complex and highly evolved aspects of language. The degree of cerebral dominance appears to vary widely, not only among individuals, but among different functions within individuals.

Handedness is generally taken to be one measure of cerebral dominance, but this relation is far from clear. Probably, handedness, like the other forms of cerebral dominance, is a graded characteristic (Palmer, 1960). Right-handedness seems to be regularly associated with left cerebral dominance, but left-handedness is not associated with the same regularity with right cerebral dominance (Truex and Carpenter, 1963).

A dominant, or leading, eye has been thought to be another aspect of cerebral dominance. Specifically, monocular preference in sighting has been used extensively as an important index of general lateral dominance. However, according to Jasper and Raney (1937), there is no adequate analysis of the fundamental nature of ocular dominance, its relation to the motor or perceptual aspects of the visual system, and its functional importance in the language mechanism. They discuss some of the reasons for this confusion on the nature of ocular dominance. One is the complex anatomical nerve pathways which control the motor and the sensory visual processes. Gahagan (1933) has shown that ocular dominance in monocular sighting is predominantly a motor function, since the dominant eye (as determined by a paper sighting task) is not related to the eye possessing the best visual acuity. Given that this type of ocular dominance is a motor function, it should be related more closely to handedness, which is also a motor function. The relation between motor eyedness and handedness, however, is only moderate (Jasper, 1932; Updegraff, 1933; Berner and Berner, 1953). This suggests that even motor eyedness may not be a completely unilateral function.

As Jasper and Raney (1937) and Berner and Berner (1953) have pointed out, a clear distinction between ocular dominance in monocular sighting and dominance in visual perception must be made. This distinction is necessary because the sensory and motor aspects of the visual mechanism need not necessarily show the same laterality of dominance. Also, the central representation of each eye is bilateral and is related to one half of each eye, while cortical dominance in the control of eye movement and in tests for retinal rivalry may be related to only one eye. Washburn, Faison, and Scott (1933) have shown that ocular preference in sighting is related more closely to handedness, but that it is not closely related to the dominant eye in tests of retinal rivalry. The problems of both sensory and motor dominance within vision are complicated by the fact that the two eyeballs themselves do not constitute a pair of structures, one member of which may be expected to dominate. The two portions of each retina are each connected separately with the two lateral halves of the brain. (See Figure I.) The group of oculorotary muscles inserted on one globe turn that globe only. Only in that one respect is the group a lateral unit - the left medial rectus is yoked with the right lateral rectus in the conjugate component of binocular movement, but it pairs with the right medial rectus in the disjunctive components. Therefore, there are three possibilities of asymmetric function in the visual mechanism: 1) dominance in the motor control of the eyes; 2) dominance in the receptor mechanism of the eye itself; and 3) dominance in the central projection areas of the two eyes. Each of these three types of dominance may be quite independent of each other. Jasper and Raney (1937), by using the phi test and rivalry phenomena, show clearly that here is at least one kind of ocular dominance which is not connected with brainedness and is also in no way related to whatever essential asymmetry underlies sighting dominance. Walls (1951) offers an interesting explanation of motor and sensory dominance. According to him, for any individual who has a motor dominant eye an innervation record is kept only for the muscles of that eye. For him this is what motor dominance really means. This explains all the properties of the dominant eye both in binocular vision and in so far as these properties differ from those of the other eye when each eye is used alone.

The purpose of the above was to present the problems in both ocular and hand dominance which must be kept in mind throughout the rest of this paper.

It is generally considered that the inventive for the evolution of cerebral laterality (of which hand dominance and perhaps motor eye dominance are symptomatic) has been the enormous physiological complication created by the function of speech, and the whole constellation of activities that are involved in symbolization. According to Walls (1951), the peculiarly mammalian partial decussation of the optic nerves resulted in one hemisphere being in control of the complex motor operation of both eyes. This produced smooth binocular coordination. Partial decussation, however, leaves the organism with a coequal pair of bilateral control systems, each centering in one hemisphere. Directional dominance placed the perceptual ability of both eyes in a single center. This was not a center of brain anatomy but of the left vs. right set of eye muscles and the bilaterally distributed nerve adnexa of one set.

Laterality, or right and left sidedness, is one of the first things learned by a child about his body. The human body is anatomically and neurologically designed to be an excellent right-left discriminator because it is externally bilaterally symmetrical. Since there are no objective directions in space, we attribute directions to external space on the basis of activities which take place within the body. Children experiment with the two halves of the body,observe differences between movement, compare these differences with differences in sensory impressions and thus learn lateralization (Kephart, 1962). According to Kephart (1962) the primary pattern out of which this differentiation develops is that of balance. Children must learn how to innervate one side against the other, how to detect which side has to move and how it has to move in order to execute the appropriate compensatory movements. They keep this learning of sides straight by developing one side as leading. This learning process leads to dominance and its consequent motor eyedness and handedness. Gesell (1940) notes that this handedness begins to develop around age two. This learning of lateralization is very important to the developing child. The only difference between the external points 'A' and 'B' is one of laterality. If there is no left and right inside, there can be no projected left and right outside, and the directional characteristics of left and right will disappear. It follows that this sense of left and right lateralization is very necessary in learning to read; otherwise, the child will not consistently orient from left to right across a page, nor will he be able to distinguish such reversal letters as 'b' and 'd'.

In Kephart's view the development of adequate form perception depends upon the adequate acquisition of basic sensory motor skills. Constructive form is dependent upon the relation between elements. In visual perception, these relations are relations in space. The coordination of space, and, hence, the coordination upon which the relativity of form must be built, are acquired. This learning begins with the development of laterality, and thus the relation between laterality and reading. The first information the child gains about form is kinesthetic and tactual. He must learn kinesthetic laterality before visual form. He must be able to project this laterality in the form of directionality outside of his body before he has a basis for maintaining the relations involved in form.

Orton (1936), a neurologist, proposed the first cerebral dominance theory of laterality in relation to reading disability. He suggests that memory images or records of letters and words exist in the brain in both right and left orientations - one in each hemisphere like mirror images. He hypothesized that learning to read involved selecting the memory image in one hemisphere, the dominant one. Therefore, if the child has not developed lateralization and a dominant side of his brain, there will be conflict between the two sides of the brain. The result is a tendency to make reversals in reading.

Dearborn (1931) has probably done the most research in trying to establish a relationship between reading disability and lateral dominance. Among his clinical cases he found greater incidence of left dominance, crossed dominance (either right handed and left eyed or vice versa), and lack of dominance than among good readers. In his sample he found that reading difficulties were most likely in children who were changed in handedness or whose lateral dominance had never been established. Eames (1934) found lateral dominance anomalies much more frequently among poor readers than among the unselected cases he used as a control. Crosland (1939) suggests an association between left eyedness and reading failure. Similar findings were also reported by Witty and Kopel (1936), Teegarden (1932), and Monroe (1932).

For a while it seemed that the problem of lateral dominance was a significant factor in the etiology of reading difficulties. However, more recent research has not confirmed this. Balow (1963), Shepherd (1956), Belmont and Birch (1963), Koos (1964), and Coleman and Deutsch (1964) all have found that lateral dominance has no relation to reading ability.

Zangwill (1960) retains the relation between dyslexia in development and mixed manual preferences but does not indicate a causal factor, since many normal readers have an uncertain manual preference or dominance. He suggests that a category of individuals may exist in which language is imperfectly lateralized in one hemisphere, this ambilateralization not implying in itself any anomaly in psychological development. Hecane and Ajuriaguerra (1964) have reported on a group of children with dyslexia, who were statistically different from normal children. Children with dyslexia were not more often left handed than the normal children but more often were poorly lateralized.

All of the aformentioned studies used motor measures of eyedness and handedness. In other words, ocular dominance in the form of sighting tasks was used to determine eyedness, and questions like "Which hand do you write with?" were used as measures of motor handedness or hand preference. Admittedly, most of the more recent studies have not found any real relation between laterality and reading ability. However, the idea that adequate form perception is determined by the learning of basic sensory motor skills as presented by Kephart (1962) is a compelling one, and the theory proposed by Orton fits into it nicely. Might not this relation exist if the measurements used were not just motor measurements, but were more central measures of handedness and eyedness?

McKinney (1963) has reported that when a human subject fixates on a luminous design under conditions of low illumination, he experiences a fragmentation of part of that figure. Since this fragmentation occurred in an organized fashion, McKinney concluded that a central perceptual breakdown was responsible. This theoretical interpretation is identical to the Hebbian interpretation of the fragmentation of stabilized images (Pritchard, Heron, and Hebb, 1960). In a later paper McKinney (1965) was concerned with whether one hemisphere or the other was more able to sustain this percept, since the fragmentation was assumed to represent a perceptual failure in the cerebral cortex. If the hemisphere contralateral to the preferred hand possessed a visual as well as a motor dominance, most fragmentation should occur within the visual field opposite the preferred hand. His data showed that the right visual field was more efficient in this perceptual task, and this is not inconsistent with the idea of a general dominance in the visual area of the left cerebral cortex. McKinney also suggested that the superiority of the right field was related to eye dominance because the superiority was greater for subjects who sighted predominantly with their right eye. No difference between the fields was found for left eye dominance subjects. If this fragmentation test is indeed a measure of perceptual breakdown and not just motor dominance, it might be a significant factor in the etiology of reading disability. In fact, it would be a central measure of eye dominance as opposed to a motor measure of eye dominance.

As mentioned before, the studies of reading disabilities usually failed to separate clearly the twin influences of left handedness ambilaterality. Individuals with ambilateral or ambidextrous tendencies were all too often classified as left handed because of a failure to consider the theoretical significance of a "differentiated vs. undifferentiated" classification of handedness. It is therefore difficult to know whether the results of these studies are due to leftness per se or to a relatively less differentiated handedness. Palmer (1964) was interested in the problem of differentiated handedness in and of itself. He devised a dowel test which involved a set of fairly complex spatial movements and orientation, requiring the integrated activity of relatively gross arm/shoulder muscalature, and which could be made to yield ordinal scores.

Perhaps this method of measuring handedness might be much more significant in the etiology of reading than a simple hand preference test. After all, the issue is that sensory motor skills must precede from perception, and balancing a dowel is certainly one way to measure this type of coordination skill.

If the issue of lateralization and directionality is taken one step further, in the developing child, the concept of body image emerges. According to Kephart (1962), body image is a learned concept resulting from the observation of movement of parts of the body, and the relation of the different parts of the body to each other and to external objects. It is the point of origin for all spatial relations outside the body. The three concepts are closely interwoven and must develop fairly simultaneously if the child is going to gain this point of origin for either perceptions or motor responses. Hecaen and de Ajuriaguerra (1964) mention a study of theirs in which the percentage of failures to recognize the sides of one's own body is higher in the children with dyslexia than in the controls (19% to 10%), and there is a greater difference (64% to 32%) when it comes to recognizing the sides of the person facing the subject. Strauss and Kephart (1955) spend a great deal of time explicating this relationship between body schema, the organization of the space world, and problems of perceptions. Although Balow (1964) did not think that the ability to discriminate left from right sides of the body was significant in reading ability per se, Belmont and Birch (1965) found a correlation. It would seem from the literature reported here that if lateralization, as measured by the more differentiating central measure of eyedness (the fragmentation test) and the sensitive Palmer dowel test for handedness were found to be related to reading ability, then knowledge of body schema would also be related. Based on this reasoning, and the studies of clinical groups in the literature, these four predictions were made:

1) Good readers and poor readers will exhibit about the same amount of laterality as measured by motor tasks for dominance.

2) Good and poor readers will exhibit about the same amount of mixed laterality as defined by crossed dominance on motor tasks.

3) Good and poor readers will exhibit about the same amount of mixed laterality when the fragmentation measure of ocular dominance is compared with other measures of dominance, both hand and eye.

4) Good and poor readers will exhibit about the same amountof knowledge of body schema, i.e., knowing left from right parts of the body.

METHOD

Subjects The subjects were obtained from the 93 boys and girls composing the entire second grade class at Midway School, Holt, Michigan. One month prior to testing, all the second grade children took the Lorge Thorndike IQ test. The experimenter administered all three parts of the Gates Primary reading test to these 93 children. The first criterion for participating in the experiment was having an IQ score between 100 and 120 in order to eliminate IQ as a possible confounding variable. Of these 27 girls and 20 boys, the top and bottom ten on the reading list were chosen as subjects. The ten girls and ten boys with the highest reading scores were designated the 'good readers' of the final sample. The ten girls and ten boys who scored lowest on the Gates reading test constituted the 'poor readers' of the sample. Later one of the boys in the good reading sample had to be eliminated. For poor readers, the group means were 48.1 for boys and 52.2 for girls; for good readers, the group means were 102.1 for boys and 104.9 for girls. This difference is quite great in terms of the test norms.

Apparatus The Gates Reading Test was used until very recently by the Michigan State University Reading Clinic to assess reading ability. The test has three parts, Primary Word Reading, Primary Sentence Reading, and Primary Paragraph Reading. Test reliability and validity are high: the lowest reliability coefficient for any of the tests was +.86. The correlation of the Gates test with other well known reading tests (e.g., the Stanford reading tests) ranged from

+.53 to +.83.

The Lorge Thorndike IQ tests had been administered by the school independently of the study. This test is one of the few IQ tests not at all based on reading ability, i.e., the teacher read the items to the second graders, and they had to circle the appropriate picture. The Lorge Thorndike thus reduces the liklihood of confounding reading ability and IQ.

The sighting tasks were first described by Johnston (1942). Three were used for this study: lining up two pencils, looking through a hole in an 8½ x 11 piece of paper, and looking at the experimenter through the large end of a cone.

Handedness in this study was defined as the preferred use of either the right or the left hand for skilled manipulations. Accordingly, a task was needed to determine the direction of handedness as well as the degree of difference between the two hands. Therefore, instead of using a preferred use inventory, the children took the Palmer Dowel Task (Palmer, 1957), which involved balancing a dowel 15" long, 5/16" in diameter, on the forefinger of each hand separately. Theoretically, this would give a measure of the dominant hand and also a measure of the difference between the two hands.

The fragmentation test is a measure of the stability of a visual image under conditions of fixation and reduced illumination (McKinney, 1963). The apparatus consists of an 8½ x 11 piece of black cardboard on which have been painted in luminous paint a

1-inch circle in the middle and two one-half inch lines on each edge. This target was presented in a totally dark, windowless room. Two such targets were made, and at the end of an hour they were switched. The one not in use was left under a lightbulb in another room to insure that the luminosity was maintained.

The Benton test of left-right discrimination (Benton, 1959) consists of 20 items. Sixteen of the items refer to the child's own body and four refer to the experimenter's body. Six in the first group are crossed commands (e.g., touch your right ear with your left hand), and six in this same group are performed with the child's eyes closed.

Procedure The children came from the classroom in groups of three or four to the small store room where the experiment was conducted. Neither the experimenter nor her co-worker knew whether the child being tested was considered to be a good reader or a poor reader. One experimenter conducted the test of sighting dominance and the fragmentation test; the other administered the dowel test, the Benton Left-Right test, and asked each child with which hand he wrote. Approximately half the children began with Experimenter One and half with Experimenter Two.

If the child began with the sighting tasks, he first looked through the large end of a cone and sighted on the experimenter's nose. All records were made at the end of each trial after each task. Then the child took the cone down from his face and repeated the procedure. The subject was then handed a pencil and told to line it up with a pencil the experimenter held in her hand. The subject repeated process giving two trials. For the last part of this test, the child looked through a hole one half inch in diameter in the middle of a 8½ x 11 piece of paper held at arm's length and focused on the experimenter who recorded the sighting eye in two separate trials.

The fragmentation test was administered to each child in a small windowless room. The target was placed six feet from the child at eye level when he was standing. When the lights were turned off the child was told to look in the direction of the target and tell the experimenter when he first began to see it. Then he was told to stare at just the circle in the middle of the target. This was repeated several times for each trial. The subject was told to report as soon as any part of the lines disappeard, "moved," "waved around," etc. When he made a verbal report, the lights were turned on, and he was asked which line has moved, disappeared, etc. This was recorded and the lights were turned off again. Each child received ten trials in this manner.

Meanwhile, the other experimenter administered the other tests to another child. First he asked which hand the child wrote with and recorded it as one measure of hand dominance. Then a measure of skill, the Palmer Dowel Test (Palmer, 1959) was administered. Subjects balanced the dowel as long as possible on the forefinger of the preferred hand by first steadying it with the other hand near the top of the dowel and then letting go and trying to keep it balanced. It was emphasized that the dowel must not touch the child's body but that he could walk around the room as he chose. The task was timed from the second the child let go with the other hand until the dowel touched his body or fell to the floor. Two practice trials were given before the beginning of the timing. After a trial with the forefinger of the preferred hand, a trial was given with the forefinger of the opposite hand, until a total of five trials with each hand was recorded.

Finally, S answered the twenty questions of the Benton Left Right Test.

RESULTS

The times for each trial were summed for each hand. Raw data on the dowel test were transformed by subtracting the summed time of the left hand (in milliseconds) from the summed time for the right hand (in milliseconds). This right minus left score indicated the relative degree of handedness. A high score on this measure indicated right handedness and presumably a degree of left cerebral dominance. This task was used as the main measure of handedness.

For statistical purposes writing with the right was recorded as +1 and with the left was recorded as -1.

Ocular dominance, subtracting the number of times the left eye was used from the number of times the right eye was used (right minus left) gave a measure of eyedness. Again, a high score on this measure indicated right eyedness and, consequently, left cerebral dominance.

Fragmentation, for this transformation, the number of times the right line was seen fragmenting (left hemisphere fragmentation) was subtracted from the number of times the left line was seen fragmenting (right hemisphere fragmentation). This left line minus right line score is used as an operational measure of lateralization in the visual system. A high score on this index reflects greater stability of the right visual field, and therefore presumably a greater degree of left cerebral dominance.

Left Right Discrimination Test. The scoring system devised by Benton (1959) was used. The number of items each child got right out of the possible twenty was used as an index of left-right discrimination. A child who reversed every answer was considered to have gotten them all correct; in other words, he was assumed to understand the concept but to misuse the label.

These transformations resulted in three major indices: degree and direction of lateral dominance in the visual system, degree and direction of ocular dominance, and degree and direction of handedness. In each of these indices, the higher the score, the greater the left cerebral dominance. This means that when a child was termed right-eyed or right-handed, he had a score above zero on these indices; a score below zero would term him left-eyed or handed, and a score of zero would term him mixed.

As mentioned above, in each of the indices the degree and direction was obtained. The degree of dominance was indicated by the absolute value of the score. The direction of the dominance was indicated by its real signed value. Hereafter, these labels will appear together: degree - absolute; direction - real.

Because of the predictions and because of the nature of the data, it appeared that a simple two-way analysis of variance or a chi square on each of the tasks was appropriate. The data were blocked for the ANOVA on good and poor readers as explained in the Method section, and on boys and girls because this was of interest to the experimenter.

As the predictions were stated, there was an implication (also present in previous studies) that there is normally a correspondence between the direction of hand motor laterality and the direction of eye motor laterality, i.e., ocular dominance. This implication was not supported by this study. The correlation between handedness and ocular dominance was +.052. Separate correlations by sex on reading ability also did not yield a significant correlation.

Ocular dominance and reading ability. There was no justification for a combined laterality score. Therefore, since the correlation between separate measures of laterality was low, the relation of reading ability to each of the separate tasks was investigated individually. First the question of ocular dominance and reading ability was investigated. Table I shows the ANOVA for degree-absolute scores on ocular dominance. There were not significant differences between groups on either variable. There was, however, a significant ($p < .05$) interaction between these two. The nature of this interaction is that good-reading boys showed less lateralization than poor-reading boys, but the good-reading girls were better lateralized than the poor-reading girls.

Table II shows the real-direction of the sighting scores for ocular dominance. The table showed no significant differences as a function of reading ability, but indicatedsignificant differences by sex and a significant interaction effect. This suggests that there are more right eyed girls than there are right eyed boys. The significant interaction means that the good reading boys tend to be left eyed, while the poor reading boys tend to be right eyed. This is reversed in the girls: there are more right eyed girls in the good reading group and more left eyed girls in the poor reading group.

Hand dominance and Reading Ability

Tables III and IV present the data for degree-absolute and direction-real scores. There were no significant differences. This indicates that there is no relation between handedness and reading ability (as measured by the Gates Reading Test) in the sample used in this study. Tables I-IV present the data relevant to Prediction 1.

Crossed Dominance

Table V shows that the chi square for total groups as well as for girls separately was not significant. The chi square for boys was significant ($p < .05$). This tends to support the second hypothesis as stated.

Crossing with Fragmentation Measures

First the differences on the fragmentation measure of ocular dominance was examined. Table VI and VII indicate no differences reflected in the two way ANOVA. Next the actual comparison of direction of ocular dominance by fragmentation with the direction of ocular and hand dominance on motor measures were compared. A chi square analysis of ipsilated vs. contralateral arrangements showed no relation with reading ability (Table VIII). This evidence supports the third hypothesis as stated.

Left-Right Test

Table IX gives the ANOVA data for scores on the Left Right

Test. No significant differences were obtained. The fourth hypothesis cannot be rejected on the basis of these data.

DISCUSSION

Prediction One: Good readers and poor readers will exhibit about the same amount of laterality as measured by motor tasks for dominance.

The measures of cerebral dominance in the motor sphere in this study were the tasks of monocular sighting and the Palmer dowel test for handedness. A combined index of these two measures of laterality was not meaningful because the intercorrelation between these two measures was so low, +.052. This lack of a relationship between ocular dominance and handedness is consistent with the findings of several neurologists (Jasper, 1932; Updegraff; and Berner and Berner, 1953), but is not what would be expected from the research presented by the reading specialists who seem to consider it an anomaly when eyedness and handedness are not ipsilateral.

Degree of Ocular Dominance

Given this lack of relationship between ocular dominance and handedness, each task was considered separately in its relationship to reading ability. Ocular dominance was first investigated. This type of dominance was assumed to be a motor function separate from visual acuity as noted in the introduction. (See Jasper and Raney, 1937; Washburn, Faison and Scott, 1933.) Since the writing of Orton (1936) monocular sighting dominance has been investigated as a possible variable in the etiology of reading disabilities. The data obtained for the monocular sighting tasks were analysed using a two by two analysis of variance with sex and reading ability as the two variables.

Neither of these variables alone was significant (the F test on reading ability was not significant, nor was the F test on sex), but the interaction between sex and reading ability on the data for ocular dominance was: girls who were good readers were better lateralized than the girls who were poor readers but the boys who were good readers were less lateralized than the boys who were poor readers (see Table I). In the concrete terms of this experiment this means that the good reading boys did more sighting tasks with both eyes than did the poor reading boys, who tended to consistently use one eye or the other. In the girls the reverse was true, for here the good reading girls tended to use one eye more consistently than the poor reading girls. In terms of the sighting tasks themselves this means that the poor reading boys and good reading girls tended to use one eye more consistently when sighting. This interaction of sex and reading ability in relationship to ocular dominance could not be found elsewhere in the literature: in fact, degree of lateralization itself has seldom been mentioned in connection with reading.

The writer has no ready explanation for this unexpected finding. However, one possible explanation would emphasize maturation rates. As Harris (1957) has found, laterality is a function of maturation. Ocular dominance, as one type of laterality, may also be assumed to be a function of maturation. Maturation is generally defined as the degree to which a child gains the physical aspects of normal growth and assumes the social and cultural roles demanded of him as an adult. These social norms are different for the two sexes. For the boys a significant part of "maturation" is gained in sports. It is in the ball park that a boy gains or loses the most rewards. It would be expected that from practice at such games a great deal of eye lateralization would develop but the time involved would be at the expense of school subjects. Reading at this age is perhaps the most important school subject and therefore it follows that it would suffer the most. This hypothesis would yield the prediction that well lateralized boys would be poorer readers, but what about the girls? Girls too have to learn to accept social norms, but the society rewards them differently. "Maturation" in girls involves rewards in the classroom, not the ball park. It follows that maturation would take place in the classroom and that laterality, partially as a function of learning to read, would also develop there. From this it would follow that girls who are more lateralized would be better readers.

To test this hypothesis a study would have to be designed to determine whether boys who are good in athletics are more eye lateralized and are not good readers. For girls it would have to be determined whether those who are good in classroom behavior in general are more lateralized and are good readers. Before such data are gathered it is impossible to judge accurately the validity of the hypothesis presented to explain the results obtained from this sample. If significant differences were obtained in the proposed study, it would be a feasible explanation of the opposing directions of the trend obtained by the interaction effects of sex and reading ability in the current study.

Whatever the results of the proposed research, the finding on this sample does indicate that, for boys at least, consistency of ocular dominance is not necessary for good reading ability. Ocular dominance may be concomitant with good reading ability as it is in the girls, but it seems that it is not a necessary pre-requisite for it.

Direction of Ocular Dominance

Direction of ocular dominance refers simply to whether the child was right or left eyed. This was determined by the same six sighting tasks which were used to determine degree of ocular dominance. Direction of ocular dominance was determined by a majority of the six sighting scores (see Table II).

The direction of ocular dominance scores was analyzed by sex and by reading group in a two-by-two analysis of variance. This resulted in no significant differences in direction of laterality as measured by these sighting tasks, but sex and the interaction between sex and reading ability were both significant. The significant sex effect reflects the greater number of right-eyed girls than right-eyed boys. Harris (1957) found that at age seven, 52.6% of his sample were strong or moderate right eyed and that 39.0% were left eyed (either strong or moderate), but he reports that the sex differences were small and within the range of chance variation. Harris had 59 seven year olds, and there were 40 seven year olds in the present study. It appears that to carry this question any further, more data are needed. When two investigations using the same tests yield such contrary results, the most appropriate thing to do is to repeat the study with a larger N in order to derive the statistics for the whole population.

The interaction between sex and reading on the direction of eyedness was also significant. This finding reflects that girls who are good readers are right eyed while the girls who are poor readers are left eyed, on the other hand the boys who are good readers are left eyed and the boys who are poor readers are right eyed. Crosland, (1939), Witty and Kopel (1936), Teegarden (1932), and Monroe (1932) all present the clinical finding that there is an association between left eyedness and reading failure. The girls of this sample are consistent with this observation, but the boys are contrary to it. This sex difference has not been noted in the literature. No explanation for the opposing directions of this trend presents itself.

It is interesting to note that the girls fit the prediction about both degree and direction of ocular dominance and its relationship to reading ability while the boys do not. Books on reading disabilities present theories of physical, intellectual, emotional, and educational deficits and their relationship to reading problems, but no one theory would adequately account for this sex difference. It may simply be that the girls in this study represent more valid a picture of the population, or other factors are also possible. Again age or maturity may be a confounding variable. Another hypothesis stresses (or is concerned with) motivation. It is possible that the girls were more serious about the tasks than the boys were and consequently obtained more accurate scores. Further research will have to control for such problems.

The other type of laterality is that of handedness. Neurologists have established a highly consistent relationship between handedness and cerebral dominance (Truex and Carpenter, 1964). In this study the Palmer dowel test was used to determine both degree and direction of handedness. Both direction and degree were analyzed by an analysis of variance with reading ability and sex as the variables. However, none of the F tests were significant, indicating that for this measure of handedness, there is no relation between cerebral dominance (as determined by handedness) and reading ability. This finding is consistent with all of the recent literature on this subject.

Hypothesis Two: Good readers and poor readers will exhibit about the same amount of mixed laterality as exhibited by crossed dominance on motor tasks.

The concept of crossed dominance is complicated by mixed lateralization. If a person is not well lateralized, that is, does not do most things with one leading side, there is no meaning to crossed dominance, i.e., having a clearly dominant eye on one side and a clearly dominant hand on the opposite side. Mixed lateralization was a factor in this study. Although hand preference starts at age two (Gesell, 1940), Harris (1957) has pointed out that it is developmental, and is not firmly established in many cases until age 10. Eyedness does seem to fluctuate but not in the consistent pattern of handedness (Harris, 1957). Most of the children in this study were seven-year-olds, and the proportion of mixed lateralization on measures of both ocular dominance and handedness was high. This means that few children were totally right or left eyed or totally right or left handed. A chi square was computed with ipsilateral and contralateral as one dimension and good and poor readers as the other dimension. This chi square was undoubtedly insignificant because crossed dominance with so much mixed lateralization is not meaningful. This finding is supported both in the analysis of the group as a whole as well as in the analysis of the data for the girls alone. However, analysis of the boys' scores disclosed a significant difference: there were more boys who were good readers with contralateral hand and eye dominance, while there were more boys who were poor readers with ipsilateral dominance. This is completely contrary to what would be expected from the literature and bears further investigation. Harris (1957) found a significant difference in crossed dominance between his groups of the reading disability children and unselected children, but attributed this difference to differences in hand dominance and gave them no additional meaning. In his study hand dominance differences were significant; in the current study they are not. Accordingly, the results of Harris's study and the present one are consistent for the groups as a whole (and just the girls of this study). Once again the boys confound the predictions of the literature while the girls conform. Studies investigating every aspect of the sex differences in reading disability are needed. Such studies must take into account the neurological implications of girls being more mature as well as the different socialization the two sexes undergo.

The task for handedness in this study differed from other work in the area in that it did not employ a questionnaire test of usage. The author feels that the behavioral task used instead is a much better measure of lateralization in general. Perhaps this use of a behavioral measure of degree of handedness as well as direction explains why one of the three results is significant. Again motivation and maturation are relevant possibilities.

Hypothesis Three: Good and poor readers will exhibit about the same amount of mixed laterality when the fragmentation measure of ocular dominance is compared with the other measures of dominance, both hand and eye.

In considering this hypothesis it must be recalled that the concept of crossed dominance may not be completely valid at this age. First a relationship between reading ability and the results of the fragmentation test for ocular dominance was investigated. The analysis of these results was an analysis of variance with sex and reading ability as the two variables. None of the $\underline{F}$ tests reached significance, implying that the type of ocular dominance measured by this task is not relevant in the etiology of reading disability.

To actually test the hypothesis, two chi square tests were computed. On one, (Table VIIIa) reading ability was one dimension and ipsilaterality (whether the side fragmenting was the same as the side of handedness) was the other. On the other table, (Table VIIIb) the only difference was that the second dimension was between side fragmenting and side of eyedness. This was to determine if the crossing of fragmentation with these measures was a predictive variable in reading problems. Neither of these chi squares was significant indicating that the fragmentation procedure as a measure of one type of ocular dominance cannot be said to be a predictive variable in the etiology of reading disability.

Prediction Four: Good and poor readers will exhibit about the same amount of knowledge of body schema, i.e., knowing left from right parts of the body.

To determine knowledge of body schema, the Benton Left Right Test was used. The statistical analysis was similar to that outlined above for the other hypotheses. None of the F tests were significant. This indicates that the hypothesis as stated cannot be rejected. For these children at least, there was no relationship between their score on the Benton test and their score on the Gates Primary Reading Test. Using different measures, Balow (1964) reported a similar finding - but the Kephart (1960) work as well as the finding of Belmont and Birch (1965) are contraindicative of this finding. Since different measures were used in allof the studies, it may be that the results are not comparable even though all are attempts to measure body image.

Essentially all of the predictions were borne out, indicating either that cerebral dominance and laterality are not significant factors in the etiology of reading or that the search for better measures must continue. All of the measures used in this study were intended as behavioral indices of both degree and direction of laterality. All have been used in other research and are excellent tools, for other samples. However, there were some drawbacks in their use in their use in this study. The Palmer dowel test may not be the best measure for this age group, since E often had to make subjective

judgments, and the children often could not follow directions. They would turn around so that the experimenter could not see them, would allow the dowel to touch their body briefly and then continue the task, would steady the dowel with the other hand and continue the task, etc. Although the experimenter tried to watch for these things carefully, undoubtedly some were not caught contaminating the data.

The Benton Test has been used with some success in previous research but again the author has some reservations about its use with seven-year-olds. The test asks the children to verbalize knowledge of the left and right parts of the body. Now a child may be able to use the laterality of his body effectively without being able to verbalize it. To use laterality effectively means several things. It means to reach for something in the right visual hemisphere with the right hand, not the left. It means controlling muscles so that the body can balance and compensate to regain balance. In short, it means manipulating and moving in the environment efficiently. It is possible that children can do this very efficiently and still not be able to articulate what they are doing or know the names for the sides of their bodies. Future research must take these possibilities into consideration and look for more sensitive tools to measure both the degree and direction of lateralization and the cerebral dominance it may imply.

Another consideration of studies of this type is choice of population. The one chosen for this study was a normal school population and the discriminating reading test was a test of reading achievement. It is reasonable to assume that a study based on a clinic population vs. a non-clinic population would obtain greater differences. Even Harris (1957) notes that if he had removed poor readers from the school children he was using as a control against his clinic cases, he would have obtained more differences. This study did not involve a clinic at all and therefore the consistenly extremely poor end of reading disabilities was not used. This population problem is one which must be carefully considered in both future research and in comparing the result of the present study with those of the literature. However, this study was an attempt to discriminate differences in the etiology of reading disabilities in a normal population of children in an average school within the normal range of IQ. It was reasonable to assume that differences obtained would not be great, but it is hoped that further research will use this experimental design to determine what does go wrong in the reading habits of the child who is in a 'normal' situation.

Table I

Sighting
Degree of Lateralization

	Male	Female
Good Readers $\overline{X}$	4.7	5.6
Poor Readers $\overline{X}$	5.8	3.2

Analysis of Variance
for Sighting (degree)

	SS	df	MS	F
Rows (reading)	2.02	1	2.02	< 1
Columns (sex)	4.22	1	4.22	1.41
Interaction	38.02	1	38.02	12.72*
Error	107.70	36	2.99	
Total	151.97	39		

*$p < .05$

Table II

Sighting
Direction of Lateralization

	Male	Female
Good Readers $\overline{X}$	4.2	11.2
Poor Readers $\overline{X}$	8.2	7.6

Analysis of Variance
for Sighting (direction)

	SS	df	MS	F
Rows (reading)	1.6	1	1.6	<1
Columns (sex)	115.6	1	115.6	6.42*
Interaction	160.0	1	160.0	8.88*
Error	647.2	36	18.0	
Total	924.4	39		

*$p < .05$

Table III

Handedness
Degree of Lateralization

	Male	Female
Good Readers $\bar{X}$	10.5	14.7
Poor Readers $\bar{X}$	19.5	16.6

Analysis of Variance
for Handedness (degree)

	SS	df	MS	F
Rows (reading)	354.0	1	354.0	< 1
Columns (sex)	13.2	1	13.2	< 1
Interaction	164.1	1	164.1	< 1
Error	4197.5	36	1166.0	
Total	4778.8	39		

Table IV

Handedness
Direction of Lateralization

	Male	Female
Good Readers $\bar{X}$	46.6	35.7
Poor Readers $\bar{X}$	48.5	37.8

Analysis of Variance
for Handedness (Direction)

	SS	df	MS	F
Rows (reading)	184.9	1	184.9	<1
Columns (sex	722.5	1	722.5	2.18
Interaction	770.9	1	770.9	2.33
Error	11883.7	36	330.1	
Total	13262.0	39		

Table V

Chi Square Comparisons
for Ipsilaterality of
Handedness and Eyedness

TOTAL GROUP

	Good Readers	Poor Readers
Number of Ipsilateral	8	12
Number of Contralateral	11	8

$X^2 = 1.33$

BOYS

	Good Readers	Poor Readers
Number of Ipsilateral	3	8
Number of Contralateral	6	2

$X^2 = 4.25$
$p < .05$

GIRLS

	Good Readers	Poor Readers
Number of Ipsilateral	5	4
Number of Contralateral	5	6

$X^2 = 0.2$

Table VI

Fragmentation
Degree of Lateralization

	Male	Female
Good Readers $\bar{X}$	4.3	2.9
Poor Readers $\bar{X}$	3.6	2.3

Analysis of Variance
for Lateralization

	SS	df	MS	F
Rows (reading)	2.0	1	2.0	< 1
Columns (sex)	13.2	1	13.2	1.61
Interaction	.3	1	.3	
Error	296.3	36	8.23	
Total	311.8	39		

Table VII

Fragmentation
Direction of Lateralization

	Male	Female
Good Readers $\bar{X}$	13.0	8.9
Poor Readers $\bar{X}$	12.4	10.9

Analysis of Variance
for Fragmentation (direction)

	SS	df	MS	F
Rows (reading)	18.2	1	18.2	<1
Columns (sex)	46.2	1	46.2	2.32
Interaction	4.3	1	4.3	<1
Error	713.3	36	19.9	
Total	785.0	39		

Table VIIIa

Chi Square Comparisons
for Ipsilaterality of
Eyedness

	Good Readers	Poor Readers
Number of Ipsilateral	8	10
Number of Contralateral	11	9

$X^2 = 1.5$

Table VIIIb

Chi Square Comparisons
for Ipsilaterality of
Handedness

	Good Readers	Poor Readers
Number of Ipsilateral	8	12
Number of Contralateral	11	7

$X^2 = 1.7$

Table IX

Left-Right Scores

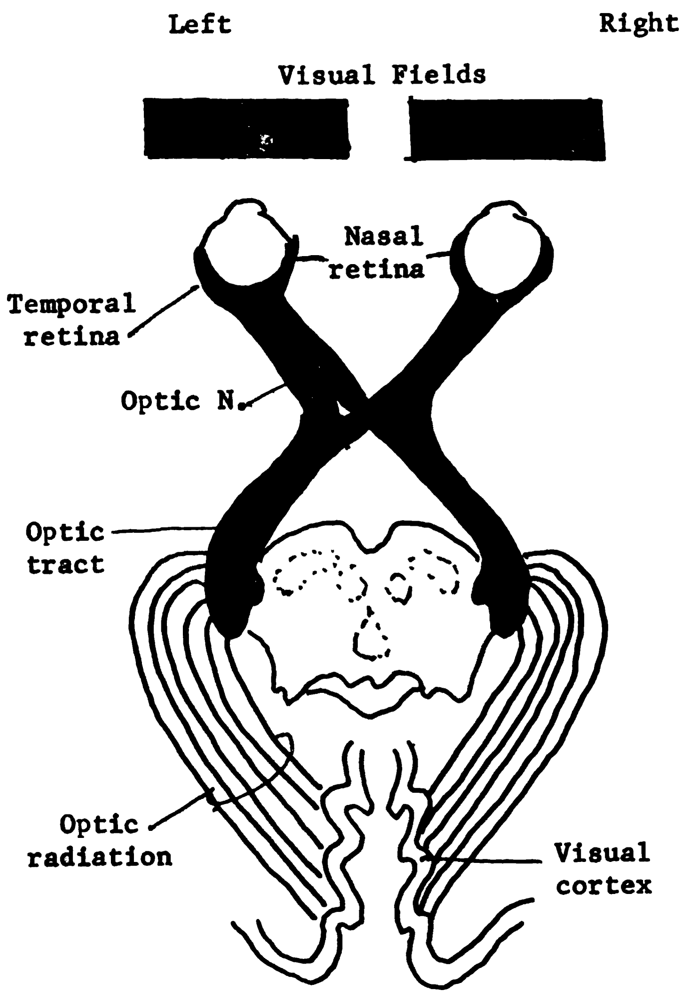
	Male	Female
Good Readers $\bar{X}$	15.3	16.6
Poor Readers $\bar{X}$	13.0	17.7

Analysis of Variance
for Left-Right Scores

	SS	df	MS	F
Rows (reading)	..2	1	.2	< 1
Columns (sex)	140.6	1	140.6	3.74
Interaction	9.1	1	9.1	< 1
Error	1338.1	36	37.2	
Total	1488.0	39		

Figure I

Diagram of Common Lesions
Within the Visual Pathway



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