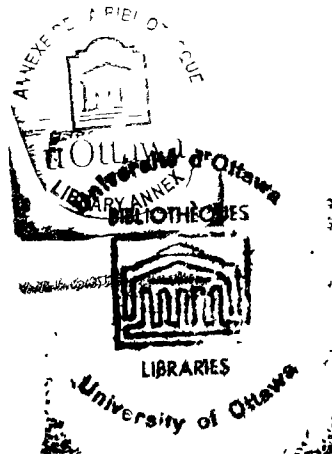


**A STUDY OF THE POSSIBLE DISTINCTION
BETWEEN "CONTROLLING EYE" AND "DOMINANT
EYE" AND THE RELATION OF BOTH, WITH
HAND DOMINANCE, TO READING
ACHIEVEMENT**

by Robert W. Boos

**Thesis presented to the Faculty of
Education of the University of
Ottawa as partial fulfillment of
the requirements for the degree of
Doctor of Philosophy**



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CURRICULUM STUDIORUM

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INTRODUCTION

From Socrates to Comenius to Dewey to Mrs. Franks in New York to Mrs. Curran in Chicago, educators have eternally struggled with the problem of knowing and stimulating young minds. This problem is not a new one.

The greatest challenge to the young mind is that offered by the necessity to master the visual aspect of our language, reading. Within recent years there has evolved a most pressing demand to know more of the intellectual, neurological, and visual relationship to reading.

As yet, no satisfactory plan to deal with the still growing problem of reading disability has been presented as is noted by the plethora of educational statistics indicating the rising incidence of this problem in our schools.

The remediation of this disability is essential not only for the happy, confident, and productive individual but for our society in general. The effect of reading disability is well known and recognized by our law enforcement agencies. This difficulty is frequently found in children and adolescents with chronic, antisocial behavior.

A very reasonable relationship has been offered between vision and reading if we, by vision, consider more than merely eyes and eyesight. We must think not only of the eye and its retina as a sense receptor but also the

brain as a control center. Some of our reading problems may be immediately traceable to visually associated or laterality problems.

1. The Purpose.

The primary purpose of this study is to clarify the equivocal research on laterality and reading achievement through the investigation of the possible distinction between the "controlling" eye determined through tests of binocular vision and the "dominant" eye normally referred to in studies of laterality.

A related purpose includes an analysis of the relationship of crossed control, crossed dominance, and mixed dominance to reading achievement in a junior high school population wherein eye-hand dominance was earlier found to be unrelated to intelligence, reversals, reading differential, and reading achievement at the primary level.

An effort is also made to identify a possible difference in the dominance patterns between male and female subjects.

A final purpose of this study is to evaluate, at the junior high school level, a developmental trend away from mixed dominance as reported in an earlier study which followed this same population from kindergarten to mid-third grade.

2. Justification.

The need for such a study might be questioned because of the large number of existing studies related to this subject. It might appear surprising that it still entices investigation and could negate the importance of this topic as an area for further research were it not for the many discrepancies that have been found in these studies.

One area of confusion lies in the fact that the studies fall within two distinct categories. They are either clinical studies or studies of children in public school situations. Although there are a greater number of clinical studies, the fact that the subjects are certainly far more disabled in reading than their counterparts in a public school situation may tend to distort the findings.

Other areas of confusion lie in the diversity of achievement criteria and in the instruments used to measure laterality. Achievement criteria range from tasks such as identifying and reproducing letters and words to achievement on standardized tests of reading and intelligence. It is generally accepted that clinical settings offer the availability of more instruments and greater time to do a more detailed examination of laterality.

Still another source of confusion in the literature is derived from the difference between samples of the population used. The samples used may vary from pre-school

children, to children referred to clinics for severe reading or speech problems, to adults with populations drawn from such different cultural and geographical backgrounds as the Los Angeles and New York metropolitan areas, middle-western United States, London, and Scotland.

The research literature relating eye-hand dominance to reading achievement, then, is ambivalent. This study contributes to the literature as a replication of two disparate studies. It attempts to relate the Berner explanation of the difference in research, i.e., the "controlling" eye in binocular vision is not necessarily the same as the "sighting" eye usually considered in research as the dominant eye, to the field of dominance investigations by using the eighth-grade public school population which was previously tested in third grade by Millerich and which exhibited no relationship between hand-eye dominance and reading achievement.

Since research findings in the area of dominance and reading are not in agreement, further investigation, using knowledge and findings from previous studies, is in order.

3. Hypotheses.

The questions for study were established as the following hypotheses:

1. There is no significant distinction between the dominant eye used in sighting and the controlling eye used in binocular vision.
2. There is no significant difference in reading achievement between children of crossed dominance and those of unilateral dominance.
3. There is no significant difference in reading achievement between children evidencing crossed control and those with unilateral control.
4. There is no significant difference in reading achievement between children of mixed dominance and those of unilateral dominance.
5. There is no significant change in the eye-hand dominance pattern of children between second grade and eighth grade.
6. There is no significant difference in the eye-hand dominance patterns between male and female children.

4. General Plan.

Chapter one contains a review of the relevant research dealing with the causes of reading disability, the determination of laterality and its effect on reading achievement, and the problem of reversals in reading.

Chapter two includes a delineation of the procedures used in testing as well as the statistical tests used to determine the validity of the hypotheses.

Chapter three reports the findings while chapter four summarizes the conclusions reached and offers recommendations for further study.

5. Definitions of Terms.

Primary grades - kindergarten through third grade.

Laterality - eye-hand preference. This term is used synonymously with dominance. As a generic term it refers to bodily behavior characterized by the unilateral preference of the external bipartite organs.

Unilateral dominance - the preferred hand and eye are on the same side of the body: right-eyed and right-handed or left-eyed and left-handed.

Crossed dominance - the preferred hand and eye are on opposite sides of the body: right-eyed and left-handed or left-eyed and right-handed.

Mixed dominance - no clear preference is indicated for hand or eye, either singly or together: ambi-eyed and right- or left-handed, or ambidextrous and right- or left-eyed or ambi-eyed and ambidextrous.

Sighting eye - the eye that is the preferred eye in a monocular or sighting act. In this study the sighting eye is synonymous with the dominant eye.

Controlling eye - in binocular vision the two eyes are used as a unit for visual perception. Both eyes do not play an equal role but there is a rivalry and one eye controls the binocular perception while the other plays an assisting role. One consistently leads or controls in

these situations in which there must be a choice between two images.

Corresponding control - the controlling eye and preferred hand are on the same side of the body: right controlling-eye and right-handed, or left controlling-eye and left-handed.

Crossed control - the controlling eye and the preferred hand are on opposite sides of the body or no clear preference is indicated: right controlling-eye and left-handed, left controlling-eye and right-handed, ambi-eyed and right- or left-handed, or ambidextrous and right or left controlling-eye.

Sinistrals - those left-handed persons who prefer a sequence of movement by hand and eye from right to left--toward the center of the body.

Dextrals - those right-handed persons who prefer a sequence of movement by hand and eye from left to right--away from the center of the body.

Reversals - any directional confusion exhibited in dealing with printed symbols.

CHAPTER I

REVIEW OF RELATED RESEARCH

1. General Overview.

Reading disability is certainly one of the foremost problems of elementary education in our time. It exhibits itself in the inability to read normally, even though the child is endowed with average or superior intellectual capacity. Far too little is known of the etiology, diagnosis, and treatment of this form of incapacitation, and much greater attention to this obfuscation is warranted.

Reading involves not only a visual aspect but also a neurological one. Some six hundred years before patristic times, in the third century B.C., the brain had been meticulously studied in Alexandria. Neurological history identifies the early medieval encyclopedaists as well as the Byzantine schools in which Greek and medieval neurological tradition remained alive until well into the eighth century. It was a prominent surgeon of that period, William of Salicito, who revealed that a headwound on one side paralyzed the opposite side of the body.¹ This fact, supported by Hippocrates and

¹ Walter Pagel, "Medieval and Renaissance Contributions to Knowledge of the Brain and Its Functions", in The History and Philosophy of Knowledge of the Brain and Its Function, Springfield, Illinois, Charles C. Thomas, 1958, p. 97.

Aretaios, did not become medically established until the eighteenth century.

It was Alcmaeon of Croton, living in the fifth century B.C., who emerged as the first important figure in the history of the brain.² His chief anatomical discovery was that of the optic nerve. He believed that the impression made on the eye by external objects was transmitted to the brain by hollow canals now termed the optic nerves. Perhaps Alcmaeon's most brilliant contribution was his concept that each sensation had its own territory of localization in the brain; a concept that remained dormant only to be seriously revived twenty-five centuries after his time.

Hippocrates, born in the year 460 B.C., authored books contributing precociously to knowledge of the brain's function. His book, The Sacred Disease, has within it antiquity's finest discussion of this functioning.³

One finds in Hippocratic writings the observation that, "an incised wound in one temple produces a spasm in the

2 D.H.M. Woollam, "Concepts of the Brain and Its Functions in Classical Antiquity", in The History and Philosophy of Knowledge of the Brain and Its Function, Springfield, Illinois, Charles C. Thomas, 1958, p. 40.

3 Wilder Penfield, "Hippocratic Preamble: The Brain and Intelligence", in The History and Philosophy of Knowledge of the Brain and Its Function, Springfield, Illinois, Charles C. Thomas, 1958, p. 2.

opposite side of the body".⁴ It was Morgagni and Valsalva who finally established this relationship in the eighteenth century.⁵

In contrast to this ancient knowledge, the concept of cerebral dominance has existed for little more than one century. Its discovery is generally attributed to Broca in 1861, who associated aphasia with lesions of the left frontal lobe.⁶ This distinction is dimmed, however, by the occasional mention of Marc Dax's earlier contribution in 1836, a quarter century earlier.

Dax's memoir is of note for it contains the earliest mention of the left hemisphere in the function of speech. This association of aphasia with left hemiplegia, furthered in the writings of Gustav Dax, son of Marc Dax, is currently considered as one of the verities of clinical neurology.⁸

These were the origins of the concept of cerebral hemispheric dominance and the universalization that projects an exclusive representation of language in a single hemisphere.

⁴ Arthur L. Benton, "The Problem of Cerebral Dominance", in The Canadian Psychologist, Vol. 6a, No. 4, October 1965, p. 332.

⁵ Pagel, Op. Cit., p. 98.

⁶ Benton, Op. Cit., p. 333.

⁷ R.J. Joynt and A.L. Benton, "The Memoir of Marc Dax on Aphasia", in Neurology, Vol. 14, No. 9, September 1964, p. 852.

⁸ Ibid., p. 853.

This continues to be accepted but with serious doubts and reservations by many researchers.

In 1896, an English physician, Morgan, came upon a fourteen year old child exhibiting an extreme difficulty in reading and demonstrating good ability in arithmetic and algebra.⁹ He assigned as the cause congenital word-blindness, implying neurological disorder.

Hinshelwood, in 1917, presented the theory that failure in learning to read was directly related to a congenital defect in the brain.¹⁰ This association was based on the feeling that the symptomatology of disabled readers was similar to those of word-blind adults.

Lord,¹¹ in 1925, agreeing with Schmitt that children who were presumed to have a neurological defect did learn to read thereby negating pathological proof, suggested that reading disability was due to a deficit in the association fibers of the brain, to a lack of sufficient associations between the sense centers, and to improper coordination between the visual and auditory stimuli and motor responses.

9 Helen M. Robinson, Why Pupils Fail in Reading, Chicago, University of Chicago Press, 1946, p. 35.

10 Ibid., p. 36.

11 Elizabeth E. Lord, Leonard Carmichael and Walter F. Dearborn, "Special Disabilities in Learning to Read and Write", in Harvard Monographs in Education, Serial I, Vol. 2, No. 1, June 1925, p. 28.

Although Gould,¹² in 1908, reported a relationship of eyedness and handedness, it was Orton¹³ in 1928 who postulated a theory of cerebral dominance that brought the peripheral facets of dominance into great emphasis. His was the most widely known early attempt to associate language function with neurological organization.

While he believed that the hemispheres were equal in size and cellular structure, he felt that one hemisphere alone directed the associative function of language while the non-dominant side was silent or inactive. If the complete elision of the record of the impression or engram was not accomplished in the non-dominant hemisphere, confusion might result, negatively affecting facility in reading.¹⁴ He extended his hypothesis, that muscular functions on each side of the body were directed by the cerebral hemisphere on the opposite side, to visual images, declaring that subjects having mixed or cross-dominance evidenced incomplete engram elision, resulting in the confusion of images stored in the brain.¹⁵

12 G.M. Gould, Righthandedness and Lefthandedness, Philadelphia, J.B. Lippincott Co., 1908, p. 182-194.

13 Samuel Orton, "Specific Reading Disability-Strephosymbolia", in Journal of American Medical Association, Vol. 90, April 1928, p. 1096.

14 Ibid.

15 Samuel Orton, "An Impediment in Learning to Read: A Neurological Explanation of Reading Disability", in School and Society, Vol. 28, No. 715, September 1928, p. 287.

This condition was exhibited in reversals and delayed reading.

Eames¹⁶ examined one hundred reading disability cases and a control group of equal size and found evidence supporting Orton's theory. He found anomalies of lateral dominance of hand and eye particularly prevalent in children with reading disability.

Dearborn¹⁷ was in essential agreement with Orton, imparting the view that lateral dominance of one side of the body which he described as the relative valence of hand and eye--the two organs primarily involved in reading and writing--was necessary to avoid difficulties in reading and writing. In a later work, he proposed a functional or muscular etiology of reading disability resulting from mixed or crossed dominance rather than a neurological one.¹⁸ In this study he found fourteen per cent more left-eyedness and seventeen per cent more crossed dominance among a group of seventy-six severely retarded readers as compared to 129 unselected cases.

16 T.H. Eames, "The Anatomical Basis of Lateral Dominance Anomalies", in American Journal of Orthopsychiatry, Vol. 4, October 1934, p. 524-528.

17 Walter F. Dearborn, "The Nature of Special Abilities and Disabilities", in School and Society, Vol. 31, May 10, 1939, p. 633.

18 -----, "The Nature and Causation of Disabilities in Reading", in Recent Trends in Reading, Supplementary Educational Monographs, No. 49, Chicago, University of Chicago Press, 1939, p. 103-110.

In keeping with the above finding, Teegarden,¹⁹ in a study of fifty first grade children, revealed that consistent right or left dominance were conditions most favorable to success in reading.

Monroe²⁰ in a similar study of school children discovered that among the reading defect cases there existed a greater proportion of children who exhibited right-hand dominance and left-eye dominance.

In 1935, Bryngelson²¹ gave testimony that a lack of one-sidedness was a very serious condition, and any factor which operated against establishment of one-sided dominance tended to interfere with normal development of the function of reading, speaking, and writing.

Delacato²² suggested that Orton's functional rationale was tenable, excepting the concept that visual patterns were stored in the brain. He presented a preference for a neuropsychological approach. He indicated that man's neurological

19 Lorene Teegarden, "Clinical Investigation of the Prospective Non-reader", in Child Development, Vol. 3, No. 4, December 1932, p. 346-358.

20 Marion Monroe, Children Who Cannot Read, Chicago, The University of Chicago Press, 1932, xv-205 p.

21 Bryng Bryngelson, "Sidedness as an Etiological Factor in Stuttering", in Journal of Genetic Psychology, Vol. 47, No. 1, September 1935, p. 204-219.

22 Carl H. Delacato, The Treatment and Prevention of Reading Problems, Springfield, University of Chicago Press, 1959, p. 18.

organization and development ontogenetically recapitulated the phylogenetic development of the nervous system and that man's contribution to phylogenetics was not one of structure but rather of function.²³ Inherent in this principle was the notion that if there existed incomplete or absent areas of neurological organization, problems of reading might be present.

Crider has presented the conviction that Dearborn and Orton derived their hypotheses solely from clinical cases, and stated "the opinions advanced by Orton and Dearborn are commendable as hypotheses but they are not theories and even less are they facts".²⁴ He felt that conclusions which were drawn from clinical case studies should have been accepted with reservation; that theories should have been substantiated experimentally and applied to clinical cases for further verification. This author found no evidence that eye preference was related to cerebral dominance, much less to handedness.

In a report of case studies of surgical procedures involving twenty-one epileptics, Smith²⁵ based his finding

23 Carl H. Delacato, The Diagnosis and Treatment of Speech and Reading Problems, Springfield, University of Chicago Press, 1963, p. 44.

24 Blake Crider, "The Lack of Cerebral Dominance as a Cause of Disability in Reading", in Childhood Education, Vol. 10, February 1934, p. 270.

25 K.U. Smith, "The Role of the Commissural System of the Cerebral Cortex in the Determination of Handedness, Eyedness, and Footedness in Man", in Journal of General Psychology, Vol. 32, First Half, January 1945, p. 39-79.

that ocular, manual, or pedal laterality are seemingly unrelated at the cortical level on the fact that neurological conditions which effected shifts in manual or pedal sidedness did not alter at all the ocular dominance of the subjects.

The examination of electroencephalographic patterns of children with reading difficulties by Kennard et al.²⁶ revealed no greater tendency toward abnormal patterns than were displayed by children free from reading disability.

The evidence of a study by Leavell et al.²⁷ was important because it led nearer a functional explanation and suggested a condition which could be remediated by training the disabled individual. The data supported the view that, because of its relationship to the side most used, cerebral dominance was more likely an effect than a cause.

Witty and Kopel²⁸ were even more determined in their view that cerebral hemispheric dominance was a secondary characteristic, the primary characteristic being ocular and manual dominance. They presented evidence indicating that

²⁶ Margaret A. Kennard et al., "The Abnormal Electroencephalogram as Related to Reading Disability in Children with Disorders of Behavior", in The Canadian Medical Association Journal, Vol. 67, October 1952, p. 332.

²⁷ H.W. Leavell et al., "Critical Study of a Case of Aphasia", in Archives of Neurology and Psychiatry, Vol. 28, 1932, p. 1180.

²⁸ Paul A. Witty and David Kopel, "Sinistral and Mixed Manual-Ocular Behavior in Reading Disability", in Journal of Educational Psychology, Vol. 27, No. 2, February 1936, p. 119-134.

right, left, and mixed manual-ocular dominance occurred no more frequently among reading problems than among non-problems.

Harris²⁹ also gave evidence supporting the view that there was no significant difference in crossed dominance between the reading disabled and the unselected child.

In a careful investigation of 148 elementary school children in Aberdeen, Scotland, Belmont and Birch³⁰ imparted the conclusion that it was far more likely that a developmental lag in lateralization and an evidence of reading disability were independent manifestations of an underlying disturbance in neurological organization and were not etiologically related to one another.

Hillerich,³¹ in a very comprehensive statistical research of four hundred public school students, offered data to support the hypothesis that there exists no significant difference in the percentage of mixed, crossed, or unilaterally dominant in a group of below average readers as compared with a group scoring average or above in reading.

29 Albert J. Harris, "Lateral Dominance, Directional Confusion, and Reading Disability", in Journal of Psychology, Vol. 44, Second Half, October 1957, p. 283-294.

30 Lillian Belmont and Herbert G. Birch, "Lateral Dominance and Right-Left Awareness in Normal Children", in Child Development, Vol. 34, No. 2, June 1963, p. 257-270.

31 Robert L. Hillerich, A Study of the Relationships between Eye-Hand Dominance and the Reading Achievement of Selected Primary Students, unpublished doctoral dissertation, Colorado State College, 1962, x-108 p.

He suggested that differences in lateral dominance relationships between normal and retarded readers had been found when a clinical sample has been used and was not evident when a school population was examined.

This conviction was strongly shared by Belmont and Birch³² who offered findings on lateralization differing from investigators who studied retarded readers selected from a clinical setting but agreeing with those reported by researchers who had drawn the subjects from community or school populations.

In a very recent investigation Shearer,³³ an ophthalmologist, reported that visual acuity, mixed dominance, heterotropias, and myopia had little or no relationship to reading ability.

In his summary of existing knowledge of ocular and crossed dominance for ophthalmologists in 1938, Fink³⁴ offered for consideration his realization that the two eyes did not affect the visual consciousness with equal force. One eye led

³² Lillian Belmont and Herbert G. Birch, "Lateral Dominance, Lateral Awareness, and Reading Disability", in Child Development, Vol. 36, No. 1, March 1965, p. 57-71.

³³ Robert V. Shearer, "Eye Findings in Children with Reading Difficulties", in Journal of Pediatric Ophthalmology, Vol. 3, No. 4, November 1966, p. 51.

³⁴ W.H. Fink, "The Dominant Eye: Its Clinical Significance", in A.M.A. Archives of Ophthalmology, Vol. 19, No. 9, April 1938, p. 555-582.

the other, and this leading eye was called the dominant eye. He presented the view that ocular dominance seemed to be a cerebrally located process rather than a peripheral one.

In that same year an article authored by Warren and Clark³⁵ appeared indicating that there was no justification for the belief that the sighting eye was preferred, dominated, or assumed leadership in normal binocular vision, although such a belief was often expressed. They suggested that laterality of eye functioning was specifically determined by the situation in which the measurement was made.

The most decisive and authoritative support of this contention also appeared in 1938 as a study by Berner and Berner.³⁶ It was their strong conviction that as binocular vision develops, there developed a rivalry between the two eyes, and one eye controlled binocular perception. The other eye played an assisting role. The "controlling" eye was not necessarily the eye with which a person sighted.³⁷ The "sighting" eye had usually been considered in research as the

³⁵ Neil Warren and Brant Clark, "A Consideration of the Use of the Term Ocular Dominance", in Psychological Bulletin, Vol. 35, No. 5, May 1938, p. 302.

³⁶ George E. Berner and Dorothy E. Berner, "Reading Difficulties in Children", in A.M.A. Archives of Ophthalmology, Vol. 20, November 1938, p. 829-833.

³⁷ -----, "Relation of Ocular Dominance, Handedness, and the Controlling Eye in Binocular Vision", in A.M.A. Archives of Ophthalmology, Vol. 50, November 1953, p. 603-608.

dominant eye. They further suggested that crossed control rather than crossed dominance was a significant factor in low reading achievement.

This may be another explanation of differences in the research.

In a more recent investigation, Leavell³⁸ gave substantial credence to the theories of Berner and Berner and offered case studies to support the remediation of pupils with crossed control problems.

It becomes apparent to the reader of this brief survey that the problem of dominance and its relationship to reading have had more basis in theory than in fact. In subsequent selections of this chapter research studies are presented that will illumine the neurological basis of reading disability, the relationship between dominance and reading, the significance of reversal errors in reading, and the problem of laterality testing.

2. Neurological and Physiological Basis for Reading Disability.

Very early contributors to this topic include Alcmaeon of Croton, Isodorus of Seville, and Hrabanus Maurus,

³⁸ Ullin W. Leavell, "The Problem of Symbol Reversals and Confusions, Their Frequency and Remediation", in Peabody Journal of Education, Vol. 32, No. 3, November 1954, p. 130-141.

who were medical encyclopaedists, and William of Solicito, Theodoric, Aretaios, the renowned Hippocrates, Morgagni, Valsalva, Marc and Gustav Dax, and Broca.³⁹

The English physician, Morgan, in 1896, designated congenital word-blindness, implying neurological disorder, as the cause of extreme reading disability in a fourteen year old boy with good ability in arithmetic and algebra.⁴⁰

Two decades later Schmitt⁴¹ assigned the term "developmental alexia" to those poor readers otherwise normally endowed mentally, thereby accepting a neurological anomaly view.

Congenital word-blindness came to be recognized as a condition existing in children who were seriously disabled or retarded in reading without other explainable etiologies, and was related to adult word-blindness, a term often applied to adults who lose their ability to read, usually coincidental with brain injury.

The feeling that the two halves of the brain were mirrored counterparts of each other, together with reversals

³⁹ Pagel, "Medieval and Renaissance Contributions to Knowledge of the Brain and Its Functions", p. 95-114.

⁴⁰ Robinson, Why Pupils Fail in Reading, p. 35.

⁴¹ Clara Schmitt, "Developmental Alexia", in Elementary School Journal, Vol. 18, May 1918, p. 680.

in reading and stuttering disabilities, led Orton⁴² to postulate that a pattern established in the dominant hemisphere would produce a response in harmonious orientation with the stimulus pattern, while the same pattern of the opposite or non-dominant hemisphere would, if activated uninhibitedly, produce as a response the mirrored image of the stimulus pattern.

Orten, one of the first investigators placing great emphasis on dominance in reading problems, states:

[...] engrams must be formed in the non-dominant as well as in the dominant hemisphere. To account then for the difference in effect of damage in the two sides we must assume that the engrams of one side become the controlling pattern through establishment of a physiological habit of use of that set and that the other set of recorded engrams is latent or elided. Variation in the completeness of this physiological selection, i.e., failure of elision of the non-dominant engrams, forms the kernel of my conception of the reading disability. Such a theory conforms nicely to our observations that these cases are not to be divided into two categories, that is, cases of word-blindness and cases of slow acquisition of reading, but that they form a series graded in severity according to the degree of confusion which exists in choice of engrams and it also offers an explanation of certain errors and peculiarities which characterize their performance.⁴³

⁴² Orten, "An Impediment in Learning to Read: A Neurological Explanation of Reading Disability", p. 286-290.

⁴³ -----, "The 'Sight-reading' Method of Teaching Reading, as a Source of Reading Disability", in Journal of Educational Psychology, Vol. 20, February 1929, p. 139.

While he saw no structural contrast between the two hemispheres, Orton⁴⁴ held that in the normal reader the reciprocally paired engrams operate with the concept in reading but the anti-tropic or mirrored mate must be elided or remain inoperative. Failure of complete elision resulted in reversals, confusion of letter form, and a facility in mirror reading and writing.

He also postulated three levels of cortical activity, i.e., perception, recognition, and elaboration. The latter was the level at which the printed symbol was linked with meaning and was described as the association, concept or symbolic level.⁴⁵ The third level, unlike the others, was affected by the destruction of but one hemisphere.

Crider⁴⁶ suggested that Orton had not cited satisfactory experimental evidence; that he generalized solely from clinical cases the number of which was not stated. He expressed a preference for experimental substantiation initially, followed by further verification in clinical cases.

This author declared that the physiological theory seemed to be an oversimplification of the reading problem and failed to take into consideration higher mental processes,

⁴⁴ Orton, "Specific Reading Disability-Strephosymbolia", p. 1095-1099.

⁴⁵ -----, "Word Blindness in School Children", in Archives of Neurology and Psychiatry, Vol. 14, 1925, p. 581-615.

⁴⁶ Crider, "The Lack of Cerebral Dominance as a Cause of Disability in Reading", p. 238.

low intelligence, inadequate visual perception, personality factors, poor methodology, eye muscle imbalance, and many other factors.⁴⁷ He held that Orton's opinions were commendable as hypotheses, but they were not theories and even less were they facts.

The evidence of a study by Smith⁴⁸ of twenty-one epileptics who underwent surgical procedures challenged the theory which postulated that, in those with definite sidedness, the dominant contralateral hemisphere controlled the activity of the preferred side of the body and, by inhibition of the other hemisphere, also directed regulatory control over the motor functions of the non-preferred side. This challenge was based on knowledge of neurological conditions which effects that shifts in manual or pedal sidedness did not change at all the ocular dominance, as well as the reverse.

The results of an investigation by Mintz⁴⁹ to verify the facts described by both Orton and Monroe⁵⁰ opposed their theory that reading disability was based on lack of unilateral

⁴⁷ Ibid., p. 239.

⁴⁸ Smith, "The Role of the Commissural System of the Cerebral Cortex in the Determination of Handedness, Eyedness, and Footedness in Man", p. 39-79.

⁴⁹ Alexander Mintz, "Reading Reversals and Lateral Preferences in a Group of Intellectually Subnormal Boys", in Journal of Educational Psychology, Vol. 37, No. 8, November 1946, p. 487-501.

⁵⁰ Monroe, Children Who Cannot Read, xv-205 p.

cerebral dominance. As a result of the determination of dominance status of ninety-five primary school boys, this writer identified no strephosymbolia or statistically significant difference in the frequencies of orientation errors in the various laterality types.

Ketchum⁵¹ revealed that recent evidence did not support the view that mixed preferences for use of hand, sighting eye, or foot were symptoms of children's failure to establish one-sided cerebral dominance. He purported that the hypothesis of mixed dominance, based on Orton's anti-tropic and engrammatic views of the cortex, seemed no longer tenable.

In definite agreement was Capobianco⁵² who offered data from a study of thirty-eight male and twenty female retarded students at the Johnstone Training and Research Center. Although the difference was not statistically significant, the non-established laterality group surpassed the established laterality group on all reading tasks, thereby contrasting Orton's hypothesized relationship between the confusion of mental processes and incomplete cerebral

⁵¹ E.G. Ketchum, "Neurological and Psychological Trends in Reading Diagnosis", in Reading Teacher, Vol. 17, No. 8, May 1964, p. 589-593.

⁵² R.J. Capobianco, "Ocular-Manual Laterality and Reading in Adolescent Mental Retardates", in American Journal of Mental Deficiency, Vol. 70, No. 5, March 1966, p. 781-785.

dominance. However, it should be noted that the determination of laterality preferences in this type of subject as part of a diagnostic workup appeared to possess dubious practical value.

In an effort to validate Orton's engramic representation in the non-dominant hemisphere, Herren and Lindsey⁵³ destroyed a substantial percentage of the dominant hemisphere of sixteen mature male rats, expecting from half the group a better performance in a mirrored maze than from the remainder who ran the maze in its original orientation. On the contrary, the group running the maze in its original orientation had reduced their time and error scores to the level at which they completed their initial learning prior to the operation, while the other group had only one member reaching that level of efficiency.

Very relevant to the neurological basis for reading disability were the contributions of Carl H. Delacato, who accepted Orton's functional rationale with the exception of the concept that visual patterns were stored in the brain. The basic premise of his neuropsychological approach, based in part on Orton's theories, was outlined by Delacato as:

⁵³ R. Yorke Herren and Donald B. Lindsey, "A Note Concerning Cerebral Dominance in the Rat", in Journal of Genetic Psychology, Vol. 47, No. 2, December 1935, p. 469-472.

[...] neurological organization is that physiologically optimum condition which exists uniquely and most completely in man and is the result of a total and uninterrupted ontogenetic neural development. This development recapitulates the phylogenetic neural development of man and begins during the first trimester of gestation and ends about six and one-half years of age in normal humans. This orderly development in humans progresses vertically through the spinal cord and all other areas of the central nervous system up to the level of the cortex, as it does with all mammals. Man's final and unique development progression takes place at the level of the cortex and it is lateral.

This whole phylogenetic process is recapitulated ontogenetically with each human being. In the event there is some obstruction to this ontogenetic recapitulation, communication and language dysfunction occur.

Trauma of the controlling cortical hemisphere results in loss of language skills, but equally important, trauma of the sub dominant area results in loss of tonal factors.⁵⁴

Delacato⁵⁵ insisted that the areas of neurological organization which have not been completed or were absent could be corrected by teaching them to those who exhibited problems of speech and reading. He felt that when the neurological organization was complete, the problem would have been overcome. He urged a program of therapy, including testing for neurological organization and dominant laterality, in special education classes.⁵⁶

⁵⁴ Delacato, The Treatment and Prevention of Reading Problems, p. 19-20.

⁵⁵ Ibid., p. 9.

⁵⁶ -----, "Ontogeny of Reading Problems", in Claremont Reading Conference Yearbook, Vol. 27, 1963, p. 119-125.

In a report of literature based on Delacato's theories, Sister St. Francis⁵⁷ reinforced his notion that neither right- nor left-handedness was preferable; the objective was to establish unilaterality. When neurological organization was complete through all levels to total unilaterality, the problems of the retarded readers began to vanish, and reading methods were secondary.

Perkins⁵⁸ in a report addressed to the Claremont Reading Conference summarized many objections to Delacato's assumptions. He declared that the most frequently considered objections included the following: (1) there was a lack of evidence from comparative neurology supporting the recapitulation theory; (2) there was a lack of evidence that omission of a phase like crawling led to later reading handicaps; (3) there was only the utilization of simple case reports as proof of his theory; (4) there were involved only cases which were complex ones from his clinic, most involving brain damage; (5) there was a lack of evidence supporting his premise that early motor development was predictive of later

⁵⁷ Sister St. Francis Campbell, "Neurological Approach to Reading Problems", in Catholic Educational Review, Vol. 63, No. 1, January 1965, p. 28-34.

⁵⁸ F. Theodore Perkins, "Problems Arising from Assertions or Assumptions of Delacato", in Claremont Reading Conference Yearbook, Vol. 28, 1964, p. 119-131.

intellectual development; and (6) there was a neglect of any question of motivational factors.

Bergquam,⁵⁹ in 1962, agreed with the cerebral hemispheric dominance assertions. She noted that when there was mixed dominance of the right and left cerebral hemisphere, sometimes expressed as a lack of control by the dominant hemisphere, neural confusion resulted. She estimated that from ten to fifteen per cent of children are handicapped in varying degrees by these conflicts.

Despite its broad acceptance, this generalization which postulated an exclusive representation of language in one or the other hemisphere is received with grave reservations by many students.

In a report to the Claremont Reading Conference, Jones⁶⁰ indicated that neurologists lately appeared to believe that it was inaccurate to try to pinpoint precise areas of the brain as being entirely responsible for specific performances. Subsequent to a survey of research, he posed the question whether the measure of peripheral dominance, hand, eye or foot, was a valid measure of cerebral or neurological dominance.

⁵⁹ Hazel Bergquam, "Neural Confusion and Academic Failure", in Education, Vol. 81, No. 6, February 1962, p. 363.

⁶⁰ A.W. Jones, "Issues in Beginning Reading", in Claremont Reading Conference Yearbook, Vol. 28, 1964, p. 109.

The quandry of cerebral hemispheric dominance versus peripheral dominance appears to be a reasonable one based on the ambivalence noted in the related research.

Fink,⁶¹ as early as 1938, indicated that ocular dominance seemed to be a centrally located process rather than a peripheral one as it is related to vision, refraction, habits, and other factors.

Belmont and Birch⁶² carefully and extensively examined 148 normal elementary school children in Aberdeen, Scotland, for eyedness and handedness. They concluded that it was far more likely that a developmental lag in lateralization and an evidence of reading disability were independent manifestations of a more general underlying disturbance in neurological organization and were not etiologically related to one another.

Gesell and Ames⁶³ making a careful short-interval documentation of normal infants, preschool children, and elementary school children disclosed that handedness, a peripheral trait, was an extremely complex characteristic and was inextricably bound up with the total action system

⁶¹ Fink, "The Dominant Eye: Its Clinical Significance", p. 555-582.

⁶² Belmont and Birch, "Lateral Dominance and Right-Left Awareness in Normal Children", p. 257-270.

⁶³ Arnold Gesell and Louise B. Ames, "The Development of Handedness", in Journal of Genetic Psychology, Vol. 70, Second Half, June 1947, p. 155-175.

of the child. They approached their problem from the standpoint of ontogenetic patterning and organization.

There were other studies supporting the premise that manual dominance and ocular dominance were in some way intimately dependent upon right or left cerebral hemispheric dominance.

Sister St. Francis⁶⁴ concluded that the whole human organism operated as a single unit physiologically, psychologically and intellectually. She supported the view that peripheral activity and peripheral modalities, vision and dexterity, were meaningless in remediation if the total neurological organization was defective.

In a study of the dominance characteristics of seven hundred clinical stuttering patients in 1935, Bryng Bryngelson⁶⁵ stated that our prime concern should be that of neurological sidedness, and that eyedness, footedness, and handedness were, in turn, indications of the laterality of the nervous organization. His conclusions were based on what appeared to be a questionable method of determining handedness.

⁶⁴ Sister St. Francis Campbell, "Neurological Approach to Reading Problems", p. 28-34.

⁶⁵ Bryngelson, "Sidedness as an Etiological Factor in Stuttering", p. 204-219.

This view, however, was supported in a study by Crider⁶⁶ in which he presented data indicating that eye dominance, in terms of unilateral sighting performance, was related to hemispheric dominance.

Several studies presented the notion that peripheral dominance was the prime determinant, cerebral dominance being of secondary consideration.

Witty and Kopel,⁶⁷ in a statistical investigation using one hundred subjects in grades three through six, presented evidence indicating that cerebral hemispheric dominance was a secondary characteristic and that the primary characteristic was ocular and manual dominance.

In a critical study of a case of aphasia, Leavell et al.⁶⁸ gave evidence which supported the view that cerebral dominance was related to the side most used and was therefore more likely an effect than a cause.

Smith,⁶⁹ after a careful clinical examination of twenty-one epileptics, who had surgery on one side of the

⁶⁶ Blake Crider, "Certain Visual Functions in Relation to Reading Disabilities", in Elementary School Journal, Vol. 35, No. 4, December 1934, p. 295-297.

⁶⁷ Witty and Kopel, "Sinistral and Mixed Manual-Ocular Behavior in Reading Disability", p. 119-134.

⁶⁸ Leavell et al., "Critical Study of a Case of Aphasia", p. 1178-1181.

⁶⁹ Smith, "The Role of the Commissural System of the Cerebral Cortex in the Determination of Handedness, Eyedness, and Footedness in Man", p. 39-79.

brain to restrict convulsive seizures, suggested if any kind of cortical or cerebral dominance existed at all it had very little significance in determining sidedness.

In a study of the electroencephalographic patterns of children with reading difficulties, Kennard et al.⁷⁰ found the subjects had no more tendency toward abnormal patterns than did children without reading difficulty.

There exists a very unusual and extremely relevant consideration referred to obliquely in several studies and examined critically in none. It has been suggested that studies of hand and eye dominance were based on faulty anatomical evidence.

The first mention of this ocular anatomical consideration appeared in an unpublished doctoral thesis written by Blake Crider.⁷¹ He pointed to a factor, accepted by many, which was often neglected in considering dominance. The nerve paths from the hands and feet to the brain completely cross, so that the cortical center for each side lies in the opposite side of the brain. The nerve fibers for the eyes are not thought to follow this pattern. The nerve fibers

⁷⁰ Kennard et al., "The Abnormal Electroencephalogram as Related to Reading Disability in Children with Disorders of Behavior", p. 330-333.

⁷¹ Blake Crider, Ocular Dominance: Its Nature, Measurement, and Development, unpublished doctoral thesis, Department of Psychology, Western Reserve University, 1934, ix-187 p.

from the nasal side decussate at the optic chiasma and terminate in the opposite hemisphere, while the nerve fibers from the temporal side remain on the same side with no decussation. See Appendix 4.

Moreover, he found that in right-handed persons the right side of the retinas were more sensitive than the left. Since the fibers of the right side of the retinas end in the right hemisphere, if it were dominant the individual would be left-handed. So for neurological expediency, one should be right-handed and left-eyed or vice versa. In actuality, the low correlation between the two types of dominance substantiated this theory.

Warren and Clark⁷² expressed it differently. They stated that the functioning of each eye was controlled by both cerebral hemispheres. The left half of each retina was represented in the left hemisphere and the right half in the right hemisphere. Since the functioning of either eye as a whole was dependent upon both cerebral hemispheres, such functioning could not be an indication of dominance of either hemisphere.

⁷² Warren and Clark, "A Consideration of the Use of the Term Ocular Dominance", p. 298-304.

This very relevant and neglected anatomical consideration was also referred to in a study by Kravitz⁷³ in 1948, by Robinson⁷⁴ in 1953, and Schubert⁷⁵ in 1957.

More evidence to support this anatomical consideration is urgently needed for, if true, eye dominance does not exist in the manner in which most reading investigators have assumed, nor is it related to hand dominance or cerebral dominance. It would account for the fact that most studies of these factors as conducted by reading technicians have had meaningless or confusing results.

There is in the vast research in the realm of dominance little evidence of a relationship between visual acuity and ocular dominance.

Crider⁷⁶ referred to this lack of relationship as early as 1928. He checked more than one thousand subjects

73 Daniel Kravitz, "Visual-Field Interpretations in Chiasmal Lesions", in American Journal of Ophthalmology, Vol. 31, No. 4, April 1948, p. 415-426.

74 Helen M. Robinson, Corrective Reading in Classroom and Clinic, Chicago, University of Chicago Press, 1953, proceedings of the Annual Conference on Reading, Vol. 15, No. 79, December 1953, p. 49-79.

75 Delwyn G. Schubert, The Doctor Eyes the Poor Reader, Springfield, Charles C. Thomas, 1957, xv-101 p.

76 Blake Crider, "A Battery of Tests for the Dominant Eye", in Journal of General Psychology, Vol. 31, December 1928, p. 629-632.

for visual acuity and the dominant eye, only to find that visual acuity was unrelated to eye dominance.

Gahagan⁷⁷ determined the ocular dominance both at near-point and far-point fixation as well as the visual acuity of one hundred undergraduate university students. He concluded that dominance and acuity were independent phenomena. Superior visual acuity of a given eye was not indicative of a corresponding dominance of that eye.

Helen Robinson⁷⁸ revealed that eye preference appeared to be a unique characteristic, probably not related to other aspects of vision. This was based on an evaluation of 162 grade one, grade four, and grade five subjects.

Crider,⁷⁹ in 1935, in a study of 229 elementary school students all having eye muscle insufficiency and of twenty-eight students exhibiting squint, did find that, in all but two outstanding exceptions, the eye with the muscle insufficiency failed to be the sighting or dominant eye. He proposed this as a valuable method for determining eye dominance.

⁷⁷ Lawrence Gahagan, "Visual Dominance-Acuity Relationships", in Journal of General Psychology, Vol. 9, No. 2, October 1933, p. 455-459.

⁷⁸ Helen Robinson and Charles B. Haelsman, Jr., "Visual Efficiency and Progress in Learning to Read", in Clinical Studies in Reading II, Chicago, University of Chicago Press, No. 77, January 1953, p. 31-63.

⁷⁹ Blake Crider, "The Relationship of Eye Muscle Balance to the Sighting Eye", in Journal of Experimental Psychology, Vol. 18, No. 1, February 1935, p. 152-154.

Among the research relating vision to reading success, there exists a study by Swanson and Tiffin⁸⁰ of 267 freshmen at the Reading Clinic at the University of Iowa. Their evidence made it seem most improbable that differences in visual efficiency were causally related to differences in reading ability among college students. Far-point and near-point fusion, lateral muscle imbalance, vertical muscle imbalance, stereopsis level, visual acuity, and ametropia were not significantly different between poor and good readers.

This conclusion was also offered by Gates and Bond⁸¹ who examined sixty-five retarded readers and an equal number of unselected subjects.

However, Blake and Dearborn,⁸² using college students as subjects, found a higher proportion of far-sightedness among those having difficulty in reading and a higher proportion of near-sighted astigmatism among good readers.

⁸⁰ D.E. Swanson and J. Tiffin, "Bett's Physiologic Approach to the Analysis of Reading Disabilities as Applied to the College Level", in Journal of Educational Research, Vol. 29, No. 6, February 1936, p. 433-448.

⁸¹ Arthur I. Gates and Guy L. Bond, "Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading", in Journal of Educational Psychology, Vol. 27, No. 6, September 1936, p. 450-456.

⁸² Maybelle B. Blake and Walter F. Dearborn, "The Improvement of Reading Habits", in Journal of Higher Education, Vol. 6, February 1935, p. 83-88.

In a study by Eames,⁸³ of 114 reading disability cases at the Harvard Psycho-Educational Clinic and of 143 unselected school children, the principal fact presented was that, in reading disability, the eyes were more exophoric at the reading distance. It was also revealed that hypermetropia was more common among disabled readers. The difference was highly reliable statistically and was regarded as being very significant.

Farris⁸⁴ evaluated the visual mechanisms of 304 seventh-grade pupils and disclosed that the group exhibiting less than normal progress in reading was associated with both hyperopia and strabismus, while myopia and myopic astigmatism were associated with more than normal progress in reading. Types of eye defects other than the myopic, hyperopic, and strabismic types were found to have little effect upon progress in reading.

Of 298 children tested at the Reading Center at Michigan State University with the Vision Tester, Ball⁸⁵

⁸³ T.H. Eames, "A Comparison of the Ocular Characteristics of Unselected and Reading Disability Groups", in Journal of Educational Research, Vol. 25, No. 3, March 1932, p. 211-215.

⁸⁴ L.P. Farris, "Visual Defects as Factors Influencing Achievement in Reading", in California Journal of Secondary Education, Vol. 10, No. 1, October 1934, p. 50-51.

⁸⁵ R.J. Ball, "Visual Functioning in Reading Disability", in Education, Vol. 82, No. 3, November 1961, p. 175-178.

reported that 40.3 per cent failed. Because the Vision Tester was an instrument capable of checking only grossly a small percentage of the potential sources of reading disability, he felt that the true percentage would almost certainly be much higher than the already alarming 40.3 per cent.

Sister Bernetta Zietz⁸⁶ in an attempt to relate vision and reading, suggested that although studies using various methods with different populations have not shown complete agreement, they did indicate that hyperopia, binocular incoordination, hyperopic astigmatism and aniseikonia may be detrimental in learning to read.

Opposing these studies relating certain visual aberrations to reading disabilities, Stromberg,⁸⁷ in 1938, related his study of a group of 142 fast and slow readers selected from among twelve hundred University of Minnesota students. Optometrical measurements of acuity, ametropia, fusion and stereopsis were found unrelated to reading efficiency as measured by the Chapman-Cook Speed Reading Test.

Dearborn⁸⁸ reported on two hundred cases at the Harvard Psycho-Educational Clinic of which seventy-six were

⁸⁶ Sister M. Bernetta Zietz, "Relation of Vision and Reading", in Education, Vol. 81, No. 1, September 1960, p. 45-47

⁸⁷ Elroy L. Stromberg, "The Relationship of Measures of Visual Acuity and Ametropia to Reading Speed", in Journal of Applied Psychology, Vol. 22, No. 6, December 1938, p. 70-78.

⁸⁸ Dearborn, "The Nature and Causation of Disabilities in Reading", p. 103-110.

severely retarded in reading. He concluded that visual acuity, eye movement, and muscular imbalance have been over-emphasized causes of reading deficiency.

Refractive error appeared to have little influence on the reading achievement of fifty-seven pupils doing passing work in an investigation by Eames,⁸⁹ while hypermetropia did contribute to some retardation among sixty-four reading failures. He found that myopia contributed to some additional retardation among the reading failures but to a lesser extent. When the comparatively small sample was subdivided into the various conditions studied, the subgroups were correspondingly reduced, thus affording concern for the validity of the conclusions.

Goldberg⁹⁰ in his study of one hundred students with a reading disability concluded that refractive errors and muscle imbalance played only a small part in the problem reader, but the effort to overcome such a weakness and to see binocularly might cause fatigue and discourage reading. These defects could result in the slow reader, but would have little to do with the retarded reader.

⁸⁹ Thomas H. Eames, "The Influence of Hypermetropia and Myopia on Reading Achievement", in American Journal of Ophthalmology, Vol. 39, No. 3, March 1955, p. 375-376.

⁹⁰ Herman K. Goldberg, "The Ophthalmologist Looks at the Reading Problem", in The American Journal of Ophthalmology, Vol. 47, No. 1, January 1959, p. 67-74.

A similar finding was noted by Shearer⁹¹ who screened 2,177 elementary students and selected 220 who were one year or more retarded in reading to be further evaluated with the Keystone Telebinocular. He related that visual acuity, heterotropias, and myopia have no relationship to reading ability. He expressed the belief that visual problems were not causative factors in reading disability.

There are, however, investigators who claim that there exists a variance in the effectiveness of the retinal halves or fields of each eye.

Grosland,⁹² in a study of thirty-four defective readers of normal or higher intelligence compared with thirty-one superior readers, used an original "range of attention tachistoscopic experiment" to conclude that superior readers excelled the defective readers in the left visual field while the inferior readers excelled in the right visual field.

LaGrone,⁹³ in his statistical research of sixty representative college freshmen, disclosed that inferior readers

91 Shearer, "Eye Findings in Children with Reading Difficulties", p. 46-53.

92 H.R. Grosland, "Superior Elementary-School Readers Contrasted with Inferior Readers in Letter-Position, 'Range of Attention' Scores", in Journal of Educational Research, Vol. 32, February 1939, p. 410-427.

93 Cyrus W. LaGrone, Jr., "An Experimental Study of the Relationship of Peripheral Perception to Factors in Reading", in Journal of Experimental Education, Vol. 11, No. 1, September 1942, p. 37-49.

surpassed the superior readers in accuracy of perception in the right peripheral field, while superior readers excelled in the left hemifield. As might be projected from this conclusion, the investigator found accuracy in the left peripheral field correlated with reading ability; accuracy in the right peripheral field resulted in low reading achievement.

The majority of investigations tend to refute the visual field conclusions stated above.

A representative study was one by Leavell and Beck⁹⁴ wherein an examination of thirty-eight male retarded readers referred to the McGuffey Reading Clinic offered evidence of superiority in the left visual field as compared to their scores in the right visual field.

Using the Dodge type tachistoscope, the Snellen Chart, readiness tests, and teacher ratings, Dyer and Harcum⁹⁵ evaluated sixty-six preschool and primary school children with normal vision. His data indicated that although the preschool subjects did not manifest difference of accuracy between the left and right hemifields, the school age children

⁹⁴ Ullin W. Leavell and Harry S. Beck, "Ability of Retarded Readers to Recognize Symbols in Association with Lateral Dominance", in Peabody Journal of Education, Vol. 37, No. 1, July 1959, p. 7-14.

⁹⁵ D.W. Dyer and E.R. Harcum, "Visual Perception of Binary Patterns by Pre-School Children and by School Children", in Journal of Educational Psychology, Vol. 52, No. 3, June 1961, p. 161-165.

made fewer errors in reproducing stimuli in the right visual field rather than the left. These investigators observed that this developmental change appeared to have been the result of instruction in reading rather than maturation.

According to Forrest,⁹⁶ the stimulation of the retina did not cause a picture to be projected to the brain. It did, however, trigger electrical impulses to the integrative centers of the brain where they were decoded, stored, coordinated with past experiences, integrated with the incoming impulses from all sense organs, monitored by feedback controls, and where undesirable impulses were suppressed.

3. Lateral Dominance and Reading Achievement.

Of all the peripheral characteristics of lateral dominance, handedness has enjoyed the greatest attention and by its readily observable nature, knowledge of this facet of laterality extends back into antiquity.

It is well known that the civilized people of this world are predominately right-handed. It was thought possible, though, that predominant right-handedness was a product of the activities of civilization and the enculturing process.

⁹⁶ E.B. Forrest, "Vision and the Vision Process", in Education, Vol. 82, No. 5, January 1962, p. 299-301.

With this question in mind, Delacato⁹⁷ examined photographs of aborigines engaged in using a single arm for one purpose or another and attempted to determine their handedness. He found from his limited observation that present-day aborigines throughout the world are right-handed and concluded that predominant right-handedness is universal and not necessarily a product of civilization.

As far back as the most recent ice age, 18,000 B.C., there were indications that man was in the main right-handed. A study of handprints found in many caves revealed that the left hand was placed against the wall and its outline traced with the right hand.⁹⁸

An investigation by Professor Dart⁹⁹ of forty-two skulls of baboons used as food by the ancient Australopithecus disclosed that forty were crushed on the left side, indicating that this ancient man was right-handed.

An examination of history to the time of the early Greeks and Romans offered proof of predominant right-handedness. Sculptors' models held the discus, shot the bow, or balanced the javelin with their right hands; warriors

⁹⁷ Delacato, The Diagnosis and Treatment of Speech and Reading Problems, p. 41.

⁹⁸ Ibid., p. 43.

⁹⁹ Raymond A. Dart and Dennis Craig, Adventures with the Missing Link, New York, Harper and Bros., 1959, p. 106.

carried their shields on their left arms and their spears in their right hands; and finally statesmen could not have gestured with their left arm when their togas were properly draped.

Further evidence was given by a classical archaeologist who stated that the word "sinister", or left, had already come to mean awkward in the classical period. During medieval days left-handers were considered potential court jesters.¹⁰⁰ The word "gauche" meant left-handed.

Today we are more accepting of left-handedness, and schools no longer force all children to be right-handed. Delacato¹⁰¹ reported that today fifteen per cent of the population, as compared with five to eight per cent in 1920, were left-handed.

Cuff,¹⁰² in 1931, examined 237 children in grades one through eight and 109 college students for handedness by administering nine tests, including throwing, batting, sweeping, reaching, receiving and writing. He concluded that twenty to thirty per cent were natively right-handed and that there appeared to be a slightly greater dominance of this

¹⁰⁰ Delacato, The Treatment and Prevention of Reading Problems, p. 54.

¹⁰¹ -----, The Diagnosis and Treatment of Speech and Reading Problems, p. 54.

¹⁰² H.B. Cuff, "Study of Eyedness and Handedness", in Journal of Experimental Psychology, Vol. 14, No. 2, April 1931, p. 164-175.

hand in the higher elementary grades than in the lower. This observation must be accepted with reservation, based on the assumption that his tests of handedness were of a type that was affected by prior experience and culture.

Contrary testimony was offered by Weiser¹⁰³ who, over a five-year period, evaluated handedness and leggedness of hundreds of children who ranged in age from fourteen to eighteen and who were born in twenty-four countries but were living in Israel. He revealed that inborn cases of left-handedness were extremely rare. He further suggested that it was unfortunate that 12.7 per cent of our children, as the author found existed, were allowed to develop this sinistral manual condition.

Benton,¹⁰⁴ in 1965, offered authoritative evidence that pointed to a need to re-examine the concept of manual dominance with particular reference to its nature. He suggested that it appeared to be a continuous variable, with few adults and even fewer children proving to be absolutely right- or left-handed. The category of left-handedness was a most heterogeneous one because an astoundingly large number

103 J. Weiser, "Handedness, Leggedness, Eyedness", in Journal of Experimental Education, Vol. 33, No. 4, Summer 1965, p. 347-350.

104 Arthur L. Benton, "The Problem of Cerebral Dominance", in The Canadian Psychologist, Vol. 6, No. 4, October 1965, p. 332-348.

of self-classified left-handers showed equal or greater preference for use of the right hand in various activities. This was not true of self-classified right-handers. This, the writer feels, was attributable to the fact that while the natural propensity of the right-hander was positively reinforced so that there was every reason for him to become strongly right-handed, the natural inclination of the left-hander was constantly thwarted, either deliberately or simply because of conventional social arrangements. He felt that this might push him toward a state of ambidexterity or "mixed" handedness.

Orton,¹⁰⁵ in 1937, summarized earlier studies and proffered his feeling that the so-called ambidexterous person was usually a native sinistral who had acquired through training a considerable measure of skill in certain right-sided activities.

In a study of the manual dominance of forty-four preschool children in 1948, Hildreth¹⁰⁶ found that there did not exist two distinct categories of handedness, but that handedness existed as a matter of degree. She purported that

¹⁰⁵ Samuel T. Orton, Reading, Writing, Speech Problems in Children, New York, W.W. Norton and Co., Inc., 1937, vii-215 p.

¹⁰⁶ Gertrude Hildreth, "Manual Dominance in Nursery School Children", in Journal of Genetic Psychology, Vol. 72, First Half, March 1948, p. 29-45.

since a right-handed bias prevailed everywhere in our civilization most children became right-handed, and that handedness was a developmental trait which emerged as an effect of social conditioning.

In agreement with this proposal were Koch et al.¹⁰⁷ who investigated the hand preference of 201 undergraduate college students. Their data indicated that hand preference was a trait influenced by many factors, among which were probably instruction, example, convenience, obviousness of choice, previous habits, specific nature and familiarity of the tasks to be performed, hand strength and genetic factors.

The idea that the preferred foot was a more reliable measure of laterality than the preferred hand was expressed by Robinson¹⁰⁸ in 1946. She felt that less social pressure was involved in the ontogeny of footedness.

In a more recent evaluation of 561 second and fourth graders, Harris,¹⁰⁹ utilizing his exhaustive tests of manual preference, discovered marked changes in handedness with increasing age in both a reading disability group and a control group. He uncovered a marked decrease in mixed ratings

¹⁰⁷ H.L. Koch et al., "A Study of the Nature, Measurement, and Determination of Hand Preference", in Genetic Psychology Monographs, Vol. 13, No. 2, 1933, p. 117-218.

¹⁰⁸ Robinson, Why Pupils Fail in Reading, p. 39-47.

¹⁰⁹ Harris, "Lateral Dominance, Directional Confusion, and Reading Disability", p. 283-294.

and an increase in right-hand ratings in both groups, although a clear preference for one hand developed more slowly in a significantly larger percentage of reading disability cases than in unselected children.

Gesell and Ames¹¹⁰ clinically investigated cases at different age levels of from eight weeks to ten years and postulated that handedness was a product of growth. The children tended to remain somewhat ambidextrous until about the age of six and one-half at which time a dominant foot and eye became established. They further concluded that perfect ambidextrality, if it existed at all, would seem to be an abnormality because attentive adjustments required an asymmetric focalization of motor set. Accordingly all normal children mature to be left- or right-handed.

Durost¹¹¹ offered the sole contrary report and disclosed that his examination of 1300 school children in metropolitan New York indicated that handedness changes in his subjects, coincidental with chronological age, were found to be relatively slight.

¹¹⁰ Gesell and Ames, "The Development of Handedness", p. 155-175.

¹¹¹ W.N. Durost, "The Development of a Battery of Objective Group Tests of Manual Laterality, with the Results of Their Application to Children", in Genetic Psychology Monographs, Vol. 16, No. 4, October 1934, p. 223-335.

As early as 1908, Gould,¹¹² although confusing acuity with dominance, indicated that the origin of handedness was based on eyedness; i.e., the better eye compelled the hand on the same side to operate with it.

Four years later, a study by Stevens and Ducasse¹¹³ revealed a similar conclusion. It was their feeling that by reason of a marked difference in the space sense of the two retinal halves, those objects in the right half of the field of vision, by appearing larger, attracted the visual attention which in turn led to grasping movements of the right hand. The hand thus favored by earliest experience acquired a special skill which caused it to be used in manual acts requiring the greatest precision.

A similar cause for right-handedness was offered by Parson¹¹⁴ who related that the eye determined native handedness. Some reservation is ascribed to results of this survey because the author determined the handedness of his subjects by question alone.

A considerable number of investigators in the area of manual dominance have found a significant association between left-handedness and a degree of reading inefficiency.

112 Gould, Righthandedness and Lefthandedness, p. 182-194.

113 H.C. Stevens and C.J. Ducasse, "The Retina and Righthandedness", in The Psychological Review, Vol. 19, No. 1, January 1912, p. 1-31.

114 B.S. Parson, Left Handedness: A New Interpretation, New York, Macmillan, 1924, p. 125.

Monroe¹¹⁵ was one such investigator. In her analysis of hand preference of 101 school children to determine the relationship between dextrality and reading difficulty, she disclosed evidence which specified a significantly greater incidence of left-eye preference among reading defect cases. The results of this study further indicated that left-eye preference was associated with fluent mirror-reading, and this, in turn, was associated with reading disability. She also pointed to the obstructive aspect of the nose to the left movement of the right eye and vice versa.

In an evaluation of one hundred children with reading disability, an ophthalmologist, Goldberg,¹¹⁶ discovered a surprisingly high incidence of ambidexterity or left-handedness. In these same retarded readers he noticed the persistence of a normal childhood tendency to reverse letters and symbols.

In a research by Travis and Johnson¹¹⁷ involving ninety-two stutterers, evidence supported a relationship between stuttering and left-handedness in the hereditary background of the immediate families of his subjects. The

115 Monroe, Children Who Cannot Read, xv-205 p.

116 Goldberg, "The Ophthalmologist Looks at the Reading Problem", p. 67-74.

117 Leo E. Travis and Wendell Johnson, "Stuttering and the Concept of Handedness", in Psychological Review, Vol. 14, No. 6, November 1934, p. 534-562.

data also made necessary the conclusion that changes of peripheral handedness occurred significantly more often among stutterers than among normal speakers.

To indicate an essential ambivalence in research related to the relationship of handedness to reaching achievement, a number of investigations are hereafter considered supporting the antithetic position of no relationship.

Haefner,¹¹⁸ in a rather extensive examination of the manual dominance of sixty-eight right- and left-handed groups of intermediate grade children matched in terms of age and sex, identified no significant difference between handedness and achievement or intelligence.

Similar results were obtained by Woody and Phillips¹¹⁹ in an examination of 136 pairs of right- and left-handed pupils matched according to sex, chronological age, mental ability, and reading ability, and with handedness as the only variable. They concluded that handedness, per se, had little or no influence on the type of reading response between the two groups; left-handed pupils reacted to the various reading situations just as right-handed pupils did. A criticism of this study might result from the fact that in selecting

118 R. Haefner, The Educational Significance of Left Handedness, New York, Bureau of Publications, Teachers College, Columbia, 1929, 84 p.

119 Clifford Woody and Albert J. Phillips, "The Effects of Handedness on Reversals in Reading", in Journal of Educational Research, Vol. 27, No. 9, May 1934, p. 651-662.

subjects, only pure handedness was considered, avoiding those children in which neither the right nor the left hand was dominant.

Conclusions drawn from a scrutiny of two hundred high school seniors and college students, classified as left-handed, ambidextrous, and shifted, revealed that none of these traits was accompanied by any significant inferiority on the Minnesota Reading Examination.¹²⁰ Pace did identify a relationship between these traits and some inferiority on the Minnesota Speed of Reading Test.

Schonell¹²¹ carefully examined complete case studies of 104 backward readers whose I.Q.'s were in the main over eighty-five and whose reading ability was at least one and one-half years below mental age, and presented the inference that left-handedness, per se, was not a cause of reading disability but could be a possible contributing factor.

In an evaluation of 232 seventh-grade pupils in which there existed no control for intelligence and in which handedness was checked through the cooperation of the classroom

¹²⁰ Robert C. Pace, "Handedness and Reading Ability in High School and College Students", in Journal of Educational Research, Vol. 31, No. 3, November 1937, p. 205-210.

¹²¹ Fred J. Schonell, "The Relationship of Reading Disability to Handedness and Certain Ocular Factors", in British Journal of Educational Psychology, Vol. 10, November 1940, p. 227-234; and Vol. 11, February 1941, p. 20-27.

teachers, Jones¹²² presented data which suggested no significant difference in reading deficiency between clearly left- and clearly right-handed children.

Groff,^{123,124} in 1962, concluded that generally there was not a substantial relationship between handedness and reading achievement among left- and right-handed students in the total population of grades four, five and six in two suburban school districts in southern California.

In a recent study by Balow,¹²⁵ it was found that the hand dominance of 302 first-grade children did not seem to be related to reading achievement. The children with mixed-hand dominance, as a group, scored as high as the children with consistent hand dominance on each measure of reading achievement. From this he drew the conclusion that lateral dominance screening of children at the beginning of the first grade did not provide the teacher with information which would aid her in identifying children likely to have difficulty in learning to read.

122 Mary M. Wilcox Jones, "Relationship Between Reading Deficiencies and Left-Handedness", in School and Society, Vol. 60, No. 1554, October 7, 1944, p. 238-239.

123 P.J. Groff, "Study of Handedness and Reading Achievement", in Reading Teacher, Vol. 16, No. 1, September 1962, p. 31-34.

124 -----, "Spelling and Language Achievement of Left-Handed Children", in Elementary English, Vol. 39, No. 5, May 1962, p. 466-469.

125 Irving H. Balow, "Lateral Dominance Characteristics and Reading Achievement in the First Grade", in Journal of Psychology, Vol. 55, No. 2, April 1963, p. 323-328.

In considering the above reported research it appeared that the majority of research, both in terms of recency and exhaustive use of public school samples, supported the contention that, in general, there was little or no relationship between the various traits of handedness and reading retardation.

A second facet of peripheral dominance often associated with learning problems was ocular preference.

Ocular dominance was not found mentioned prior to 1593, when Giovanni Battista della Porta apparently was the first to refer to this phenomenon in his work, De refractione.¹²⁶ Following this, few references appeared in the literature until 1861, when Humphrey discussed the correspondence of function between hand and eye and advanced the theory that eyedness was a cause of handedness.¹²⁷ This ocular dominance theory of handedness became a subject of considerable controversy with the result that most studies of eyedness have been incidental to handedness.

It was only in this century that any systematic study was given to ocular dominance. Its influence and educational significance was not generally recognized because it was much less observable than manual dominance.

¹²⁶ Fink, "The Dominant Eye: Its Clinical Significance", p. 555-582.

¹²⁷ Ibid., p. 558.

Updegraff,¹²⁸ in 1932, found that ocular dominance, as measured by the Miles A-B-C Test, was not established before the age of three and thereafter it was commonly found.

This same researcher one year later investigated the ocular dominance of seventy-four children ranging in age from two to six attending preschool labs of the Iowa Child Welfare Research Station.¹²⁹ She found that a right-eyed child was more apt to be right-handed than a left-eyed child was to be left-handed. This finding tended to support the premise that ocular dominance might well play an etiological role in hand preference.

Robinson,¹³⁰ evaluating the eye preference of seventy-five fourth, fifth and sixth graders on five tests, stated that seventy per cent preferred the right, and twenty per cent the left eye.

Coons and Mathias¹³¹ in an early study of 112 high school subjects using the Snyder Test of Eye Preference

¹²⁸ Ruth Updegraff, "Ocular Dominance in Young Children", in Psychological Bulletin, Vol. 29, No. 9, November 1932, p. 654.

¹²⁹ -----, "The Correspondence between Handedness and Eyedness in Young Children", in Journal of Genetic Psychology, Vol. 42, No. 2, June 1933, p. 490-492.

¹³⁰ Helen M. Robinson, "Visual Efficiency and Reading", in Clinical Studies in Reading I, Chicago, University of Chicago Press, No. 68, June 1949, p. 90-112.

¹³¹ J.C. Coons and R.J. Mathias, "Eye and Hand Preference Tendencies", in Pedagogical Seminary and Journal of Genetic Psychology, Vol. 35, December 1928, p. 629-632.

disclosed that with an increase in age the tendency was to greater amblocularity.

Snyder and Snyder¹³² in examining 410 normal high school students also found that amblocular tendencies seemed to increase, and monocular tendencies seemed to decrease, with age. Their findings supported the premise that eye preference was not necessarily caused by the superiority or inferiority of one eye.

The literature considering ocular dominance and its relationship to reading was very divergent. One major point of view regarding this relationship was the result of the work of those who believed that left-eye dominance or a lack of dominance were conditions associated with reading disability.

In his testing of one hundred cases exhibiting extreme difficulty in learning to read, Dearborn¹³³ noticed a preponderance of left-eyedness as well as a lack of ocular dominance. He stated that, while the dextral sequence of eye movement was kinesthetically the essence of reading, left-eyed children might tend to move sinistrally and

¹³² A. Snyder and M. Snyder, "Eye Preference Tendencies", in Journal of Educational Psychology, Vol. 19, No. 6, September 1928, p. 431-433.

¹³³ Walter F. Dearborn, "Ocular and Manual Dominance in Dyslexia", in Psychological Bulletin, Vol. 28, No. 9, November 1931, p. 704.

therefore exhibit uncertainty about the correct ordering or sequence of letters or word forms.

Stromberg¹³⁴ in a rather poorly documented study suggested that there was fundamentally, in most of his defective reader subjects, a condition of left eye dominance.

Thirty-four defective readers of normal or high intelligence who ranked in the lowest quartile in reading ability, and thirty-one superior readers, all ten years or more in age, were studied by Crosland.¹³⁵ He revealed that tests of eye dominance disclosed a majority of defective readers were left-eyed and a larger majority of superior readers were right-eyed. It was inferred that left-eye dominance had some kinship with defective reading, although it appeared to Crosland that there were other causative factors leading to poor skill in reading.

Discrepant to the above finding, Imus et al.,¹³⁶ in a report of a comprehensive visual survey of 636 college freshmen in 1936, revealed that ocular dominance was only a minor factor in reading inefficiency.

¹³⁴ E.L. Stromberg, "Monocular and Binocular Letter-Position Scores of Defective Readers in 'Range of Attention' Experiment", in Psychological Bulletin, Vol. 31, No. 8, October 1934, p. 589.

¹³⁵ Crosland, "Superior Elementary-School Readers Contrasted with Inferior Readers in Letter-Position, 'Range of Attention' Scores", p. 410-427.

¹³⁶ Henry A. Imus, John W.M. Rothney and Robert M. Bear, An Evaluation of Visual Factors in Reading, New Hampshire, Dartmouth College Publications, 1938, 144 p.

Spache,¹³⁷ in an intriguing conclusion, stated that when there was a definite eye preference, there was a marked difference in the reading ability of separate eyes in about three of four cases. Using a small sample of forty-four subjects, he found that when there was a marked preference for one eye, the best reading was done with this eye, the next best with the opposite eye, and the poorest with both eyes.

The conclusion of the above study departed very abruptly from the majority of the related research and might be contested or impeached in light of its few subjects.

Eye dominance has been offered above and hereafter follows the extensive research related to mixed and crossed lateral dominance.

In reviewing the research in this area, it was difficult to discover a pattern or to account for the wide ambiguity of the findings.

Dearborn,¹³⁸ in an address delivered before the Harvard Teacher's Association in Cambridge in 1930, and based on an extensively and authoritatively prepared case study, generalized that, in order to avoid difficulties in reading

¹³⁷ George Spache, "One-Eyed and Two-Eyed Reading", in Journal of Educational Research, Vol. 37, No. 8, April 1944, p. 616-618.

¹³⁸ Dearborn, "The Nature of Special Abilities and Disabilities", p. 632-636.

and writing, one should be either left-handed and left-eyed or right-handed and right-eyed, preferably the latter. He suggested that difficulties appeared especially in children who have "changed over" in handedness or whose "one-sidedness" has never been well established.

This same investigator co-authored with Blake¹³⁹ a study of diagnosis and treatment of reading habits among 477 freshmen attending Smith College. They summarized that right-handed and left-eyed individuals stood a greater chance of being handicapped in reading than those who were right-handed and right-eyed. It was interesting to note that, although the above generally was true, the authors found that a few of the best readers appeared to have crossed dominance or sinistral tendencies.

Teegarden¹⁴⁰ used as her sample some fifty children who were scattered throughout the range of 258 students entering first grade. Handedness was determined by having the children respond to a maze problem as well as loading a "Bizzy Andy, Jr." with marbles. Eye dominance was tested with a manoptoscope. Her data revealed that consistent right dominance or left dominance, or ambidexterity with use of the right eye or left eye, were the conditions of lateral

¹³⁹ Blake and Dearborn, "The Improvement of Reading Habits", p. 83-88.

¹⁴⁰ Teegarden, "Clinical Investigation of the Prospective Non-reader", p. 346-358.

dominance most favorable to success in reading. This confirmed Dearborn's premise noted above.

Two years later Eames,¹⁴¹ in his evaluation of one hundred reading disability cases and a control group of one hundred unselected school children of approximately equal age and time spent in school, found that there existed nineteen per cent more mixed dominance among the poor readers. The difference, though not preponderant, implied that lateral dominance anomalies might be one of the etiological factors in poor reading.

Monroe¹⁴² analyzed the hand and eye preference of 415 reading defectives and a control group of 101 school children. She disclosed that there existed significantly greater right-hand left-eye dominance among the retarded readers. Further, she postulated that opposite hand and eye dominance might be an impediment in the coordination of directional responses resulting in diverse directional preferences. However, it must be noted that the defective group differed from the control group in respects other than reading; i.e., 215 subjects in the experimental group had problems other than reading and a median I.Q. of 90.4, 155 had been referred

¹⁴¹ Eames, "The Anatomical Basis of Lateral Dominance Anomalies", p. 524-528.

¹⁴² Marion Monroe, Children Who Cannot Read, Chicago, The University of Chicago Press, 1932, xv-205 p.

by parents or teachers and had a median I.Q. of 100.9, the remaining forty-five were special school pupils with a median I.Q. of 77.4.

Also related to this rationale was a piece of research by Bryngelson¹⁴³ using seven hundred clinical stuttering patients in an effort to relate lateral dominance to this speech anomaly. He declared that a lack of one-sidedness was a very serious condition, based on his belief that reading and speaking had unilateral lead representation and any factor which operated against this tended to interfere with the normal establishment and development of these two functions.

Five years later this same researcher published another article using similarly handicapped subjects.¹⁴⁴ In comparing matched groups of seventy-seven stutterers and non-stutterers, he presented data indicating that only nineteen per cent of the stutterers were unilaterally dominant while fifty-one per cent of the control group exhibited unilaterality.

¹⁴³ Bryngelson, "Sidedness as an Etiological Factor in Stuttering", p. 204-217.

¹⁴⁴ -----, "A Study of Laterality of Stutterers and Normal Speakers", in Journal of Social Psychology, Vol. 2, February 1940, p. 151-155.

Robinson,¹⁴⁵ in 1937, published a relevant article in which she reviewed the literature prior to this time and stated her view that many investigators felt complications presented themselves when hand and eye dominance were not of the same order. Although lacking statistical evidence, she concluded that when a child exhibited these discrepant tendencies, he was likely to become confused in following reading material.

In this same year a study of two sets of twins, each set having one unilateral and one crossed-dominant member, appeared.¹⁴⁶ Jenkins et al. in their evaluation of these subjects referred to the Institute of Juvenile Research in Chicago, declared that mixed dominance, although not an overshadowing cause of reading disability, might present something of an obstacle.

In a more documented, statistical evaluation of 160 children referred to the Yale Clinic of Child Development because of individual adjustment problems and a control group of seventy-three cases referred for commitment to state care as dependent or neglected children, Castner¹⁴⁷ revealed that,

¹⁴⁵ Helen M. Robinson, "The Study of Disability in Reading", in Elementary School Journal, Vol. 38, No. 1, September 1937, p. 15-28.

¹⁴⁶ D.L. Jenkins, et al., "Mixed Dominance and Reading Disability", in American Journal of Orthopsychiatry, Vol. 7, No. 1, January 1937, p. 72-81.

¹⁴⁷ Burton M. Castner, "Handedness and Eyedness of Children Referred to Guidance Clinic", in The Psychological Record, Vol. 3, June 1939, p. 99-112.

at all levels, the sinistral and impartial-eyed types were relatively more frequent among the problem cases than among the controls. The atypicality of these subjects restricted and limited the degree to which one might generalize from this study.

A study of 104 backward readers was completed in 1941 by Schonell.¹⁴⁸ Data was derived from complete case studies including information on intelligence, and scholastic, emotional, physical, and environmental characteristics as well as the results of five reading tests and an analyzation of visual perception. He presented evidence that the disability of a few backward readers was in part due to mixed eyedness and handedness, particularly a condition of left-handedness with right-eyedness.

A very thorough investigation appeared several years later, conducted by Leavell and Fults,¹⁴⁹ in which the subjects were 192 of twenty-five hundred used by Brown in a related study of the measurement of lateral dominance. The writers equated sixteen groups of the subjects in grades two, four, and seven in terms of eye, hand, and foot dominance.

¹⁴⁸ Schonell, "The Relationship of Reading Disability to Handedness and Certain Ocular Factors", 1940, p. 227-234; 1941, p. 20-27.

¹⁴⁹ Ullin W. Leavell and Florence Chism Fults, "Dominance and Displacement of Visual Imagery in Relation to Reading Achievement", in Peabody Journal of Education, Vol. 21, No. 2, September 1943, p. 103-108.

These writers concluded that left dominance was less favorable to the acquisition of reading skill than was right dominance, and that crossed was least favorable.

At about this time Hildreth^{150,151} presented a statistical evaluation of data obtained from 101 boys and ninety girls in grades kindergarten through five in which no case of reading disability was attributed to lack of learning capacity. Eye dominance was determined from the use of the Parson Manoptoscope, sighting dot with Parson's Cone, and the peep show test. The author revealed that of the sixteen male cases of reading disability forty-four per cent exhibited mixed hand-eye dominance while fifty per cent of the six girls showed this condition. A total of forty-seven per cent or slightly less than half of the reading disability cases thus showed more tendency to mixed dominance.

In investigation of an atypical sample, having only ten per cent in the lower-middle socio-economic class and none lower, attending the Laboratory School of the University of Chicago, Stevenson¹⁵² identified two outstanding

¹⁵⁰ Gertrude Hildreth, "A School Survey of Eye-Hand Dominance", in Journal of Applied Psychology, Vol. 29, No. 1, February 1945, p. 83-88.

¹⁵¹ -----, "Development and Training of Hand Dominance", in Journal of Genetic Psychology, Vol. 77, First Half, March 1950, p. 39-100.

¹⁵² Lillian P. Stevenson, "Poor Readers in the Lower School of the Laboratory Schools", in Clinical Studies in Reading, I, Chicago, University of Chicago Press, No. 68, June 1949, p. 7-25.

characteristics of her poor readers as being mixed eye-hand preference and personal or emotional problems. Also included, from the data collected from these accelerated achievers having a median Stanford-Binet I.Q. of 130, was the proposal that mixed eye-hand preference might tend to make reading more difficult, especially in the early stages.

In a later study this author, collaborating with Robinson¹⁵³ in a study of all sixty-one children attending the senior kindergartens at the University of Chicago Laboratory School and evidencing the same atypicality mentioned above, disclosed that bright pupils were not handicapped in learning to read, even if their hand and eye preference differed from right consistency. This study was motivated by their earlier revelation that dominance anomalies did disadvantage the poor readers at the early stages of reading.

Wilson and Leavell¹⁵⁴ conducted a study of 749 school-age children and postulated that deficiencies in the language arts manifested themselves significantly in more instances where hand-eye confusions or visual imagery reversals or

¹⁵³ Lillian P. Stevenson and Helen M. Robinson, "Eye-Hand Preference, Reversals, and Reading Progress", in Clinical Studies in Reading II, Chicago, University of Chicago Press, No. 79, January 1953, p. 83-88.

¹⁵⁴ Grace E. Wilson and Ullin W. Leavell, A Study of the Relations of Functional Neurological Dominance to Reading Difficulties in Selected Cases of the McGuffey Reading Clinic, unpublished study, School of Education, University of Virginia, 1954, 159 p.

both were present than was true of cases where such anomalies were not found. They found crossed dominant groups were lowest in both oral and silent reading.

An investigation of eighty children who were average in intelligence but receiving remedial instruction at the Junior League Reading Center of the University of Chattanooga was made by Barbe et al.¹⁵⁵ who presented the finding that, although they discovered a constellation of anomalies in the retarded readers, 32.5 per cent were crossed dominant. They implied a relationship, stating that merely fifteen per cent of the general population were crossed dominant. This might be accepted with reserve realizing that many investigations have disclosed that approximately one-third of the normal population was crossed dominant.

Barger,¹⁵⁶ in his role as school psychologist for the city of New York, presented case studies which suggested that the high incidence of mixed dominance among children exhibiting either verbal or reading aphasia appeared significant. He suggested a functional remediation; i.e., the handedness in a child who had confused dominance should be encouraged to correspond to the dominant eye.

¹⁵⁵ Walter B. Barbe et al., "Factors Contributing to Reading Difficulties", in School and Society, Vol. 85, No. 2117, October 12, 1957, p. 285-286.

¹⁵⁶ William C. Barger, "An Experimental Approach to Aphasia and Non-Reading Children", in American Journal of Orthopsychiatry, Vol. 23, January 1953, p. 158-170.

Harris,¹⁵⁷ in 1961, examined 308 clinical reading disability cases (ninety per cent boys) and 245 unselected public school cases, all of which were in grades two, three, and four. He reported that a high proportion of reading disability children exhibited mixed, not crossed, dominance which, in turn, might lead to directional confusion. He based his determination of handedness on ten simple operations, all of which could be affected by social or cultural experience, and that of eyedness on both monocular and binocular tasks.

In the same year Jansky¹⁵⁷ reported findings from data drawn from a twelve-and-one-half year old dyslexic male referred to the Language Disorder Clinic of the Columbia Presbyterian Medical Center. She noted that laterality was not firmly established, though the child preferred his right hand. Generalizing from this sole atypical case was virtually impossible.

Sixty-two children from the University and Parent Cooperative Preschools at the University of Iowa had their lateral dominance determined by Muehl.¹⁵⁹ She summarized

¹⁵⁷ A.J. Harris, How to Increase Reading Ability, New York, Longman's Green and Co., 1961, p. 249-260.

¹⁵⁸ Jeannette Jansky, "A Case of Severe Dyslexia with Aphasic-like Symptoms", in Reading Teacher, Vol. 15, No. 2, November 1961, p. 110-113.

¹⁵⁹ S. Muehl, "Relation between Word-Recognition Errors and Hand-Eye Preference in Preschool Children", in Journal of Educational Psychology, Vol. 54, December 1963, p. 316-321.

that left-lateral subjects made more left and right recognition errors than the consistently right-lateral subjects, indicating a lag in learning to orient or respond to the total work pattern in the left-lateral subjects.

Jones,¹⁶⁰ drawing from his experience as a remedial reading teacher, stated that, clinically, left-sidedness appeared to cause less trouble than mixed dominance, with the left-eye right-hand dominance being the most troublesome of all. The author declared authoritatively that, in the event that ambiguous dominance did exist, problems with spatial and directional orientation were present in some degree and were reflected in language development. He supported the involvement of trained specialists to assist the preschool child in establishing unilaterality if it did not exist at that time.

A team of medical investigators including two ophthalmologists and a registered nurse studied 250 children referred because of a reading problem and found ninety-three had various conditions of a crossed dominance with the remaining 157 exhibiting incomplete laterality.¹⁶¹ These children, who were of normal intelligence and who had been

¹⁶⁰ Jones, "Issues in Beginning Reading", p. 107-112.

¹⁶¹ Curtis D. Benton, Jr., et al., "Dyslexia and Dominance", in Journal of Pediatric Ophthalmology, Vol. 2, July 1965, p. 53-57.

exposed to good teaching procedures, were very exhaustively and extensively examined by Benton et al. for eyedness, both monocularly and binocularly, through eleven reliable tests. The fact that all 250 subjects were found to have had crossed eye-hand dominance or a greater than normal amount of retinal rivalry, a condition that the investigators interpreted as a lack of proper eye dominance, must be tempered by the consideration that a clinical approach was used with these excessively retarded readers.

This medical team, after directing treatment at overcoming binocular conflict and establishing strong unilaterality of hand and eye, reported that, after a period of from six months to five years, eighty-seven per cent showed improvement.

In reviewing the studies presented heretofore, it appeared that lack of right dominance was most often associated with not only problems of reading, spelling, and speech but also emotional instability and other factors. It certainly was apparent that there existed a tendency among investigators to relate reading disability with crossed dominance, usually of right-hand and left-eye.

Conversely, a substantial number of studies were found available in the literature, nearly equivalent in quantity and quality, which suggested a lack of relationship between reading and laterality.

Bond and Tinker in their review of the literature on dominance and reading presented this view by stating, "the role of lateral dominance in reading disability is a controversial issue. The literature on the subject is extensive and largely equivocal."¹⁶²

In support of a lack of relationship was the study by Fendrich¹⁶³ in which he carefully matched groups of second and third grade public school children, each containing forty-seven boys and seventeen girls. In this carefully controlled investigation the groups differed in reading achievement with the experimental group being retarded at least one-half grade. This author identified no significant difference between the groups in terms of handedness, eyedness, or mixed dominance.

In comparing 316 reading disabled students with 245 unselected public school controls, Harris¹⁶⁴ identified no relationship between reading and either eye or hand dominance although the clinical group exhibited greater mixed-hand dominance at age seven. This writer accounted for the

¹⁶² Gay L. Bond and Miles A. Tinker, Reading Difficulties, Their Diagnosis and Correction, New York, Appleton-Century-Crofts, Inc., 1957, p. 99-103.

¹⁶³ Paul Fendrick, Visual Characteristics of Poor Readers, New York, Bureau of Publications, Teachers College, Columbia University, 1935, 54 p.

¹⁶⁴ Harris, "Lateral Dominance, Directional Confusion, and Reading Disability", p. 283-294.

unusually large number of mixed-handed children, one-fifth of the control group and one-third of the experimental group, by his statement that his tests were sensitive. Fourteen tests of handedness were used, many of which might have been influenced by social pressures.

Anderson¹⁶⁵ offered a carefully done case study of a fifteen year old boy stutterer with spelling disability. She identified no positive relationship between dominance and reversals or reading disability. It was her feeling that, when reading or reversal errors have been found, a diagnosis has often been made on that basis without further study of causative factors.

Witty and Kopel¹⁶⁶ carefully matched two groups of children in grades three, four, five and six as to intelligence, age, and grade placement. The experimental group was at least one semester below the grade level norms while the control group had reading scores equivalent to or above their grade level norms. Although handedness was determined solely by questionnaire, they found no relationship between reading ability and handedness or reading ability and eyedness. Further, they found that right, left, or mixed ocular-manual

165 Rose G. Anderson, "A Note on a Case of Spelling Difficulty", in Journal of Applied Psychology, Vol. 22, No. 6, December 1938, p. 211-214.

166 Witty and Kopel, "Sinistral and Mixed Manual-Ocular Behavior in Reading Disability", p. 119-134.

dominance occurred no more frequently among reading problems than among non-problems.

Very similar results were disclosed by Gates and Bond¹⁶⁷ in the same year. A group of sixty-five retarded readers with a mean age of 8.61 years were matched with a group of normal readers equivalent in age, intelligence, number of years in school, and socio-economic background, and were examined for handedness, eyedness, and visual acuity. The data obtained from groups of first grade pupils, older normal readers, and older reading problems showed no consistent tendency for eye dominance, hand dominance, or any combination of these to be related to reading achievement, word pronunciation, reversal errors, or visual perception. Handedness testing was again of a type affected by social pressures.

In close harmony was the study by Wolfe,¹⁶⁸ whose aim was to compare a group of male retarded readers with a like number of average readers on laterality of function in order to determine a primary or contributing relationship to reading disability. Her subjects were eight and nine year

¹⁶⁷ Gates and Bond, "Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading", p. 450-456.

¹⁶⁸ Lillian S. Wolfe, "Differential Factors in Specific Reading Disability: I. Laterality of Function", in Journal of Genetic Psychology, Vol. 58, First Half, 1941, p. 45-56.

olds, normal in intelligence, and were from unilingual American-born families of middle socio-economic status. She concluded that eye dominance, hand dominance, and hand versus eye dominance were not related in a primary way to reading disability of the degree represented in her subjects.

Johnston most carefully and reliably tested the handedness (with eleven tests) and the eyedness (with ten tests) of better than one hundred public school children nearly thirteen years of age. He revealed that "any observed association between anomalies of lateral dominance and reading disability can be explained on the basis of fluctuation due to the operation of chance factors."¹⁶⁹

Kirk¹⁷⁰ in a study of sixty-one "high grade" mentally defective subjects revealed no significant differences between pure and mixed laterality on the Gray Oral Reading Test.

¹⁶⁹ Philip W. Johnston, The Relation of Certain Anomalies of Vision and Lateral Dominance to Reading Disability, Monograph of the Society for Research in Child Development, Vol. 7, No. 2, Serial No. 32, Washington, Society for Research in Child Development, 1942, p. 34.

¹⁷⁰ S.A. Kirk, "A Study of the Relationship of Ocular and Manual Preferences to Mirror Reading", in Journal of General Psychology, Vol. 44, 1934, p. 192-205.

Current studies by Ihinger^{171,172} investigated the possibilities of differential achievement in reading, arithmetic, and language among 2,446 sinistral, bilateral, mixed lateral, and dextral school children of both sexes. Inasmuch as the writer observed no consistent difference in achievement with laterality classification as a variable, he concluded that lateral preference was not a cogent factor in determining levels of academic achievement.

Leavell and Beck¹⁷³ categorized thirty-eight white male elementary school pupils as to hand-eye dominance and compared them with respect to their ability to identify symbols tachistoscopically presented in the right and left visual fields. The groups were equated as to chronological age, I.Q., and reading quotient. These writers identified no significant difference between the unilateral and the mixed dominance groups, although the inferior readers in both groups were superior in the left visual field.

171 Robert F. Ihinger, "Some Relationships among Laterality Groups at Three Grade Levels of Performance on the California Achievement Tests", in Toward a Professional Identity in School Psychology, Los Angeles, California Association of School Psychologists and Psychometrists, 1963, p. 70-74.

172 -----, "Lateral Dominance and Reading Achievement", in Claremont Reading Conference Yearbook, Vol. 27, 1963, p. 126-129.

173 Leavell and Beck, "Ability of Retarded Readers to Recognize Symbols in Association with Lateral Dominance", p. 7-14.

In 1963, Hillerich¹⁷⁴ reported a four-year study which began with 722 public and parochial school kindergartners in Glenview, Illinois. The investigator determined eye dominance with the V-Scope and Hole-in-paper test and hand dominance with tests of motor skill and tapping. His subjects, numbering four hundred at the termination of this study in third grade, were placed in one of five dominance categories. The author found no significant differences among the five dominance categories in mean reading achievement, mean reading differential, mean intelligence, or mean reversal test scores. Likewise, he identified no significant difference in the percentage of mixed, crossed, or unilaterally dominant children in a group of below average readers as compared with a group scoring average or above in reading. This study did disclose a tendency toward greater unilaterality in hand-eye dominance among second graders as compared with their dominance characteristics in kindergarten, thereby suggesting a developmental trend.

This same investigator noticed that earlier studies which reported a relationship between dominance and reading disability were generally clinical studies while most of those reporting no relationship were studies of public school children.

¹⁷⁴ Hillerich, A Study of the Relationships between Eye-Hand Dominance and the Reading Achievement of Selected Primary Students, x-108 p.

Belmont and Birch¹⁷⁵ two years later also noted this possible cause for the ambivalence in related research. They felt it apparent that their results on lateralization differed from those of other investigators who studied retarded readers selected from a clinical setting, but were similar to those drawn from children in community samples. These researchers, using as subjects two hundred nine and ten year old boys attending school in Aberdeen, Scotland, revealed no reliable difference in lateral dominance between a group of retarded readers and a group of normal controls. They also concluded that the amount of mixed laterality was not distinguishable between the two groups.

Two studies appeared in 1966. One was that done on a group of thirty-eight male and twenty female mental retardates by Capobianco.¹⁷⁶ He found that handedness and eyedness, at least for the mentally retarded population, bore no relationship to reading achievement and seemingly related negatively to performance which demanded word recognition in traditional and mirror-image presentations.

¹⁷⁵ Belmont and Birch, "Lateral Dominance, Lateral Awareness, and Reading Disability", p. 57-71.

¹⁷⁶ Capobianco, "Ocular-Manual Laterality and Reading in Adolescent Mental Retardates", p. 781-785.

The final report was by de Hirsh et al.¹⁷⁷ whose predictions were largely informal and stemmed from twenty years' experience with preschool children referred to the Pediatric Language Disorder Clinic of Columbia-Presbyterian Medical Center for a variety of oral language deficits. Although an extraordinarily large proportion of these children developed reading, writing, and spelling difficulties several years later, she suggested that ambiguous lateralization at the age of between five-and-one-half and six-and-one-half years was not significantly correlated with their performance. Two-thirds of the children had settled on a preferred hand in kindergarten; those who had a preferred hand did not read or spell better at the end of second grade than those whose handedness had not been established.

Several other studies in the bibliography also reported little or no relationship between dominance and reading.

As has been suggested, there appeared a dichotomy between the studies drawing samples from clinical settings and those drawing from normal school populations. This review offers reinforcement and support for that thesis.

Other possibilities for confusion or discrepancies among research are the differences in operational definitions

¹⁷⁷ Katrine de Hirsh et al., "Early Prediction of Reading Failure", in Bulletin of the Orton Society, Vol. 16, 1966, p. 1-12.

of laterality, the various instruments and tests used to determine or measure laterality, intelligence, achievement, and discrepancies in age, socio-economic background, geographical location, and type of problem of the subjects investigated.

Another possible explanation for the confusion or discrepancy in the research has been specified by several investigators.

The most effective and conclusive of these was Berner and Berner¹⁷⁸ who, in 1938, declared that there existed a crucial difference between the controlling eye and the sighting eye, the latter being the one identified as the dominant eye in most research.

It was their opinion that when binocular vision has developed, there remained one visual act which was essentially monocular. This was the act of sighting. The sighting eye was established in early life, remained stable and was called the dominant eye. As binocularity gives way to binocular vision, it became habitual to use both eyes for visual perception. The eye that controlled the rivalry within the pattern of binocular vision they termed the controlling eye and, according to them, the other eye played an assisting role rather than an equal one. The authors suggested that

¹⁷⁸ Berner and Berner, "Reading Difficulties in Children", p. 829-838.

the controlling eye was not necessarily the eye with which one sighted. Further, the writers felt that wherein the dominant eye was stable from early life, the controlling eye could be shifted because the binocular pattern, which initiated one's motor reactions, speech, reading and writing, was easily influenced by changes in vision or could be controlled by training.¹⁷⁹

Their investigations have led them to believe that when the controlling eye, not the sighting eye, was on the side opposite that of handedness, difficulties in reading ensued. They concluded that crossed control always caused some visual motor disability which could be relieved by training that succeeded in producing corresponding control.

These investigators joined with two colleagues to offer support for their thesis by making an investigation of crossed control at the Devereaux School, a residential treatment center in Devon, Pennsylvania.¹⁸⁰ Their results were presented in a paper to the American Association for Mental Deficiency Convention in 1963.¹⁸¹

179 George E. Berner and Dorothy E. Berner, "Relation of Ocular Dominance, Handedness, and the Controlling Eye in Binocular Vision", in A.M.A. Archives of Ophthalmology, Vol. 50, November 1953, p. 604.

180 George E. Berner, et al., A Clinical Investigation of Crossed Control in a Residential Treatment Center, Devon, Pennsylvania, The Devereaux Schools, 1959, 1-14 p.

181 -----, Treatment of Visual and Visual-Motor Problems in the Mentally Deficient, paper presented at the Eighty-Seventh Annual American Association for Mental Deficiency Convention, Portland, May 1963, 1-10 p.

Support for Berner and Berner's premise was found in an article by Fink¹⁸² in 1938. He stated that the two eyes did not affect the visual consciousness with equal force; one eye led the other. He referred to this leading eye as the dominant eye.

In harmony with the above report were two that appeared in the literature at about the same time. Updegraff¹⁸³ and Lund¹⁸⁴ both reported the lead movement of one eye in binocular visual activity.

Delacato¹⁸⁵ indicated that in the first months of life an infant was biocular in visual performance, using only one eye at a time. At approximately seven to nine months of age he started to use his eyes in concert and here began binocularly, with stereopsis in vision developing at about one year. It was at this point that the controlling eye began to develop.

¹⁸² Fink, "The Dominant Eye: Its Clinical Significance", p. 555-582.

¹⁸³ Updegraff, "Ocular Dominance in Young Children", p. 654.

¹⁸⁴ Frederick H. Lund, "The Dependence of Eye-Hand Coordination upon Eye Dominance", in American Journal of Psychology, Vol. 44, No. 4, October 1932, p. 756-762.

¹⁸⁵ Delacato, "Ontogeny of Reading Problems", p. 119-125.

Warren and Clark¹⁸⁶ stated that there was no justification for the belief that the "sighting eye" was preferred, dominated, or assumed leadership in normal binocular vision, although such a belief was often expressed.

Spache¹⁸⁷ strongly supported Berner and Berner's contention that there was a fallacy inherent in the presumption that the eye indicated as preferred in monocular tests was necessarily the eye given preference in binocular situations. He declared that there existed no obvious reason why there should be a marked relation between the eye chosen to look through a cone or to sight a gun and the reading achievement of the same eye.

The most supportive study of Berners' thesis was that offered by Leavell.¹⁸⁸ He gave credence to Berners' theories and offered case studies to support the remediation of pupils with crossed control problems. This worker using the Keystone Hand-Eye Coordinator has offered effective therapy in the elimination of reversals and concomitant frustrations, with resultant improvement in the functional skills of the several language arts.

186 Warren and Clark, "A Consideration of the Use of the Term Ocular Dominance", p. 298-304.

187 George Spache, "Eye Preference, Visual Acuity, and Reading Ability", in Elementary School Journal, Vol. 43, No. 9, May 1943, p. 539-543.

188 Leavell, "The Problem of Symbol Reversals and Confusions, Their Frequency and Remediation", p. 130-141.

It seemed apparent from the ambivalence in reported literature that urgent, well-controlled research efforts are needed with normal school populations to further investigate if differences do in fact exist between the sighting eye and the controlling eye and their relationship with handedness to reading disability.

4. Reversals and Directional Confusions.

It is commonly recognized that form perception is a factor in learning to read and educators often use tests of this ability as partial determinants of a pupil's readiness for reading. Whether poor form perception as evidenced by reversal errors is caused by directional confusion or is an indication of an unfamiliarity with the printed language is an area which needs investigation.

This topic is germane to the present study as a result of the findings of many researchers relating directional confusion to a lack of unilateral dominance.

It was Orton,¹⁸⁹ in 1925, who suggested the hypothesis that the process of learning to read entailed the elision from the focus of attention of the confusing memory images of the non-dominant hemispheres. In applying this principle to visual images, he claimed that conditions of mixed or

¹⁸⁹ Orton, "Word Blindness in School Children", p. 581-615.

crossed-dominance resulted in a confusion of the images stored in the brain and thereby resulted in reversals or delayed reading.¹⁹⁰ Orton states:

The two halves of the body are strictly anti-tropic, that is reversed or mirrored copies of each other. [...] Thus the movements of sinistral (mirror) writing with the left hand are exactly comparable to those of dextrad writing with the right hand and it seems therefore highly probable that the engrams which are stored in the silent areas of the non-dominant hemisphere are opposite in sign, i.e., mirrored copies of those in the dominant. If then these opposite engrams are not elided through establishment of consistent selection from one hemisphere we would expect them to evince themselves by errors or confusion in direction and orientation and this is exactly what we find in cases of delayed reading.¹⁹¹

Orton based his theory of reversals and confusions on the fact that fifteen children from a group of 125 referred to a mental hygiene clinic showed a relationship between mirror writing, reversals, and difficulty in reading.

It must be noted that, although Orton's theory would explain the reason why "d" was confused with "b", it would not explain why "d" was confused with "p" and "q". If the letter is swung on its own axis through an angle of 180 degrees it became "p", and if it was turned completely over in an up-and-down direction it became "q". Both of these

¹⁹⁰ Orton, "Specific Reading Disability-Strephosymbolia", p. 1095-1099.

¹⁹¹ -----, "The 'Sight-reading' Method of Teaching Reading, or a Source of Reading Disability", p. 139-140.

positions were therefore considered upside-down inversions of "d".¹⁹²

Dearborn, in 1929, distinguished between reversals such as "NOT" for "TON", and alterations in correct sequence of letters, such as "FRAMING" for "FARMING". He concluded:

Reversals are associated with left-handedness and left-eyedness, and the alterations are associated with deviations from usual conditions of lateral dominance of hand and eye, as in ambidexterity of hand and eye, change of handedness and eyedness, and the combination of right-handedness and left-eyedness or of left-handedness and right-eyedness.¹⁹³

One year later in an address delivered before the Harvard Teacher's Association, Dearborn¹⁹⁴ postulated that in writing and reading the movements of both hand and eye were dextrad. It was this sequence, from left to right, which had to be followed to build up the correct image of words. Left-handed and left-eyed children had a preference for the opposite or sinistrad direction. The dextrad direction was so awkward for them that some wrote in a mirrored hand, and in reading confused the reversible letters or reversed the sequence of letters.

¹⁹² Helen P. Davidson, "A Study of the Confusing Letters - B, D, P, and Q", in Journal of Genetic Psychology, Vol. 47, No. 2, December 1935, p. 458-467.

¹⁹³ Walter F. Dearborn, "Teaching Reading to Non-Readers", in Elementary School Journal, Vol. 30, 1929, p. 266-269.

¹⁹⁴ -----, "The Nature of Special Abilities and Disabilities", p. 632-636.

The antithetic view was supported by Gates and Bennett¹⁹⁵ who extensively examined 350 students in grades two and four. Their study did not indicate a relationship between reversal errors and mixed hand-eye dominance or between reversal errors and left-handedness with left-eyedness.

Mintz¹⁹⁶ studied one hundred boys from Letchworth Village for the mentally deficient and concluded that children with indications of unstable unilateral dominance did not appear more prone to either order reversal errors or right-left reversals of letters than other children of the same reading level.

In another study of subnormal boys, Mintz¹⁹⁷ proposed to verify the facts described by Orton and Monree, and concluded, to the contrary, that frequencies of various kinds or orientation errors differed only slightly, not significantly, in the groups of boys of different laterality types. He found no evidence of strephosymbolia.

195 Arthur L. Gates and Chester C. Bennett, Reversal Tendencies in Reading, New York, Bureau of Publications, Teachers College, Columbia University, 1933, 33 p.

196 Alexander Mintz, "A Study of Indications of Unstable Unilateral Cerebral Dominance, Reading Disability and Mental Deficiency", in Psychological Bulletin, Vol. 30, No. 8, October 1933, p. 565-566.

197 -----, "Reading Reversals and Lateral Preference in a Group of Intellectually Subnormal Boys", p. 487-501.

In a statistical comparison of 136 pairs of right- and left-handed pupils matched according to sex, chronological age, mental ability and reading ability, Woody and Phillips¹⁹⁸ revealed that the various handedness and eyedness groups responded with approximately the same number of reversals.

Similar conclusions were reported by Hildreth¹⁹⁹ in 1934. She revealed that the difference between right- and left-handed children were so small as to be insignificant statistically. The number of reversals made by her subjects declined from year to year with no attention given to reversal elements as such.

This finding was born out by Phillips' study²⁰⁰ of 136 matched pairs of right- and left-handed children, in which there was no significant difference in reversals made by the two groups. This report included no description of the tests of handedness.

198 Clifford Woody and Albert J. Phillips, "The Effects of Handedness on Reversals in Reading", in Journal of Educational Research, Vol. 27, No. 9, May 1934, p. 651-662.

199 Gertrude Hildreth, "Reversals in Reading and Writing", in Journal of Educational Psychology, Vol. 25, January 1934, p. 1-20.

200 Albert J. Phillips, "Relation of Left-Handedness to Reversals in Reading", in Elementary English Review, Vol. 11, April 1934, p. 97-98 and 118.

Gilkey and Parr,²⁰¹ Spache,²⁰² and Stevenson and Robinson²⁰³ also reported findings of no relationship between conditions of handedness and reversal tendencies.

Witty and Kopel²⁰⁴ conducted a thorough study of one hundred pupils with an I.Q. of eighty or above and whose reading scores on several standardized tests were the lowest of two thousand children in grades three through six. Their data clearly indicated little, if any, relationship between reversal errors and mixed eye-hand dominance.

In a more recent investigation of forty-four second grade children, Beck²⁰⁵ disclosed that reversal of symbols was not generally attributed to either faulty binocular vision or any particular eye dominance pattern.

As seems to be true of the research relating lateral dominance to reversals, the research dealing with reversals

201 Beulah G. Gilkey and Frank W. Parr, "An Analysis of the Reversal Tendency of Fifty Selected Elementary School Pupils", in Journal of Educational Psychology, Vol. 35, May 1944, p. 284-292.

202 George D. Spache, "Factors which Produce Defective Reading", in Corrective Reading in Classroom and Clinic, proceedings of the Annual Conference on Reading, University of Chicago, Vol. 15, No. 79, December 1953, p. 49-70.

203 Stevenson and Robinson, "Eye-Hand Preference, Reversals, and Reading Progress", p. 83-88.

204 Paul Witty and David Kopel, "Factors Associated with the Etiology of Reading Disability", in Journal of Educational Research, Vol. 29, No. 6, February 1936, p. 449-459.

205 Harry S. Beck, "The Relationship of Symbol Reversals to Monocular and Binocular Vision", in Peabody Journal of Education, Vol. 38, November 1960, p. 137-142.

and their effect on reading ability was discrepant and ambivalent.

From an investigation of 120 normal and 175 retarded readers in the Iowa State Psychopathic Hospital, Monroe²⁰⁶ revealed that the retarded readers were distinguished from the normal readers consistently at each reading grade level by a greater number of reversals as well as a greater facility in mirror reading and mirror writing. Recognizing the correct orientation of letters and words was more difficult for the retarded readers.

The analyzation of the hand-eye preference of 101 children in a reading defect group and a control group several years later allowed Monroe²⁰⁷ to reinforce her earlier premise. She declared that the reading defect cases, both pure and mixed dextrals, exceeded the controls in reversals to a greater extent than the mixed dextrals of either group exceeded the pure dextrals of the same group. She did disclose a tendency for left-eyed children to make more reversal errors.

206 Marion Monroe, "Methods for Diagnosis and Treatment of Cases of Reading Disability", in Genetic Psychology Monographs, Vol. 4, Nos. 4 and 5, October-November 1928, p. 333-454.

207 Monroe, Children who Cannot Read, xv-205 p.

Nine years later, Schonell²⁰⁸ presented an evaluation of 104 ineffective readers, whose reading abilities were a minimum of one-and-one-half years below their mental ages and whose tested I.Q.'s were in the main over eighty-five. He reported that errors in the confusion of letters and reversal of words were much more frequent among backward readers, although both diminished fairly rapidly after nine years of age.

The ophthalmologist, Goldberg,²⁰⁹ in his study of one hundred children with reading disabilities, noted a persistence of a normal childhood tendency to reverse letters and symbols and, in rarer cases, a continued tendency for mirror writing.

In a review of case studies of aphasic and non-reading children prepared while a school psychologist for the New York City schools, Barger²¹⁰ found the non-reading children were able to make an adjustment to their reversals and inversions through the intermediation of a mirror which altered the axial arrangement of the letters.

208 Schonell, "The Relationship of Reading Disability to Handedness and Certain Ocular Factors", 1940, p. 227-234; 1941, p. 20-27.

209 Goldberg, "The Ophthalmologist Looks at the Reading Problem", p. 67-74.

210 Barger, "An Experimental Approach to Aphasic and Non-Reading Children", p. 158-170.

In 1954, Wilson and Leavell²¹¹ published a study of 749 school-age children in which they revealed that deficiencies in the language arts manifested themselves significantly in more cases where visual imagery reversals were present than in those cases where such aberrations were not found.

Eight years later, Bergquam²¹² postulated that children who experienced reversals were not aware of it. In the beginning the symbols were strange to them and a reversed word was just an unrecognized one. She stated that the confusion made it difficult for them to follow the thread of thought, for, as they read a sentence and came to words which contained confusing letters, they had to recall these letters into their consciousness and establish their identity. When this was necessary, the thought was lost.

Hillerich,²¹³ in a statistical study following four hundred kindergarten children through third grade, found positive correlations between reading achievement and reversal

²¹¹ Wilson and Leavell, A Study of the Relation of Functional Neurological Dominance to Reading Difficulties in Selected Cases of the McGuffey Reading Clinic, 159 p.

²¹² Bergquam, "Neural Confusion and Academic Failure", p. 362-365.

²¹³ Hillerich, A Study of the Relationships between Eye-Hand Dominance and the Reading Achievement of Selected Primary Students, x-108 p.

scores and between reading differential and reversal scores in the total group of subjects. He did not, however, find a relationship between dominance, dominance characteristics and reversal errors.

Teegarden,²¹⁴ in her rather comprehensive evaluation of fifty children who were scattered throughout a range of 258 children entering first grade, presented the proposal that the tendency to reverse occurred in varying degrees from total absence to severity and was neither abnormal nor pathological. She found the very bright child capable of overcoming a strong tendency to reverse.

This same author offered another report of 262 children entering first grade in three public schools in which her summary was very similar to her earlier study.²¹⁵ She added that the strength of reversal tendency bore a negative relation to reading achievement at the end of grade one. Her research offered a serrendipitous finding; i.e., there was a wide difference between the performance of children in poor and prosperous districts, although exceptional and extreme cases were found in each district.

²¹⁴ Teegarden, "Clinical Identification of the Prospective Non-reader", p. 346-358.

²¹⁵ -----, "Tests for Tendency in Reversal in Reading", in Journal of Educational Research, Vol. 27, No. 2, October 1933, p. 81-97.

Smith's study,²¹⁶ reported in 1950, consisted of six critical analyses of fifty retarded readers and the same number of normal readers matched according to chronological age and intelligence. She declared that the retarded readers made significantly more reversals in lower case letters than did the reading achievers.

Wolfe²¹⁷ also reported a similar finding. He found a significant difference between reading achievers and non-achievers in the reversal of geometric designs.

The final article supporting a relationship between reversals and reading inefficiency was one by Jones²¹⁸ in 1964. He suggested that, if ambiguous dominance did exist, problems with spatial and directional orientation were present in some degree and were reflected in language and reading development.

Davidson²¹⁹ studied fifty kindergarten children and 120 first grade children and concluded that it was a natural phenomenon for young children to read words backwards and

216 Linda C. Smith, "A Study of Laterality Characteristics of Retarded Readers and Reading Achievers", in Journal of Experimental Education, Vol. 18, June 1950, p. 321-329.

217 L. Julian Wolfe, "An Experimental Study of Reversals in Reading", in American Journal of Psychology, Vol. 52, 1939, p. 533-561.

218 Jones, "Issues in Beginning Reading", p. 107-112.

219 Helen P. Davidson, "A Study of Reversals in Young Children", in Pedagogical Seminary and Journal of Genetic Psychology, Vol. 45, December 1934, p. 452-465.

that they learned to perceive words as adults do as a result of increasing maturity and experience.

Such a view was voiced by Kirk and Kirk²²⁰ in their study of fifty-one mentally retarded children and thirty-seven normal or superior children. They revealed that younger superior children made more reversals than did the older sub-normal children, leading them to believe that correct orientation in writing was based on maturation or experiential factors or both. They also identified no significant difference in reversals between the left- and right-handed children.

Kennedy,²²¹ in 1954, declared that there was present a maturational process which ultimately resulted in the almost complete disappearance of reversal tendency in the work of the average or superior child. This author made the intriguing observation that, to a young child, it made no difference if the letter was facing one direction or the other. To a child, a boy was a boy regardless of whether he was facing north or south or standing on his feet or head. So it was with the material things with which the child was familiar.

220 Winnifred D. Kirk and Samuel A. Kirk, "The Influence of the Teacher's Handedness on Children's Reversal Tendencies in Writing", in Journal of Genetic Psychology, Vol. 47, No. 8, December 1935, p. 473-477.

221 Helen Kennedy, "Reversals, Reversals, Reversals", in Journal of Experimental Education, Vol. 23, No. 2, December 1954, p. 161-170.

This view was supported, three years later, by Paul McKee, who stated:

To him [the child] a rabbit is a rabbit whichever way it faces. And so the letters b and d are for him one and the same letters looking in two directions. He has to learn that the side of the upright on which the loop of the letter appears makes all the difference between a "b" and "d".²²²

In administering Potter's Test of Perceptual Discrimination to 176 first-grade children, Potter²²³ disclosed that although poor readers scored lower on the test, good readers made errors on all parts of the test. He presented the implication that reversal error was not the cause of reading difficulty, but rather a manifestation.

Similar findings were reported by Spache²²⁴ who stated that reversals were not causal in poor reading or even related to it but were a universal phenomenon present among learners of all ages who attack a new and strange group of symbols.

Krise²²⁵ suggested also that the tendency to reverse was present in varying degrees in all people at all ages.

222 Paul McKee, A Primer for Parents, Boston, Houghton Mifflin Co., 1957, p. 27.

223 Muriel C. Potter, Perception of Symbol Orientation and Early Reading Success, Contributions to Education No. 939, New York, Bureau of Publications, Teachers College, Columbia University, 1949, 43 p.

224 George D. Spache, "Factors Which Produce Defective Reading", in Corrective Reading in Classroom and Clinic, proceedings of the Annual Conference on Reading, University of Chicago, Vol. 15, No. 79, December 1953, p. 49-79.

225 Morely Krise, "An Experimental Investigation of Theories of Reversals in Reading", in Journal of Educational Psychology, Vol. 43, November 1952, p. 408-422.

In his study of twenty adults he disclosed that, although none indicated any tendency to reverse on a test of verbal symbols, given a similar test involving strange symbols, all reversed from three to seventy-five per cent of these strange symbols.

In an earlier study, Krise²²⁶ had provided a provocative hypothesis, relating reversals to general intelligence. He suggested a strong relationship, finding that many children reverse because of an inability to differentiate between symbols that look similar, a trait closely related to general intelligence. The above author felt that it was ridiculous to assume that the reversals made by great numbers of young children were manifestations of confused dominance conditions. With additional mental maturity, these children no longer exhibited reversal tendencies.

Drews²²⁷ conducted a well-controlled, thorough study of 108 retarded readers with respect to dominance, reading and reversals. She found that, when reading level was held constant, there was no significant difference between the reversal errors of second graders and those of fourth graders.

226 Morely Krise, "Reversals in Reading: A Problem in Space Perception", in Elementary School Journal, Vol. 49, January 1949, p. 278-284.

227 Elizabeth M. Drews, The Significance of the Reversal Error in Reading, unpublished doctoral dissertation, University of Michigan, 1954, 187 p.

Although the evidence presented was diverse, there was an implication that some relationship might exist between reversals and reading achievement. It seems evident that further controlled research is necessary in order to determine a possible cause-effect relationship suggested by the reported possibility that reversals are a manifestation of a reading problem.

5. Testing Laterality.

Any study of laterality runs the risk of being weakest at its very base, i.e., the tests used to measure laterality.

Most research efforts to determine handedness have been based on tests utilizing activities which may have become biased by social experience. These tests are cutting with scissors, writing, throwing and the like. Some investigators have attempted to evaluate handedness by means of activities in which social experience and enculturating influences are not excessively contributory, such as aiming, tapping, and manipulating the Critical Angle Board.

Durost,²²⁸ as early as 1934, reviewed the theories of handedness which underlie various types of tests. These were as follows: (1) the preferential view, which considered that the hand most used was the dominant hand; (2) the

²²⁸ Durost, "The Development of a Battery of Objective Group Tests of Manual Laterality, with the Results of Their Application to Children", p. 223-335.

inherited view, which was based on Orton's²²⁹ assumption of bilateral asymetry; and (3) the functional view, which assumed that handedness was determined qualitatively and quantitatively. Durost's research, which investigated the handedness of thirteen hundred children from three schools in metropolitan New York by using the push-pin test, target test, treasure test, and escape test, supported the functional view of dominance.

H.L. Koch et al.²³⁰ evaluated 201 undergraduate college students at the University of Texas by having them accomplish 105 manipulations or tasks within a thirty-minute period and disclosed that laterality was quantitative and distributed bimodally with approximately six per cent of the subjects falling within the left mode. This author, while relating other measures to the preferred hand, i.e. the preferred side for sleeping, the jaw preferred for biting, and the shoulder upon which a gun or bat rested, did find that the measurement of the relative difference in hand strength was not reliable.

229 Orton, "An Impediment in Learning to Read: A Neurological Explanation of Reading Disability," p. 286-290.

230 Koch et al., "A Study of the Nature, Measurement, and Determination of Hand Preference", p. 117-218.

Orten²³¹ also attempted to identify a consistent relationship between strength of arm and master hand by using dynamometers. He reported no relation except when the master hand had been well established and had done the major part of the manual work.

Twitmeyer and Nathanson²³² concluded that their subjects confirmed that writing was not a reliable test of native handedness. After correlating the writing hand with the aiming and tapping tests in two hundred subjects, the authors reported that social pressure could be a factor in observed handedness. It seemed to them that, in testing native handedness, greater caution should be used to incorporate activities in which social pressures have not been so prevalent a factor.

In keeping with the premise that handedness was a quantitative factor of varying intensity, Van Ripper²³³ devised the Critical Angle Board Test. This elaborate test employed the simultaneous drawings of various types of patterns upon two writing boards which could be converged

²³¹ Orten, Reading, Writing, Speech Problems in Children, vii-215 p.

²³² E.B. Twitmeyer and Y. Nathanson, "The Determination of Laterality", in Psychological Clinic, Vol. 22, 1935, p. 141-149.

²³³ C. Van Ripper, "The Quantitative Measurement of Laterality", in Journal of Experimental Psychology, Vol. 18, No. 3, June 1935, p. 372-382.

through ninety degrees from a position parallel with the subject's chest to a position perpendicular thereto. The angle of convergence at which one hand produced mirrored patterning was shown to differentiate quantitatively between thoroughly right, ambidextrous, and left-handed groups.

Koch et al.²³⁴ reported the unreliability of the broom, thumb-on-top, and needle-threading tests. Beeley²³⁵ attempted to determine the reliability of the Jones Brachimeter, an arm measurement, with 123 children and found it lacking.

Having previously used the dominance tests of cutting and writing so affected by social experience, Hildreth²³⁶ later found that spinning a top, spooning sand, and using a rattle were the most reliable tests in young children.

Hillerich²³⁷ found the connecting dots tests to be more sensitive than the tapping test with his four hundred primary school subjects.

²³⁴ Koch et al., "A Study of the Nature, Measurement, and Determination of Hand Preference", p. 117-218.

²³⁵ Arthur L. Beeley, An Experimental Study in Left-Handedness, Chicago, University of Chicago Press, 1918, 74 p.

²³⁶ Hildreth, "Development and Training of Hand Dominance", p. 39-100.

²³⁷ Hillerich, A Study of the Relationships between Eye-Hand Dominance and the Reading Achievement of Selected Primary Students, p. 67.

In examining scores of related studies, there is indicated a definite need to state a description of the handedness tests used in each instance, a factor often overlooked.

Crider²³⁸ tested the eye dominance of one thousand subjects over a ten-year period and reported finding that distance in testing had no appreciable effect on the results. He specified that visual acuity was unrelated to the preferred eye as indicated by his tests.

Snyder,²³⁹ in a study of 410 high school and college students, Gahagan²⁴⁰ with one hundred college students, Gates²⁴¹ with sixty-five retarded readers, Robinson²⁴² with 162 children in grades one, four and seven, and Coons and Mathias²⁴³ with 112 high school students were all in agreement that eye preference appeared to be a unique characteristic unrelated to visual acuity. Such findings tend to

²³⁸ Crider, "A Battery of Tests for the Dominant Eye", p. 629-632.

²³⁹ Snyder and Snyder, "Eye Preference Tendencies", p. 431-433.

²⁴⁰ Gahagan, "Visual Dominance-Acuity Relationships", p. 455-459.

²⁴¹ Gates and Bond, "Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading", p. 450-456.

²⁴² Robinson and Huelman, "Visual Efficiency and Progress in Learning to Read", p. 31-63.

²⁴³ Coons and Mathias, "Eye and Hand Preference Tendencies", p. 629-632.

invalidate Woo's²⁴⁴ selection of the dominant eye through use of visual acuity tests.

A dissenting conclusion was presented by Spache²⁴⁵ after discovering that scores in reading made with the dominant eye were superior to those made by both eyes. However, this study was poorly documented and involved fewer than thirty children.

Crider²⁴⁶ reported that hand dominance had no effect on the testing of eye dominance. He based this conclusion on the change in eye dominance on a unimanual test of eye dominance by only seventeen of 717 subjects.

Contrasting testimony was offered by Lund²⁴⁷ and by Johnston²⁴⁸ who generalized from data suggesting that tests of eye dominance can be influenced by the subject's handedness.

At the extreme of this view, Parson²⁴⁹ declared that handedness was caused by eyedness, despite the fact that of 257 left-eyed subjects, 225 were right-handed by observation.

²⁴⁴ T.L. Woo, "Dextrality and Sinistrality of Hand and Eye", in Biometrika, Vol. 22, 1928, p. 79-148.

²⁴⁵ George Spache, "One-Eyed and Two-Eyed Reading", in Journal of Educational Research, Vol. 37, No. 8, April 1944, p. 616-618.

²⁴⁶ Crider, "A Battery of Tests for the Dominant Eye", p. 629-632.

²⁴⁷ Lund, "The Dependence of Eye-Hand Coordination Upon Eye Dominance", p. 756-762.

²⁴⁸ Johnston, The Relationship of Certain Anomalies of Vision and Lateral Dominance to Reading Disability, 147 p.

²⁴⁹ Parson, Left-Handedness, A New Interpretation, 185 p.

Based on the realization that when one sights as with a gun or microscope he is likely to close one eye and sight with the other, Crider²⁵⁰ attempted to relate eye-closure behavior to ocular dominance and visual acuity. He reported that the relationship was not sufficiently high to warrant substituting eye-closure facility for a sighting test of eye dominance.

Many and varied tests for ocular dominance have been noted in the literature among which were Parson's Monoptoscope, a sighting tube, sighting pictures through a hole in cardboard, sighting over a pencil, and looking steadily at the examiner's nose between the subject's index fingers as they are brought closer together.²⁵¹ Another study used a kaleidoscope, rifle-sighting, paper-with-hole, two pencils lined up with the examiner's nose, and the paper clip test to determine ocular dominance.²⁵² Representative of tests used by other investigators were sighting dot, sighting dot with Parson's cone, and the peep-hole test used by Hildreth.²⁵³

²⁵⁰ Blake Crider, "Eye-Closure Facility and Eye Dominance", in Journal of Genetic Psychology, Vol. 58, Second Half, June 1941, p. 425-426.

²⁵¹ Robinson, "Visual Efficiency and Reading", p. 90-112.

²⁵² Belmont and Birch, "Lateral Dominance, Lateral Awareness, and Reading Disability", p. 57-71.

²⁵³ Hildreth, "A School Survey of Eye-Hand Dominance", p. 83-88.

Hillerich²⁵⁴ used a modification of the Manuscope known as a V-Scope; a cardboard tube about eight inches long and wide enough to contain both eyes at one end, while tapering to an opening of about one inch in diameter at the distant end. This tube has the advantage of requiring the use of both hands to hold it open, thereby nullifying any influence of the dominant hand.

Scheidemann's²⁵⁵ "hole-in-paper" test has been very popular in studies despite the fact that the examiner must rely on a report from the subject.

Berner and Berner,²⁵⁶ Warren and Clark,²⁵⁷ and Updegraff²⁵⁸ felt strongly that there was no justification for the belief that the "sighting eye", as was determined by nearly all the tests above, was necessarily preferred, dominates, or assumes leadership in normal binocular functioning, although such a belief has often been expressed.

²⁵⁴ Hillerich, A Study of the Relationships between Eye-Hand Dominance and the Reading Achievement of Selected Primary Students, p. 32.

²⁵⁵ N.V. Scheidemann, "A Simple Test for Ocular Dominance", in American Journal of Psychology, Vol. 43, No. 1, January 1931, p. 126.

²⁵⁶ Berner and Berner, "Reading Difficulties in Children", p. 829-838.

²⁵⁷ Warren and Clark, "A Consideration of the Use of the Term Ocular Dominance", p. 298-304.

²⁵⁸ Updegraff, "Ocular Dominance in Young Children", p. 654.

Berner and Berner²⁵⁹ strongly recommended tests that compared the relative performance of the eyes during the act of binocular vision. They suggested that the Keystone Visual Skills test of far-point vision and the Keystone Test of Binocular Skill of near-point reading were both usable in the Keystone Telebinocular. These researchers stated that the determination of ocular dominance by sighting tests was not at all necessary.

6. Summary.

In summation, the majority of the literature suggested a lack of relationship between reading and the establishment of lateral preference. The literature did suggest that there was a need to investigate, in a carefully controlled manner, the validity of the premise that the source of the confusions and discrepancies in the studies on laterality was the determination of ocular dominance by monocular tests rather than binocular tests.

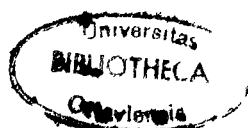
The literature also suggested the need for further efforts to explain the divergence between clinical and public school studies, with the latter tending to reject the theory that unilateral dominance favors reading success.

²⁵⁹ Berner and Berner, "Relation of Ocular Dominance, Handedness, and the Controlling Eye in Binocular Vision", p. 607.

The review of studies of reversal errors have brought into focus the probability that reversals might be manifestations of a reading problem.

Much more investigation is warranted with regard to the seldom considered proposal that studies of eye and hand dominance have been based on faulty anatomical ideas; that they have ignored the postulation that nerves from each eye end in both hemispheres and that the dominance of one hemisphere as exhibited in right- or left-handedness, has little or nothing to do with eye dominance. In other words, it may be that eye dominance does not exist in the manner in which most reading investigators have assumed, nor is it related to hand dominance or cerebral dominance. See Appendix 4.

The succeeding chapter describes the plan of this study for investigation of the problems raised in the first chapter.



CHAPTER II

PLAN AND CONDUCT OF THE INVESTIGATION

1. Purpose.

The primary purpose of this study was an attempt to clarify the equivocal research on laterality and reading achievement through investigation of the possible distinction between the "controlling" eye determined through tests of binocular vision and the "dominant" eye normally referred to in studies of laterality. Related purposes included an analysis of the relationship of crossed control, crossed dominance, and mixed dominance to reading achievement in a junior high school population wherein eye-hand dominance was found unrelated to intelligence, reversals, reading differential, and reading achievement at the primary level; and an evaluation, at the junior high level, of a developmental trend away from mixed dominance as reported in an earlier study which followed this same population from kindergarten to mid-third grade.

2. Hypotheses.

The questions for study were established as the following hypotheses:

1. There is no significant distinction between the dominant eye used in sighting and the controlling eye used in binocular vision.

2. There is no significant difference in reading achievement between children of crossed dominance and those of unilateral dominance.
3. There is no significant difference in reading achievement between children evidencing crossed control and those with unilateral control.
4. There is no significant difference in reading achievement between children of mixed dominance and those of unilateral dominance.
5. There is no significant change in the eye-hand dominance pattern of children between second and eighth grades.
6. There is no significant difference in the eye-hand dominance patterns between male and female children.

3. The Sample.

The subjects were 267 eighth-grade and ten seventh-grade students who remained from an earlier study by Hillerich¹ of four hundred children tested in kindergarten and second grade for eye-hand dominance, and in third grade for reading achievement. The children attended the Glenview Junior High School, Our Lady of Perpetual Help Parochial School, and St. Catherine Laboure Parochial School, all in Glenview, Illinois.

Since, in the earlier study, the pupils had four different teachers during the four years of study and, in

¹ Robert L. Hillerich, A Study of the Relationship Between Eye-Hand Dominance and the Reading Achievement of Selected Primary Pupils, an unpublished doctoral dissertation, Colorado State College, Greeley, Colorado, 1962, 100 p.

the intervening years, pupils were not moved on to subsequent grades intact as classes, but rather, little attempt was made to maintain original groupings, it has been assumed that the teacher variable was nullified. In all instances, from kindergarten testing through the intervening years to the final testing in eighth grade, placement of pupils in classes was as heterogeneous as was possible to achieve.

4. Selection of Tests.

The tests for the dominant eye, the controlling eye and the dominant hand were selected and interpreted in terms of the reported Berner and Berner² and Hillerich³ studies so that the two studies could be accurately replicated as well as defensibly related to each other.

The dominance tests used by Hillerich in the earlier study and used in this current effort were selected on the basis of reliability as reported by other investigators and on the basis of suitability for the age level being tested.

Tests for the Dominant Eye

V-Scope.- One of the most popular tests for eyedness has been the Manuscope or a modification of this instrument

² G.E. Berner and D.E. Berner, "Reading Difficulties in Children", in A.M.A. Archives of Ophthalmology, Vol. 20, April 1938, p. 555-582.

³ Hillerich, Op. Cit., 108 p.

known as the V-Scope. As used in the earlier study, the latter was a cardboard tube about eight inches long and wide enough to contain both eyes at one end, while tapering to an opening of about one inch in diameter at the distant end.⁴ This identical V-Scope was used in this investigation.

The tube had the advantage of requiring the utilization of both hands to hold it open, so that the influence of the dominant hand was nullified.

Hole-in-paper.- This test made use of a seven-inch square of tagboard, containing a one-inch hole in the center. The subject looked through the hole with both eyes open, while holding the square with both hands at arm's length. The hole-in-paper test used in the earlier study and used in this present effort was adapted from the test of the same name originally reported by Scheidemann.⁵

Tests of Hand Dominance

Tapping.- One test for manual dominance was a modified tapping test. Tapping avoided the danger of social pressure, but unless an electric stylus was used, scoring

⁴ Guy Bond and Miles Tinker, Reading Difficulties: Their Diagnosis and Correction, New York, Appleton-Century-Crofts, Inc., 1957, p. 99-103.

⁵ H.V. Schiedemann, "A Simple Test for Ocular Dominance", in American Journal of Psychology, Vol. 43, No. 1, January 1931, p. 126.

could have become subjective. Considering this, a typewriter was used on which the key B was marked in red. Ten seconds of tapping with each hand comprised one testing. The hand which tapped the greater number of B's was considered dominant. Both speed and accuracy were important in determining handedness, since this was both a qualitative and a quantitative phenomenon. This typewriter and the method of its use were identical to that used in the earlier Hillerich study.⁶

Cutting, Writing, Throwing, Eating, Hammering, Batting, and Kicking.- In an effort to completely replicate the testing procedures of the Berners,⁷ each subject performed the manual operations of cutting with a scissors, writing one's name, throwing a ball, handling eating utensils, kicking a falling object, striking a spike with a simulated hammer, and assuming a batting stance.

Connecting Dots Test.- A replica of the Connecting Dots Test appears in this study as Appendix 3. Each subject was given two copies of this test: one used for the right hand and one for the left hand. It consisted of nine horizontal rows of paired dots that had to be perfectly joined by as many penciled lines as was possible to complete in forty-five seconds.

⁶ Hillerich, Op. Cit., 108 p.

⁷ Berner and Berner, Op. Cit., p. 555-582.

Test of Reading Achievement

The California Achievement Test.- The reading section of the California Achievement Test,⁸ Form W, Junior High Level, was administered to determine the reading achievement of the subjects. The choice of the tool was made based on the prior use of the Upper Primary Level of the same test with these subjects in the third grade.

Test of Intelligence.- The California Short Form Test of Mental Maturity was administered to determine intelligence. A group test was selected by Hillerich since this was the type of instrument usually available to, and used by, public school personnel. This specific group test was chosen because of its relationship to the reading test used.

Tests for the Controlling Eye

The Keystone Telebinocular.- The Keystone Telebinocular was used for determining the controlling eye in binocular vision as was true in the Berners'⁹ investigation. The controlling eye at binocular far-point vision was determined by the use of the Keystone test cards DB-1D, DB-2D, and DB-3D¹⁰ as viewed with the Telebinocular. The controlling

⁸ California Test Bureau, California Achievement Test, Los Angeles, California Test Bureau, 1957.

⁹ Berner and Berner, Op. Cit., p. 555-582.

¹⁰ William S. Gray, Keystone Test of Binocular Skill, Meadville, Pennsylvania, Keystone View Co., 1962, 1-11 p.

eye at binocular near-point reading distance was determined by the use of Gray's Oral-Reading Paragraphs, i.e., cards DG-9, DG-10, and DG-11, with the Telebinocular.

5. Administration of Tests.

Tests for Dominance

All tests of dominance, both ocular and manual, were administered by this investigator as hereafter described.

V-Scope.- The examiner stood about ten feet to the front of the subject who had been given the scope to hold with both hands. The student was asked to "look through the tube with both eyes open and guess what I am holding in my hand". While the interest of the child was centered on a small object held by the examiner near the examiner's own eyes, the latter could plainly see which eye was used by the subject, since the non-dominant eye was hidden by the tube.

Five trials or identical repetitions of this test were given to each subject.

Hole-in-paper.- Because of the possibility of error in relying on a report of the subject, the investigator had to observe the eye used. Instructions to the subject were: "Hold this cardboard with both hands as far from your face as possible. Now, please attempt to fit my face in this small hole. Remember, keep both eyes open." The examiner then moved approximately ten feet away and signaled the subject to raise the tagboard.

As was with the V-Scope, five trials were given to each subject.

Tapping.- The subject was seated squarely before a typewriter and told he must race to note the number of times he could hit the painted B center key. The choice of preferred hand was his. One practice test was allowed and followed by two closely-timed tests of ten seconds for each hand. In cases of unclear choice or question, a third test was administered.

Connecting Dot Test.- Each subject was requested to draw a penciled line perfectly connecting two dots arranged in vertical pairs along horizontal rows. Instructions included the caution to pass the penciled line between the two dots and that if one of the dots was not touched, it was not considered a proper, valid measure. An example of the desired maneuver was demonstrated by the examiner on a chalk board. After the subject chose the hand he preferred and was given a practice opportunity, he was allowed forty-five seconds to successfully join as many of the nine horizontal rows of paired dots as was possible. This completed, he then repeated this test with the opposite hand.

Cutting, Writing, Throwing, Eating, Hammering, Batting, and Kicking.- In an effort to further measure manual dominance, each subject was given instructions to perform the manual operations of a very usual nature, i.e.,

cutting a piece of paper with a scissors, writing one's name on one of the tests, throwing a small ball to the examiner, mimicking the operation of several eating utensils available to the subject, striking a pencil with a simulated hammer, assuming a batting stance as investigator pantomimes a pitching delivery, and kicking a falling object. Each of these operations was completed before other handedness tests were attempted so knowledge of the purpose was denied the subject.

Tests for the Controlling Eye

To assure an exact replication of the Berner¹¹ study, the very same technique of determining the controlling eye in binocular vision was used. D.E. Berner served as a consultant and trained this investigator in the exact methods and scoring used in the earlier study.

The instrument used in this testing was the Keystone Telebinocular with six test slides or cards, all of which were manufactured by the Keystone View Company, Meadville, Pennsylvania.¹²

Each subject was tested individually in a quiet place where he was free from distractions and where other persons could not hear his responses. The examiner used a

11 Berner and Berner, Op. Cit., p. 555-582.

12 Gray, Op. Cit., 1-11 p.

stop watch and charted the subject's responses on the appropriate record forms. The Telebinocular and table were adjusted for the comfortable posture of each subject with his arms resting on the table.

If prescriptive lenses were worn constantly by the subject from arising until bedtime, testing for controlling eye was made with lenses. If the child wore glasses for classroom and/or reading only, evaluation of far-point vision was made without glasses and near-point reading was tested with glasses. Finally, if glasses were worn "sometimes" but never consistently by the pupil, all evaluations were accomplished without glasses. These standards for examining pupils with prescriptive lenses were identical to those used by the Berners in making their evaluations of controlling eye.

Controlling Eye Near-Point Reading.- Using the Keystone Telebinocular the subject was shown three slides or cards of the Standardized Gray Oral Reading Check Tests¹³ which allowed the child to display the efficiency of each eye, and of both eyes together, in the act of reading. The examiner measured speed and quality of reading in terms of elapsed time and number of errors.

¹³ Ibid., p. 5.

While the subject read, a record of the elapsed time in seconds was taken. A continuing record of each error was also made on the record form.

The examiner gave each subject the instructions which appeared in the manual provided with the test: "I want you to read this story out loud to me. Begin reading when I say 'begin'. If you find some hard words, read them as well as you can without help and continue reading. Now, begin!"¹⁴

Controlling Eye Far-Point Reading:- Far-point was the equivalent of an actual distance of twenty feet. Cards were again presented with the Keystone Telebinocular. Each subject was expected to display the efficiency of each eye and both eyes together in distant vision. The examiner very carefully followed the relevant instructions appearing in the manual provided with the Telebinocular.¹⁵

Standardized Tests

The California Short-Form Test of Mental Maturity was administered by the classroom teachers in accordance with the instructions in the manual accompanying those tests.

¹⁴ Ibid., p. 9.

¹⁵ Keystone View Company, Manual of Instruction for Use with the Keystone Visual Survey Service, Meadville, Pennsylvania, Keystone View Company, 1956, 1-20 p.

The California Achievement Test, "Reading Section," was administered by this investigator to all subjects.

6. Schedule for Testing.

The tests used in this investigation were administered to the subjects as outlined in Table I.

7. Organization of the Data.

The eye-dominance battery consisted of five trials with the V-Scope and five trials with the hole-in-paper test. If fewer than eight of the ten trials at a given level were consistent, the subject was considered as having mixed-eye dominance.

Hand dominance test results were recorded in terms of a score for the right hand and a score for the left hand. In the tapping test this score was the total number of B's typed with the given hand, regardless of whether the subject had two or three trials. With the dot test, the score for each hand was the number of dots actually connected with the pencilled line.

The raw scores on each of the two handedness tests above were converted to ratio scores by means of the formula $(\frac{R}{R+L}) 100$, where R was the raw score of the right hand and L was the raw score of the left.

Table I.-
The Testing Schedule for Determining
the Controlling Eye, the Dominant Eye,
Manual Dominance, and Reading Achievement.

Purpose of Test	Name of Test	Number of Trials	Criteria	Test Re- licated
Controlling Eye Far-point	DB-1D	Practice test	Not considered	Berner
	DB-2D	1	Compare score for each eye	Berner
	DB-3D	1	Compare score for each eye	Berner
Controlling Eye Near-point	DG-9	1	Compare rate and errors	Berner
	DG-10	1	Compare rate and errors	Berner
	DG-11	1	Compare rate and errors	Berner
Dominant Eye	V-Scope	5	8/10=clear right or left	Hillerich
	Hole-in-paper	5	8/10=clear right or left	Hillerich
Dominant Hand	Cutting	1	3/4=clear right or left	Berner
	Writing	1	3/4=clear right or left	Berner
	Throwing	1	3/4=clear right or left	Berner
	Eating	1	3/4=clear right or left	Berner
	Tapping ^a	3/hand	Converted to ratio scores	Hillerich
	Connecting Dots ^b	45 sec/hand	Converted to ratio scores	Hillerich
Reading Achieve- ment	Calif. Ach. Test	1	Grade equivalent	Hillerich

a The raw scores on each test were converted to ratio scores by means of the formula $R \div (R+L)100$, where R is the raw score for the right hand and L for the left. The total group then was divided into right-inclined and left-inclined groups, and any subject whose score fell more than $1\frac{1}{2}$ s.d. from the mean of the group in the direction of ambidexterity (ratio score of 50) was considered ambidextrous.

b The same as "a" above.

On each of these two handedness tests, the total group was then divided into a left-inclined group with scores of forty-nine and below and a right-inclined group with scores of fifty-one and above. Mean and standard deviation were computed separately for the right-inclined and the left-inclined group. Any subject exceeding one and one-half standard deviation from the mean in the direction of ambidexterity was considered mixed-handed and was included with the subjects who scored exactly fifty. Finally, results of both handedness tests had to be in agreement or the subject was classified as mixed-handed.

As a further measure of manual dominance, the subject was given one trial of cutting, writing, throwing, eating, hammering, batting, and kicking. Placement in the left control group was made if major motor activity employed the operation of the left hand, and in the right control group if the right hand carried on the major motor activity. There was crossed control when major motor activity was employed on both sides of the body. Assessments were made based on hand use, not preference.

Subjects, on the basis of dominance test results, were grouped into three dominance categories: unilaterally dominant, crossed dominant, and mixed dominant which included all subjects who were unclear in eye dominance, hand dominance, or both eye and hand dominance.

Scoring of the tests for the controlling eye resulted in placing subjects in one of three categories of control: left-corresponding control, right-corresponding control, or crossed control which included all subjects who exhibited one or more of the three following factors: a) lesser binocular efficiency for distant vision in the eye on the side of major motor use; b) lesser binocular efficiency in the act of reading on the side of major motor use; or c) significant ambidexterity.

Efficiency for distant vision in each eye was measured by percentage points, four being deducted for a completely missed response and two deducted for a corrected response. Speed of response, when markedly different in either eye, was also a consideration. When one eye scored six or more percentage points lower than the other, it was designated as the lesser efficient.

Near-point efficiency in each eye was determined by adding the seconds of elapsed reading time to the number of reading errors including reversals. When one eye scored nine or more points higher than the other, it was considered to be the less efficient.

These cut-off points were those established by the Berners in their research.

Those subjects which displayed visual problems, such as convergent vision, alternating vision, or monocular vision,

were placed in a special category and were not included in any statistical comparisons.

In addition to a total reading achievement score, a reading differential score was desired in which the factor of intelligence could be held constant. This score was attained in the following manner. The subject's chronological age was computed as of the testing month and the I.Q. determined by use of the California Test of Mental Maturity. With this data a reading expectancy was determined by means of the formula $CA + \frac{3(CA \times IQ)}{4} - 5$. Subtracting the actual reading expectancy yielded a figure which was the reading differential, plus or minus, for each subject.

This was in keeping with Hillerich's earlier study.

8. Treatment of the Data.

Significance of difference between the controlling eye and the sighting eye was determined by chi square. Changes in eye-hand dominance from second to eighth grade was also evaluated by chi square. This statistical method was also used to determine differences in eye-hand dominance patterns between male and female children.

Subjects were grouped into three dominance categories: unilaterally dominant, crossed dominant, and mixed dominant. Significance of difference in mean reading achievement and mean reading differential among the three dominance groups was determined by the t test.

A similar grouping, in terms of unilateral control and crossed control, allowed comparison of both reading achievement and reading differential for these groups. Again significance of difference in both mean reading achievement and reading differential was determined by the t test.

As a further check against differences among laterality groups, subjects were divided into two groups, those at and above grade level and those below grade level in reading achievement. Significance of difference in dominance characteristics and control characteristics of the two groups was determined by chi square.

To assure accurate replication of the Berners' study in terms of the Keystone testing, Mrs. Berner, who did the testing in that study, served as a consultant in training the investigator in use of the telebinocular. Results and their interpretation were reviewed by Dr. Hansi Patience, a Glenview, Illinois, ophthalmologist. Dr. Robert L. Hillerich, also to ensure accurate replication of his research, trained the investigator in the use and interpretation of the dominance tests administered to these subjects in kindergarten and second grade.

The following chapter details the findings which were the result of this testing.

CHAPTER III

FINDINGS

The purposes of this study were to investigate a possible distinction between the controlling eye in binocular vision and the dominant eye used in sighting, and to investigate the relationship between both hand-eye dominance and control characteristics with reading achievement and reading expectancy. A corollary investigation was made of a possible developmental trend away from mixed dominance as reported in an earlier study which followed the same population from kindergarten to mid-third grade.

1. Determination of Dominance.

To determine eye dominance, the V-Scope and hole-in-paper tests were administered five times each in kindergarten, in grade two, and again in grade eight. A minimum of eight of the ten responses was arbitrarily designated as establishing clear eyedness. Fewer than eight consistent preferences were considered an indication of unclear or mixed eyedness. While the rank order of each of the dominance characteristics was the same, there was a marked increase in the percentage of ambi-eyedness or mixed eyedness in eighth grade at the expense of both right eyedness and left-eyedness. This data would tend to remove support from Berner's contention that the

dominant eye used in sighting is developed shortly after birth and does not change throughout the growth and development of each individual unless altered by trauma. Table II shows the results of the eye dominance tests.

Hand dominance was tested in kindergarten, in grade two, and again in grade eight by means of a modified tapping test, using the B key on a typewriter. In grades two and eight, the connecting dots test was also administered to the subjects. In the case of both hand-dominance tests, raw scores were converted to ratio scores by means of the formula used by Hillerich in his study.¹ A ratio score of fifty represented exact equality of hand skill or ambidexterity. Subjects with ratio scores above fifty were considered right-inclined and those with scores below fifty were considered left-inclined. In the case of both the right-inclined group and the left-inclined group, one and one-half standard deviation from the mean in the direction of a score of fifty was established as the cut-off point between clear and mixed handedness. Handedness on both tests had to be in agreement or the subject was classified as mixed handed or ambidextrous. Results of the distribution of the ratio scores are reported in Table III.

¹ Ratio score = $\frac{(R)}{(R+L)} 100$, where R was the raw score for the right hand and L was the raw score for the left hand.

Table II.-
Results of Eye Dominance Tests.

Dominant Eye	Kindergarten		Grade 2		Grade 8	
	Number	Per cent	Number	Per cent	Number	Per cent
Right	232	58.00	240	60.00	148	54.21
Left	136	34.00	142	35.50	67	24.54
Mixed	32	8.00	18	4.50	58	21.25
Total	400	100.00	400	100.00	273	100.00

Table III.-

Distribution of Ratio Scores
on Grade Eight Handedness Tests.

Laberal Group	Tapping			Connecting Dots		
	Mean	S.D.	Cut-off	Mean	S.D.	Cut-off
Below 50	46.7	4.6	Below 50	40.92	4.24	Below 47
Above 50	52.83	1.26	Above 51	60.29	4.32	Above 54

The range of ratio scores was quite narrow on the tapping test, and a good deal wider on the connecting dots test as indicated in Table IV. The connecting dots test appeared to be the better test for the determination of handedness because the factors of both accuracy and speed were more clearly involved.

An examination of Table V evidenced that the decrease in percentage of right-handed children from kindergarten through grade two has continued through grade eight, while the percentage of ambidextrous children continued the increase that was noted between kindergarten and grade two. This would seem to make untenable Hillerich's observation that the increase noted in grade two was primarily the result of the inclusion of the connecting dots test.

Table VI shows the number and percentages of subjects in each dominance group in the three grades tested. Decreases that were evident from kindergarten to grade two in the unilateral and crossed dominant categories have continued into grade eight. The two mixed dominance categories which had shown a percentage increase from kindergarten to grade two continued their growth. The three other mixed dominance categories which had decreased slightly in grade two reversed this trend and displayed a noticeable increase in grade eight. These changes were the result of an increase of both mixed eyedness (Table II) and mixed handedness (Table V).

Table IV.-

Cut-offs for Handedness Tests at Grade Eight Based
on Hillerich's Criteria.

Test	Left-Handed	Ambidextrous	Right- Handed
Tapping Test	0-49	50-51	52-100
Connecting Dots Test	0-46	47-54	55-100

Table V.-
Results of Hand Dominance Tests.

Dominant Hand	Kindergarten		Grade 2		Grade 8	
	Number	Per cent	Number	Per cent	Number	Per cent
Right	330	82.50	304	76.00	121	44.32
Left	41	10.25	31	7.75	22	8.06
Mixed	29	7.25	65	16.25	130	47.62
Total	400	100.00	400	100.00	273	100.00

Table VI.-

Number and Percentage of Children in Each Dominance Group at Kindergarten, Grade Two and Grade Eight.

Eye-Hand Dominance	Kindergarten		Grade 2		Grade 8	
	Number	Per cent	Number	Per cent	Number	Per cent
Right-Right	197	49.25	187	46.75	75	27.47
Left-Left	17	4.25	15	3.75	8	2.93
Right-Left	17	4.25	12	3.00	6	2.20
Left-Right	112	28.00	105	26.25	29	10.62
Right-Mixed	18	4.50	41	10.25	67	24.55
Left-Mixed	7	1.75	22	5.50	28	10.26
Mixed-Mixed	4	1.00	2	0.50	33	12.09
Mixed-Right	21	5.25	12	3.00	17	6.22
Mixed-Left	7	1.75	4	1.00	10	3.66
Total	400	100.00	400	100.00	273	100.00

The final grouping of subjects, divided in terms of sex and based on the Hillerich dominance tests in grade two, together with the results from grade eight, is reported in Table VII. This data more emphatically presents the increase in the mixed dominance category from second to eighth grade, at the expense of a decrease in percentage of subjects in various unilateral and crossed dominance categories. There was an increase of 36.5% in mixed dominance subjects while the greatest decrease was in the unilaterally right dominant group with a loss of over 19%.

2. The Dominant Eye and the Controlling Eye.

A problem was encountered in attempting to identify the distinction between the dominant eye used sighting and the controlling eye used in binocular vision. While Hillerich presented very definite cut-offs to distinguish the dominant eye characteristics, thereby allowing a definite placement to be made, no such definite cut-offs were suggested by the Berners for determination of the controlling eye. The Berners' interest was in unilateral or crossed control with no allowance for a mixed controlling-eye category. Therefore, in evaluating the first hypothesis, this investigator was forced to make the following determinations of the controlling eye: subjects, who had been placed in the unilateral control group as a result of the Berner criteria and whose handedness

Table VII.-
 Eye-Hand Dominance of Subjects
 in Grade Two and Grade Eight.

Eye-Hand Dominance		Number			Per Cent
		Boys	Girls	Total	
R-R	Grade 2	87	100	187	46.75
	Grade 8	34	41	75	27.47
L-L	Grade 2	6	9	15	3.75
	Grade 8	5	3	8	2.93
R-L	Grade 2	4	8	12	3.00
	Grade 8	4	2	6	2.20
L-R	Grade 2	48	57	105	26.25
	Grade 8	14	15	29	10.62
Mixed	Grade 2	44	37	81	20.25
	Grade 8	65	90	155	56.78

was assessed to be right, were said to exhibit right controlling eyedness. By the same token, those subjects who were assessed to have unilateral control and whose handedness evaluation was left were placed in the group of left controlling eyed subjects. Subjects, who had been placed in a crossed control category based on the Berner criteria and whose visual efficiency in one eye exceeded the cut-off at one distance and not at the other distance, were placed in the mixed controlling eye category. Subjects who exceeded the Berner cut-offs for the left eye at both far-point distance and at near-point distance were placed in the left controlling eye category and similarly those whose right eye exceeded the cut-offs were placed in the right controlling eye category.

A data analysis was conducted to determine whether or not a distinction existed between the dominant eye and the controlling eye. The chi square test of significance was chosen. The region of rejection consisted of the values of chi square which had a probability associated with occurrence of .05 or less under the null hypothesis.

The dominant eye and controlling eye groups were established in three categories, in each of which the actual number of right-eyed, left-eyed, and mixed-eyed subjects were compared to an expected frequency based on a hypothesis of independence. Results are presented in Table VIII.

Table VIII.-

Computation of Chi Square to Determine Distinction
Between Dominant and Controlling Eye.

Observed Frequency (fo)		Expected Frequency (fe)		fo - fe		(fo-fe) ² /fe ratios	
Dominant Eye	Controlling Eye	Dominant Eye	Controlling Eye	Dominant Eye	Controlling Eye	Dominant Eye	Controlling Eye
147	152	149.5	149.5	-2.5	2.5	0.042	0.042
66	31	48.5	48.5	17.5	-17.5	6.314	6.314
60	90	75.0	75.0	-15.0	15.0	3.000	3.000

$$df = (3-1) (2-1) = 2 \quad x^2 = 18.712$$

FINDINGS

The value for chi square was found to be 18.712. The table for values of chi square revealed that the probability associated with obtaining a value as large as the observed value was better than .001 for two degrees of freedom with a two-tailed test. As a result, the first null hypothesis was rejected at the .05, .01, and .001 levels in favor of the research hypothesis: there is a significant distinction between the dominant eye used in sighting and the controlling eye used in binocular vision.

3. Crossed Dominance and Reading Achievement.

Subjects' reading achievement was based on the total reading score of the California Achievement Test administered at grade 8.2. The significance of difference in mean reading achievement between the group of crossed dominant and unilaterally dominant subjects was determined by the t test. The t tests in this study were based on the assumption that two independent random samples were taken from normal populations whose variances were not necessarily equal. The Smith-Satterthwaite test was used to test the null hypothesis. See Appendix 6.

Table IX presents a calculated t value of 0.1527 which, when compared to a table of t using a degree of freedom of 60.05, was less than 1.96. This test indicated acceptance of the null hypothesis at the .05 level: there is no significant

Table IX.-

A Comparison of Differences in Mean Reading Achievement
Between the Crossed Dominant Group and the
Unilateral Dominant Group.

Dominance	Number	Reading Achievement in Grade Equivalent		t	t.05
		Mean	Variance		
Crossed	35	9.8971	2.2579	0.1527	1.96
Unilateral	83	9.8518	1.9557		

difference in reading achievement between children of crossed dominance and those of unilateral dominance.

The comparison of mean reading achievement did not consider the influence of intelligence, per se. To minimize this influence a reading differential was computed by deducting each subject's reading achievement for an expected achievement based on his I.Q. A comparison of mean reading-differential scores between the crossed dominant and unilateral groups is shown in Table X.

4. Crossed Control and Reading Achievement.

The t test was also used to determine the significance of difference between the group of crossed control subjects as contrasted with the unilateral control group. Results are presented in Table XI.

The computed t of 1.7436 reported was less than the table value of 1.96 at the .05 level of significance using the degree of freedom 196.43. This test resulted in the retention of the null hypothesis: there is no significant difference in reading achievement between children of crossed control and those with unilateral control.

Again, to obviate the influence of subjects' I.Q., the data in Table XII, based on reading differential, was submitted to analysis by t test.

Table X.-

A Comparison of Differences in Mean Reading Differential
Between the Crossed Dominant Group and the
Unilateral Dominant Group.

Dominance	Number	Reading Differential in Grade Equivalent		t	$t_{.05}$
		Mean	Variance		
Crossed	35	0.3257	1.1449	0.7715	1.96
Unilateral	83	0.1674	0.7766		

Table XI.-

A Comparison of Differences in Mean Reading Achievement
Between the Crossed Control Group and the
Unilateral Control Group.

Control	Number	Reading Achievement in Grade Equivalent		$\bar{t}$	$\bar{t}.05$
		Mean	Variance		
Crossed	101	9.7227	2.1561	1.7436	1.96
Unilateral	172	10.0348	1.8390		

Table XII.-

A Comparison of Differences in Mean Reading Differential
Between the Crossed Control Group and the
Unilateral Control Group.

Control	Number	Reading Differential in Grade Equivalent		<u>t</u>	<u>t.05</u>
		Mean	Variance		
Crossed	101	.2703	1.0381	1.1057	1.96
Unilateral	172	.1290	1.0381		

The t value resulted in the acceptance of the premise that differences in mean reading differential between the two control groups were not significant at the .05 level using a degree of freedom of 209.04.

5. Mixed Dominance and Reading Achievement.

An effort was made to determine the difference in both mean reading achievement and reading differential for children exhibiting mixed dominance as contrasted with those of unilateral dominance by use of the t test. Results follow as Table XIII.

The two-tailed t test analysis, using a degree of freedom of 167-07, revealed that the mixed dominant group did not significantly differ in mean reading achievement from the unilateral group at the .05 level of significance. The null hypothesis was retained: there exists no significant difference at the .05 level between mixed and unilaterally dominant groups in terms of mean reading achievement.

To remove the influence of I.Q. on results, reading differential scores were computed. The comparison of mixed and unilaterally dominant pupils, in terms of reading differential, is reported in Table XIV. The t .05 value was determined using a degree of freedom of 197.52.

Table XIII.-

A Comparison of Differences in Mean Reading Achievement
Between the Mixed Dominant Group and the
Unilateral Dominant Group.

Dominance	Number	Reading Achievement in Grade Equivalent		$\bar{t}$	$\bar{t}_{.05}$
		Mean	Variance		
Mixed	155	9.9607	1.9383	0.5731	1.96
Unilateral	83	9.8518	1.9557		

Table XIV.-

A Comparison of Differences in Mean Reading Differential
Between the Mixed Dominant Group and the
Unilateral Dominant Group.

Dominance	Number	Reading Differential in Grade Equivalent		<u>t</u>	<u>t.05</u>
		Mean	Variance		
Mixed	155	0.1536	1.1506	-0.1075	1.96
Unilateral	83	0.1675	0.7766		

An analysis of the data provided by Tables XIII and XIV necessitated the acceptance of the fourth hypothesis at the .05 level: there was no significant difference in reading achievement between children of mixed dominance and those of unilateral dominance.

In a further effort to discover a possible relationship between dominance and reading achievement as presented by the second, third, and fourth hypotheses, all subjects who scored below their grade norm of 8.2 were compared, in terms of percentages in each dominance group, with the percentages in those same dominance groups of subjects who scored at or above grade level. The results are reported in Table XV.

Table XV reveals a slight tendency for subjects below grade level in reading achievement to represent a larger percentage of crossed dominance when compared to those above grade level, while the above-grade-level subjects exhibit a greater percentage of mixed dominance as compared to those below grade level. Chi square was used to determine the significance of this finding. The three dominance groups reported in Table XV were established in three categories, in each of which the actual number of subjects below grade level was compared with those at or above grade level.

Table XV.-

Eye-Hand Dominance of Subjects Below Grade Level in Total Reading Score Compared with the Dominance of Subjects At or Above Grade Level.

Dominance	<u>Below 8.2</u>		<u>At and above 8.2</u>	
	Number	Per cent	Number	Per cent
Unilateral	11	32.35	73	30.04
Mixed	17	50.00	139	57.20
Crossed	6	17.65	31	12.76
Total	34	100.00	243	100.00

Table XVI reveals a chi square of .005 which compared to 5.991, the value given in the chi square table for the .05 level of significance at a degree of freedom of 2, indicates no significant difference in the groups.

6. Dominance Difference Between Children
in Second and Eighth Grade.

The results of a statistical analysis of the data relating to the fifth hypothesis, i.e., that there is no significant difference in the eye-hand dominance pattern of children between second and eighth grade, would lack reliability without an evaluation of the dominance characteristics of subjects who were dropped from the second grade population as a result of the re-location of family residences. A comparison of subjects dropped and those retained in the study at eighth grade, in terms of dominance characteristics as tested at grade two, is presented in Table XVII.

The greatest disparity shown in the table exists in the right-mixed dominance group, which offers a difference in percentage between subjects remaining and those dropped of only 5.41.

As further evidence of the similarity of both groups, Table XVIII lists the percentages in each of the three dominance categories under consideration.

Tables XVII and XVIII indicate that, while optimum condition of the presence of all second grade subjects in

Table XVI.-

Computation of Chi Square to Determine Difference in Dominance
Between Subjects Below Grade Level in Total Reading Score
Compared with the Subjects At or Above Grade Level.

Observed Frequency (fo)		Expected Frequency (fe)		fo - fe		(fo-fe) ² /fe ratios	
At or Above Grade Level	Below Grade Level	At or Above Grade Level	Below Grade Level	At or Above Grade Level	Below Grade Level	At or Above Grade Level	Below Grade Level
73	11	73.7	10.3	- .7	.7	.007	.047
139	17	136.9	19.1	2.1	-2.1	.032	.230
31	6	32.5	4.5	-1.5	1.5	.069	.511

$$df = (3-1) (2-1) = 2 \quad x^2 = .885$$

Table XVII.-

Eye-Hand Dominance Characteristics of Grade Two Subjects Who
Remained in the Grade Eight Study as Compared to Those
Dropped from the Study.

Eye	Hand	Total in Grade Two	Subjects Remaining	Subjects Dropped	Remaining; Per cent in each category	Dropped; Per cent in each category
Right	Right	187	132	55	47.65	44.72
Right	Left	12	5	7	1.81	5.69
Right	Mixed	41	33	8	11.91	6.50
Left	Left	15	6	9	2.17	7.32
Left	Right	105	76	29	27.44	23.58
Left	Mixed	22	15	7	5.41	5.69
Mixed	Mixed	2	2	0	0.72	0.00
Mixed	Right	12	5	7	1.81	5.69
Mixed	Left	4	3	1	1.08	0.81
Total		400	277	123	100.00	100.00

Table XVIII.-

Comparison of Unilateral, Crossed, and Mixed Dominant Groups
in Terms of Percentage Dropped or Retained from the
Original Grade Two Study.

Dominance	Remaining: Per cent in each category	Dropped: Per cent in each category
Unilateral	49.82	52.04
Crossed	29.25	29.27
Mixed	20.93	18.69
Total	100.00	100.00

grade eight was not in existence, the percentage of subjects dropped was reasonably in keeping with the percentage remaining in the study, thereby obviating the concern that subjects remaining in grade eight were not a true sample of the original population from grade two.

The decrease in mixed eyedness between kindergarten and grade two, as reported by Hillerich, was found to reverse itself in grade eight, and the mixed handedness increase reported by the same author showed a rapid acceleration in grade eight, as noted in Tables II and V respectively.

The three dominance groups reported in Table XV were established as three categories in each of which the same children, both as second grade subjects and eighth grade subjects, were compared with an expected frequency to determine whether or not dominance characteristics of these subjects had changed. Results of this comparison are reported in Table XIX.

The computed chi square of 72.255 when compared to 13.815, which was the largest chi square value given for the .001 level at a degree of freedom of 2, was regarded as extremely significant and the hypothesis of no difference between the two groups in terms of dominance characteristics must be rejected.

Table XIX.-

Computation of Chi Square to Determine the Difference in
Dominance Characteristics Between Grade Two and
Grade Eight.

Observed Frequency(f_o)		Expected Frequency(f_e)		$f_o - f_e$		$(f_o - f_e)^2 / f_e$	
Second Grade	Eighth Grade	Second Grade	Eighth Grade	Second Grade	Eighth Grade	Second Grade	Eighth Grade
136	83	109.5	109.5	26.5	-26.5	6.413	6.413
59	155	107.0	107.0	-48.0	48.0	21.533	21.533
78	35	56.5	56.5	21.5	-21.5	8.181	8.181

$$df = (3-1) (2-1) = 2 \quad \chi^2 = 72.255$$

7. Dominance Differences Between Male and Female Subjects.

A generally accepted premise has been that because female students are more apt than male subjects to engage in small muscle activity, they are also more likely to establish handedness earlier and more firmly. This prompted the effort to determine a relationship between the eye-hand dominance patterns of boys and girls.

Chi square was used to test the significance of difference. The three dominance groups reported in Table XV were again established as three categories in which the actual number of male and female subjects was compared. Results are reported in Table AA.

Rejection of this sixth hypothesis required a chi square of greater than 5.991 to be significant at the .05 level with two degrees of freedom. The chi square of 1.296 is considerably less than significant, leading to acceptance of the hypothesis: there is no significant difference in the eye-hand dominance patterns of male and female children.

The succeeding pages offer an interpretation of these findings and suggest some possible areas for future research.

Table XX.-

Computation of Chi Square to Determine the Difference in
Dominance Characteristics Between Male and Female
Students in Grade Eight.

Observed Frequency (fo)		Expected Frequency (fe)		fo - fe		(fo-fe) ² /fe ratios	
Male	Female	Male	Female	Male	Female	Male	Female
39	44	37.092	45.908	1.908	-1.908	0.098	0.079
65	90	69.267	85.733	-4.267	4.267	0.263	0.212
18	17	15.641	19.359	2.359	-2.359	0.356	0.287

$$df = (3-1) (2-1) = 2 \quad \chi^2 = 1.296$$

CONCLUSIONS AND RECOMMENDATIONS

1. Summary.

A total of 277 subjects were involved in an investigation of the possible distinction between the controlling eye in binocular vision and the dominant eye used in sighting, and in an investigation into the relationship between both hand-eye dominance and control characteristics in regard to reading achievement and reading differential. A corollary investigation was made of a possible developmental trend away from mixed dominance as reported in an earlier study which followed this same population from kindergarten to mid-third grade.

The subjects were administered two eye-dominance tests, the V-Scope and the hole-in-paper test, in grade eight. The controlling eye was determined at both far-point and reading distances by the use of the Keystone Telebinocular.

A modified tapping test and a connecting dots test were administered. Further determination of handedness was made by observing the subjects in the act of writing, throwing, eating, hammering, batting, and kicking.

The California Short-Form Test of Mental Maturity was used to determine the reading expectancy and the California Achievement Test assessed reading achievement.

On the basis of the tests for control, the subjects were divided into three groups: unilateral control, crossed control, and visual problems. Using the dominance tests, subjects were placed into three groups also: unilateral dominance, mixed dominance, and crossed dominance.

The t test was used to determine significance of differences in reading achievement and reading differential between crossed and mixed dominant groups as compared with the unilaterally dominant group and between the crossed control group as compared with the unilateral control group.

Chi square was used to identify differences in dominance configurations of subjects below grade level in reading as compared with those at and above grade level. Significance of differences between the controlling eye and the dominant eye was determined by chi square as were changes in eye-hand dominance from second to eighth grade. This statistical method was also used to determine the differences in eye-hand dominance patterns between males and females.

2. Conclusions.

As a result of these investigations, the following hypotheses failed to be rejected at the .05 level:

1. There is no significant difference in reading achievement between children of crossed dominance and those of unilateral dominance.

2. There is no significant difference in reading achievement between children evidencing crossed control and those with unilateral control.
3. There is no significant difference in reading achievement between children of mixed dominance and those of unilateral dominance.
4. There is no significant difference in the eye-hand dominance patterns between male and female children.

The following hypotheses were rejected at the .05 level:

1. There is no significant distinction between the dominant eye used in sighting and the controlling eye used in binocular vision.
2. There is no significant difference in the eye-hand pattern of children between second and eighth grade.

3. Interpretation.

Any study of laterality is weakest at its very base: the tests used to determine laterality are not conclusively validated. In this study, tests were selected which had been used in earlier studies by Hillerich and by Berner.

The rejection of the first hypothesis, comparing dominant eye status of subjects with that of their controlling eye, was based on this investigator's subjective identification of the controlling eye as indicated by Berner's general description of control. The Berner research determined the general control status but did not present cut-offs for determination of the controlling eye specifically. This

acknowledgment might debilitate the power of the rejection of this hypothesis.

Rejection of the second hypothesis was based on the findings regarding both eye and hand dominance.

Use of the tapping test and connecting dots test replicated from Hillerich's study, supported the brief that handedness is a matter of degree, ranging from exact equality of hand to extreme differences in skill with the right or left hand. Based on Hillerich's tests, right-handed subjects have decreased in number by 31.68 per cent in grade eight from grade two and the ambidextrous subjects have increased by nearly the same amount. This finding is in opposition to the premise that the dominant hand develops rather early in life and strengthens in preference thereafter. This finding might be explained by the fact that as children grow and develop, they actually become less dependent upon their dominant hand and motor activity becomes more diversified. This greater diversification of motor activity may have resulted in the increase of children in the ambidextrous category.

Using the V-Scope and the hole-in-paper test to determine eye dominance, there was identified a marked increase in the percentage of mixed eyedness in grade eight at the expense of right-eyed and left-eyed subjects. This data would tend to remove support from Berner's contention that

the dominant eye used in sighting is developed shortly after birth and does not change throughout the life of each individual unless altered by trauma.

The results of the dominance testing in eighth grade indicated that twenty-seven per cent of the population was unilaterally right dominant, while slightly better than half was in the mixed dominant category. These findings were rather inconsistent with those of other investigators because of the emphatic increase in mixed dominant subjects.

The suspicion that a longitudinal study might disclose a trend away from mixed dominance was not confirmed by this study. In comparing the results of dominance testing in grade eight with those in grade two, the investigator found that the mixed dominance category showed an increase of ninety-six and the unilaterally dominant group a decrease of fifty-three. This removed support from the prediction of Hillerich, based on his identification of a decrease of mixed eyedness between kindergarten and second grade, that a further decrease might be noticed in these subjects by grade eight.

A possible limitation developed from the longitudinal facet of this study. The sample used was only a part of the original sample tested in kindergarten and second grade with 277 subjects remaining from the original number of four hundred. The effect of this limitation was diminished after

a comparison of the percentages of remaining subjects and dropped subjects in each dominance category revealed differences that failed to invalidate the results.

It was established by Hillerich that a larger percentage of boys was mixed dominant and below grade level in reading. This fact suggested a possible explanation for the relationship found by some other investigators between mixed dominance and reading disability: usually studies reporting a relationship between these two factors were studies of boys. This prompted the inclusion of a sixth hypothesis comparing eye-hand dominance patterns between males and females in grade eight.

Although it seems probable that boys, because of the more varied and more gross physical activity, were later in developing established handedness, analysis of the data evidenced that the differences were not significant at the eighth grade level. This finding would suggest that slower development of handedness in boys and their comparative lack of readiness to begin reading may have no other relationship than co-existence.

It was readily apparent that in the sample investigated, dominance was not a significant factor in reading achievement. The factor of intelligence was obviated by the finding that differences in reading differential between the dominance groups were not significant. This result

certainly buttresses the earlier findings of Hillerich with the same sample.

Further support and reinforcement for this conclusion came from the ascertainment that the dominance configuration of subjects below grade level in reading did not significantly differ from those at or above grade level.

Control characteristics were also found to be non-significant factors in both reading achievement and reading differential. This result with these subjects was contrary to the finding of the Berners that crossed control was an extremely significant and causative factor in reading disability. As a possible explanation for this discrepancy, it is noted that Berners' results were based on retarded readers in a clinical setting while the sample for this study was drawn from a normal school population.

While the group of 277 subjects was a sufficiently large sample, other factors might have had a limiting effect on this study. The subjects were generally well above the national norms in both reading achievement and intelligence. Furthermore, their home and school environments were academically richer. While these factors had no apparent effect on dominance itself, the question arises as to whether the richer background helped to overcome some presumed handicap of dominance.

4. Recommendations.

As a result of findings reported in this study, the following recommendations are suggested:

1. Because of the definite lack of agreement among investigators in the area of dominance and reading, further studies into the causes of reading disability might prove more fruitful if conducted in an area other than that of dominance.
2. Probative efforts should be made into the effect of the decussation of the optic nerve allowing the right retinal fibers of both eyes to terminate solely in the right cerebral hemisphere and the left retinal fibers of both eyes to terminate solely in the left cerebral hemisphere. Disquisition of this rarely referred to neurological premise might discredit future dominance research.
3. Previous studies attempted to identify a relationship of crossed control to reading disability but further efforts should be expended to determine the effect of the controlling eye discrepancies at varied distances.
4. This study suggested a difference between clinical and public school studies in relating dominance and control characteristics to reading disability. Other studies should attempt to investigate this divergence further.
5. This study offered evidence of definite changes in dominance status over a nine-year period. Other longitudinal studies could contribute to research by identifying changes in control as well as dominance status.
6. Visual acuity has been discounted in previous research as a measure of eye dominance. A question might be raised regarding the visual acuity of a given eye and its role of control in binocular vision.

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Ball, R.J., "Visual Functioning in Reading Disability", in Education, Vol. 82, No. 3, November 1961, p. 175-178.

The author reported the testing of two hundred children at the Reading Center at Michigan State University and suggested the advisability of a complete visual analysis by a vision specialist before being seen by a reading specialist. Of questionable use because of the gross measuring device used.

Balow, Irving H., "Lateral Dominance Characteristics and Reading Achievement in First Grade", in Journal of Psychology, Vol. 55, No. 2, April 1963, p. 323-328.

A presentation of the relationship between hand dominance, eye dominance, directionality, and reading achievement. A better recent contribution to the literature.

Barbe, Walter B., Virginia Gannaway, and Thelma Williams, "Factors Contributing to Reading Difficulties", in School and Society, Vol. 85, No. 2117, October 12, 1957, p. 285-286.

This investigation found a constellation of anomalies in the retarded readers receiving remedial reading instruction at the Junior League Reading Center of the University of Chattanooga. A clinical approach.

Barger, William C., "An Experimental Approach to Aphasic and to Non-Reading Children", in American Journal of Orthopsychiatry, Vol. 23, January 1953, p. 158-170.

A school psychologist of the Board of Education, City of New York, drew inferences from a number of case studies of aphasics and non-readers. Limited by the number of subjects.

Beck, Harry S., "The Relationship of Symbol Reversals to Monocular and Binocular Vision", in Peabody Journal of Education, Vol. 38, November 1960, p. 137-142.

A well-planned and controlled statistical study of forty-four second grade children. The result of this research involving public school students was a bit weakened by a limited sample.

Beeley, Arthur L., An Experimental Study of Left-Handedness, Chicago, University of Chicago Press, 1918, 74 p.

A study of forty-two "pure mirror writers" revealed that all were left-handed. This report also included a discussion of the reliability of certain handedness tests.

Belmont, Lillian and Herbert G. Birch, "Lateral Dominance, Lateral Awareness, and Reading Disability", in Child Development, Vol. 36, No. 1, March 1965, p. 57-71.

This was a report of research on a public school population in Aberdeen, Scotland, in which laterality was not found to be significantly related to reading disability. Statistically reliable.

-----, "Lateral Dominance and Right-Left Awareness in Normal Children", in Child Development, Vol. 34, No. 2, June 1963, p. 257-270.

These researchers discovered no etiological association between visual discrimination, right-left awareness, and preferential hand or eye usage. This study was based on a comprehensive investigation of the subjects' laterality status.

Bennett, Annette, "An Analysis of Errors in Word Recognition Made by Retarded Readers", in Journal of Educational Psychology, Vol. 33, January 1942, p. 25-28.

An analysis of 34,274 errors in reading reported to the author by tutors indicated that the reversal of initial consonants and of whole words accounted for twelve per cent of all errors in reading.

Bennett, C.C., An Inquiry into the Genesis of Poor Reading, New York, Bureau of Publications, Teachers College, Columbia University, 1938, vii-137 p.

A statistical investigation into the problem of laterality related two matched groups of fifty children, one of retarded readers and the other of normal readers. No significant difference was found in this recommended piece of research.

Benton, Arthur L., "The Problem of Cerebral Dominance", in The Canadian Psychologist, Vol. 6a, No. 4, October 1965, p. 332-348.

This author presented a good background regarding the concern for dominance from antiquity. Considered contributions of neurosurgery and neurology as well as the subject of manual dexterity.

Benton, A.L. and F.L. Menefee, "Handedness and Right-Left Discrimination", in Child Development, Vol. 28, June 1937, p. 237-242.

This report searched for a relationship between laterality and directionality. There was found an association between right-left awareness and established laterality.

Benton, Curtis D., James W. McCann, and Marguerite Larson, "Dyslexia and Dominance", in Journal of Pediatric Ophthalmology, Vol. 2, July 1965, p. 53-57.

Two ophthalmologists and one registered nurse examined 250 children with reading disability and normal intellectual endowments for abnormalities of their binocular function and eye-hand dominance. They found all subjects with either crossed eye-hand dominance or greater than the normal amount of retinal rivalry. Used with reserve.

Berner, George E. and Dorothy E. Berner, "Reading Difficulties in Children", in Archives of Ophthalmology, Vol. 20, November 1938, p. 829-838.

In an investigation of better than five hundred patients, the two authors revealed a difference between the dominant eye used in monocular vision and the controlling eye in binocular vision. They suggested that it was the controlling eye that, when on the side opposite the dominant hand, resulted in difficulty in learning to read. Important to this study.

-----, "Relation of Ocular Dominance, Handedness, and the Controlling Eye in Binocular Vision", in A.M.A. Archives of Ophthalmology, Vol. 50, November 1953, p. 603-608.

The authors treated 353 patients with crossed control by shifting their eye control to the side of their dominant hand. Improvement in reading skills was reported in each instance. Relevant to this study.

Berner, George E., Dorothy E. Berner, Walter M. Uhler and Marguerite B. Horn, A Clinical Investigation of Crossed Control in a Residential Treatment Center, a printed report of the Devereaux Schools, Devon, Pennsylvania, The Devereaux Schools, 1963, 1-14 p.

The clinical observation of 750 children with family-academic problems resulted in the declaration that treatment of crossed control in the Berner manner leads to improved academic achievement and general progress.

Berner, George E., Dorothy E. Berner, Walter H. Uhler and Marguerite B. Horn, Treatment of Visual and Visual Motor Problems in the Mentally Deficient, a paper presented at the Eighty-Seventh Annual American Association for Mental Deficiency, Devon, Pennsylvania, The Devereaux Schools, 1963, 1-10 p.

Among the seven major helps from the eye care education team serving a group of children with some degree and type of retardation was the use of monocular vision for reading when necessary and the development of good binocular vision and convergence where possible. A functional explanation.

Bergman, Hazel H., "Neural Confusion and Academic Failure", in Education, Vol. 81, No. 6, February 1962, p. 362-365.

A description of neural confusion or reversals and its possible effect upon the state of letter-sound association ability in the elementary school child. This was not a statistical presentation.

Blake, M.B. and Walter F. Dearborn, "The Improvement of Reading Habits", in Journal of Higher Education, Vol. 6, No. 2, February 1935, p. 83-88.

This piece dealt with the diagnosis and treatment of reading problems among 477 Smith College freshmen placed in two groups: a reading disabled group and a control group of normal readers. A relationship of both crossed dominance and anisometropia with retarded reading was reported.

Bond, Guy L. and Miles A. Tinker, "Lateral Dominance", in Reading Difficulties: Their Diagnosis and Correction, New York, Appleton-Century-Crofts, Inc., 1957, p. 99-103.

A very easily understood and complete depiction of a cardboard V-scope is offered in a review of research included herein. This was a valuable contribution to this study.

Bryngelson, Bryng, "Laterality of Stutterers and Normal Speakers", in Journal of Social Psychology, Vol. 2, February 1940, p. 151-155.

An association between speech defectives and sinistrals and/or ambidextrousness was identified. A very noticeable relationship was noticed between lack of unilaterality and stuttering when comparing matching groups of seventy-eight young adults. Findings were based on an atypical population.

-----, "Sidedness as an Etiological Factor in Stuttering", in Journal of Genetic Psychology, Vol. 47, No. 1, September 1935, p. 204-217.

This author after examining seven hundred clinical stuttering patients found the lack of one-sidedness a very

serious condition as writing, speaking, and reading have unilateral lead representation. As was true with his later study reported above, the sample used was atypical.

Campbell, Sister St. Francis, "Neurological Approach to Reading Problems", in Catholic Educational Review, Vol. 63, No. 1, January 1965, p. 28-34.

In an attempt to support or negate Delacato's hypothesis of neurological re-education, this author investigated five hundred patients, both normal and disabled in reading, speech, and writing. She imparted knowledge of the Archdiocese of Chicago's school system's efforts in neurological re-education.

Castner, Burton M., "Handedness and Eyedness of Children Referred to a Guidance Center", in The Psychological Review, Vol. 3, No. 8, June 1939, p. 99-112.

The author described his attempt to relate reading problem cases with the laterality status in 160 adjustment cases referred to the Yale Clinic of Child Development compared to seventy-three neglected children referred for commitment to state care. Cautious acceptance of the conclusions because of the abnormality of both the experimental and the control groups.

Capobianco, R.J., "Ocular-Manual Laterality and Reading in Adolescent Mental Retardates", in American Journal of Mental Deficiency, Vol. 70, No. 5, March 1966, p. 781-785.

This research presented the relationship of reading achievement between a group of subjects with established laterality and one with non-established laterality. The fifty-eight subjects were adolescent mental retardates in a full day program at a research center. The determination of laterality preference in this type of subject appeared to possess dubious practical value.

Coons, J.C. and R.J. Mathias, "Eye and Hand Preference Tendencies", in Pedagogical Seminary and Journal of Genetic Psychology, Vol. 35, December 1928, p. 629-632.

This writer concluded that visual acuity did not determine eye preference as tested by the Snyder Test of Eye Preference in her sample of 112 high school students. This agrees with the majority of research in this area.

Crider, Blake, "A Battery of Tests for the Dominant Eye", in Journal of General Psychology, Vol. 31, December 1928, p. 629-632.

The tests, administered to one thousand subjects over a ten-year period, indicated a reliability of .98 to .99. The

author concluded that distance in testing and the use of the dominant hand had no appreciable effect on results.

Crider, Blake, "Eye-Closure Facility and Eye Dominance", in Journal of Genetic Psychology, Vol. 58, Second Half, June 1941, p. 425-426.

After studying the eye-closure behavior of 499 children, the writer concludes that the relationship between eye-closure behavior and the dominant eye was not sufficiently high to substitute such a test for a sighting test of eye dominance. Reliable.

-----, "The Lack of Cerebral Dominance as a Cause of Disability in Reading", in Childhood Education, Vol. 10, February 1934, p. 238-239 and 270.

A discussion of the evolution of a theory of lateral dominance jointly shared by Orton and Dearborn. The writer concluded that the theory was drawn from clinical case studies and, therefore, must be accepted with reservation.

-----, Ocular Dominance: Its Nature, Measurement, and Development, an unpublished doctoral thesis, Department of Psychology, Western Reserve University, 1934, ix-187 p.

This report referred to an often neglected factor in laterality, i.e., although the nerve paths from the hands and feet to the brain completely cross and terminate in the opposite cerebral hemisphere, retinal nerve pathways do not follow this pattern. This is a very relevant consideration.

-----, "Certain Visual Functions in Relation to Reading Disabilities", in Elementary School Journal, Vol. 35, No. 4, December 1934, p. 295-297.

The findings indicated that eye-muscle imbalance, alternating vision, lack of fusion, and ocular dominance in sighting were in some way related to hemispherical dominance. Accepted with reservation.

-----, "The Relationship of Eye Muscle Balance to the Sighting Eye", in Journal of Experimental Psychology, Vol. 18, No. 1, February 1935, p. 152-154.

Two hundred fifty-seven subjects with eye muscle insufficiency or squint were examined and the data overwhelmingly supported the theory that the dominant sighting eye was that one with the greatest muscle sufficiency. Cautious use because of the atypical subjects.

Crosland, H.R., "Superior Elementary-School Readers Contrasted with Inferior Readers in Letter-Position, 'Range of Attention' Scores", in Journal of Educational Research, Vol. 32, February 1939, p. 410-427.

The author used a sample of thirty-four defective readers and thirty-one superior readers to conclude a relationship between visual fields and eye dominance. Accepted with question because of the I.Q. variable--defectives' mean was 97, the superiors' mean was 127.

Cuff, M.B., "Study of Eyedness and Handedness", in Journal of Experimental Psychology, Vol. 14, No. 2, April 1931, p. 164-175.

With a group of 237 elementary school children and one of 109 college students, the writer used three tests of eye dominance and nine tests of hand dominance to identify an association between eyedness and handedness. Introduced winking as one test of eyedness.

Davidson, Helen P., "A Study of Reversals in Young Children", in Pedagogical Seminary and Journal of Genetic Psychology, Vol. 45, December 1934, p. 452-465.

The author administered a series of reversal tests to 170 kindergarten and first-grade children and declared that reversals are natural for young children. These errors decreased with advancement in mental and chronological age. A rather complete study of the subject at this grade level.

Dearborn, Walter F., "The Nature and Causation of Disabilities in Reading", in Recent Trends in Reading, Supplementary Educational Monograph, No. 49, Chicago, University of Chicago Press, 1939, p. 103-110.

In this clinical study of two hundred children referred to the Harvard Psycho-Educational Clinic, it was reported that visual acuity, eye movement, and muscular imbalance had been eliminated as etiological factors in reading disability. A relationship was found between laterality differences and reading deficiency.

-----, "The Nature of Special Abilities and Disabilities", in School and Society, Vol. 31, No. 799, May 10, 1930, p. 632-636.

A discussion of the value of dextrad and sinistrad movements of the eye and hand in reading and writing. Lacked statistical support.

Dearborn, Walter F., "Ocular and Manual Dominance in Dyslexia", in Psychological Bulletin, Vol. 28, No. 9, November 1931, p. 704.

A preponderance of left-eyedness and mixed or unclear conditions of ocular and manual dominance were found to be characteristics of one hundred subjects having extreme difficulty in learning to read. Inadequate, short description of the subjects and measurement tools.

-----, "Teaching Reading to Non-Readers", in Elementary School Journal, Vol. 30, 1929, p. 266-269.

Correlates reversals with left-handedness and left-eyedness, and alterations of correct sequence of letters with unclear or mixed dominance of hand and eye. Accepted with reservation.

deHirsch, Katrine, Jeanette J. Jansky and William S. Langford, "Early Prediction of Reading Failure", in Bulletin of the Orton Society, Vol. 16, 1966, p. 1-12.

Predictions of reading failure were based on twenty years of experience working with children referred for a variety of oral language deficits to the Pediatric Language Disorder Clinic, Columbia-Presbyterian Medical Center. Interesting use made of local tests reflecting postulates of Piaget, Gesell, and Werner.

Delacato, Carl H., The Diagnosis and Treatment of Speech and Reading Problems, Springfield, Illinois, Charles C. Thomas, 1963, x-185 p.

This work was subsequent to his earlier book The Treatment and Prevention of Reading Problems and drew conclusions from examining five hundred severely brain-injured children, 500 brain-injured adults, 100 post-operative neurological patients, 200 deceased lab rabbits, 600 children with speech and/or hearing problems, and 800 normal children. Not a statistical study.

-----, "Ontogeny of Reading Problems", in Claremont Reading Conference Yearbook, Vol. 27, 1963, p. 119-125.

Presented the development of the bilateral pattern from birth to maturity, from homolaterality and biocularly to bilaterality and binocularly. An interesting presentation.

-----, The Treatment and Prevention of Reading Problems, Springfield, Illinois, Charles C. Thomas, 1959, vii-110 p.

The author's major contribution to the subject of man's neurological organization. Suggested man's development ontogenetically recapitulates the phylogenetic development of the nervous system. Offered many case studies to support his views.

Dreifuss, F.E., "Delayed Development of Hemispheric Dominance", in Archives of Neurology, Vol. 8, No. 5, 1963, p. 510-514.

Four patients were presented in whom speech development was markedly delayed and who had poorly developed hand preference, all indicating evidence of bilateral hemisphere disease. Reserve judgment on findings of merely four subjects.

Drews, Elizabeth H., The Significance of the Reversal Error in Reading, unpublished doctoral dissertation, University of Michigan, 1954, 187 p.

The author found no significant relationship between reading, which was held a constant, and dominance or reversals. A reliable source.

Durrell, Donald Dewitt, Reading Disability in the Intermediate Grades, unpublished doctoral dissertation, Graduate School of Education, Harvard University, 1930, 163 p.

This was a clinical study of 1,130 children in the Harvard Growth Study directed by W.F. Dearborn. Retarded reading was more frequent among those with normal or superior intelligence than among dull children. A statistical evaluation.

Durost, W.N., "The Development of a Battery of Objective Group Tests of Manual Laterality, with the Results of Their Application to Children", in Genetic Psychology Monographs, Vol. 16, No. 4, October 1934, p. 223-335.

From the presented data, the investigator concluded that handedness, as measured by the push-pin test, target test, treasure test, and escape test, was essentially unitary and not specific to the type of test. A sample of 1,300 children.

Dyer, D.W. and E.R. Harcum, "Visual Perception of Binary Patterns by Pre-School Children and by School Children", in Journal of Educational Psychology, Vol. 52, No. 3, June 1961, p. 161-165.

Fewer errors in the right visual hemifield were made by school children than among pre-schoolers. This would seem to be because of reading instruction rather than maturation. Used with restraint.

Eames, T.H., "The Anatomical Basis of Lateral Dominance Anomalies", in American Journal of Ophthalmology, Vol. 4, October 1934, p. 524-528.

Mixed dominance was found to be more common among one hundred reading disability cases than among one hundred unselected school cases, both groups of equal age and time spent in school. A fair source.

Kames, T.H., "A Comparison of the Ocular Characteristics of Unselected and Related Disability Groups", in Journal of Educational Research, Vol. 25, No. 3, March 1932, p. 211-215.

One hundred forty-three reading disabled cases at the Harvard Psycho-Educational Clinic were found to have eyes more exophoric at the reading distance than a group of unselected school children. The difference is highly reliable statistically.

-----, "The Influence of Hypermetropia and Myopia on Reading Achievement", in American Journal of Ophthalmology, Vol. 39, No. 3, March 1955, p. 375-376.

Refractive errors were found to have little statistical influence on the reading achievement of pupils doing passing work. This study was limited by the small number of cases after being subdivided according to the various conditions studied.

Farris, L.P., "Visual Defects as Factors Influencing Achievement", in California Journal of Secondary Education, Vol. 10, No. 1, October 1934, p. 50-51.

A survey of 364 seventh-grade pupils gave evidence that children with defects in visual acuity were not always handicapped with respect to the learning of reading. This study was used with reservation.

Fendrick, Paul, Visual Characteristics of Poor Readers, New York, Bureau of Publications, Teachers College, Columbia University, 1935, 1-55 p.

No significant difference was found between a group of sixty-four retarded readers and a control group of normal children, both composed of second and third grade children, examined for laterality and visual perception. A relevant study for this report.

Fink, W.H., "The Dominant Eye: Its Clinical Significance", in A.M.A. Archives of Ophthalmology, Vol. 19, No. 9, April 1938, p. 555-582.

This study included an early description of the operation of the dominant eye in binocular vision. This work was an important basis of Berners' contribution which was replicated in this study.

Forrest, E.B., "Vision and the Vision Process", in Education, Vol. 62, No. 5, January 1962, p. 299-301.

This contribution considered vision as an integrative process; i.e., the operation of the sense receptor and the brain which decodes, stores, coordinates, integrates, monitors, and suppresses visual impulses. This was not a statistical presentation.

Gahagan, Lawrence, "Visual Dominance-Acuity Relationships", in Journal of General Psychology, Vol. 9, No. 2, October 1933, p. 455-459.

The testing of the visual acuity and ocular dominance of one hundred undergraduate university students disclosed that superior visual acuity of a given eye was not indicative of a corresponding dominance. The sample did not include individuals of indefinite ocular dominance.

Gates, Arthur and Chester C. Bennett, Reversal Tendencies in Reading, New York, Bureau of Publications, Teachers College, Columbia University, 1933, 33 p.

This work failed to disclose an association between reversal errors and mixed hand-eye dominance or left hand-eye dominance. Significant.

Gates, Arthur I. and Guy L. Bond, "Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading", in Journal of Educational Psychology, Vol. 27, No. 6, September 1936, p. 450-456.

Data obtained from 242 first graders, older normal readers, and older reading problems, connoted no consistent tendency for eye dominance, single eye superiority in acuity, hand dominance, or any combination thereof to be related to reading achievement or reversals. Highly regarded.

Gesell, Arnold and Louise B. Ames, "The Development of Handedness", in Journal of Genetic Psychology, Vol. 70, Second Half, June 1947, p. 155-175.

The systematic Yale developmental examination revealed that handedness was a symptom of the current status of an ever-changing action system. Handedness was, in other words, a process of growth. Excellent documentation at short intervals.

Gilkey, Beulah G. and Frank W. Parr, "An Analysis of the Reversal Tendency of Fifty Selected Elementary-School Pupils", in Journal of Educational Psychology, Vol. 35, May 1944, p. 284-292.

The authors examined 324 elementary school children for reversal tendencies and found them present in children with all degrees of intelligence. They suspected emotional imbalance as one principal cause of the reversal tendency. Exhaustive testing was done.

Goldberg, Herman K., "The Ophthalmologist Looks at the Reading Problem", in The American Journal of Ophthalmology, Vol. 47, No. 1, January 1959, p. 67-74.

The observations, based on a study of one hundred reading problems, suggested that refractive errors and muscle

imbalance played only a minor part in the problem reader. By causing fatigue they may indirectly discourage reading. A reliable contribution.

Groff, P.J., "Spelling and Language Achievement of Left-Handed Children", in Elementary English, Vol. 39, No. 5, May 1962, p. 466-469.

This study supported the conclusion that there was not a substantial relationship between handedness, spelling and language achievement in grades four, five, and six. Few and incomplete tests of handedness.

-----, "Study of Handedness and Reading Achievement", in Reading Teacher, Vol. 16, No. 1, September 1962, p. 31-34.

This work supported the conclusions of his earlier study reported above. The evidence suggested that there is no difference in reading achievement among boys and girls in this study. A weakness in testing handedness.

Haefner, R., The Educational Significance of Left Handedness, New York, Bureau of Publications, Teachers College, Columbia University, 1929, 84 p.

Evidence from sixty-eight matched groups of right- and left-handed children in grades four, five, six, and seven indicated no association of handedness with achievement or intelligence.

Harris, Albert J., How to Increase Reading Ability, New York, Longman's Green and Co., 1961, p. 249-260.

A complete presentation of the Harris Tests of Lateral Dominance appears on pages 249-260. Observations based on 308 disabled readers and 245 unselected students revealed that mixed hand dominance decreased with age. This, however, was not a longitudinal study.

-----, "Lateral Dominance, Directional Confusion, and Reading Disability", in Journal of Psychology, Vol. 44, Second Half, October 1957, p. 283-294.

Using the Harris Tests of Lateral Dominance, the author disclosed no evidence that eye dominance or foot dominance manifested significant change with age. No significant difference in the number of crossed dominance cases between the reading disability group and the unselected child. Strongly recommended.

Hebb, Donald O., The Organization of Behavior, New York, John Wiley and Sons, 1949, 335 p.

This author proffered a treatment of the neurological basis of human behavior. Marked care given the neurological determinant of speech.

Hildreth, Gertrude H., "Development and Training of Hand Dominance", in Journal of Genetic Psychology, Vol. 76, First Half, March 1950, p. 39-100.

It was reported that strengthening hand dominance aided the adjustment of some children as old as ten or twelve; but not so with older students. Greater unilaterality was found among non-stutterers. This author is a liberal contributor to the literature.

-----, "Manual Dominance in Nursery School Children", in Journal of Genetic Psychology, Vol. 72, First Half, March 1948, p. 29-45.

The author gathered data from forty-four nursery school children which resulted in a premise that handedness is a developmental trait and that social conditions largely account for the emergence of hand dominance. Small sample accounts for acceptance reservation.

-----, "Reversals in Reading and Writing", in Journal of Educational Psychology, Vol. 25, January 1934, p. 1-20.

The inconsistency of the reversal tendency in 335 primary grade children prevented a conclusion that reversal tendency was a cause of poor reading. No significant difference in handedness and reading reversals was found. Her earliest reported research on this topic.

-----, "A School Survey of Eye-Hand Dominance", in Journal of Applied Psychology, Vol. 29, No. 1, February 1945, p. 83-88.

The author, studying 101 boys and ninety girls from kindergarten through grade six, concluded that mixed dominance was not a prevailing condition in reading disability. She found 44-50 per cent mixed dominant. Dependable.

Hillerich, Robert L., A Study of the Relationship Between Eye-Hand Dominance and the Reading Achievement of Selected Primary Pupils, unpublished doctoral dissertation, Colorado State College, 1962, x-108 p.

This was a four-year study of four hundred primary school students disclosing no significant difference in the percentage of mixed, crossed, or unilaterally dominant children in a group of below average readers as compared with a group scoring average or above in reading. A decisive statistical study.

Herren, R. Yorke and Donald B. Lindsey, "A Note Concerning Cerebral Dominance in the Rat", in Journal of Genetic Psychology, Vol. 47, No. 2, December 1935, p. 469-472.

To test Orton's hypothesis that comparable engrams in the two cerebral hemispheres produced motor expressions which were mirrored counterparts of each other, the author investigated the handedness status and its relationships in sixteen mature male rats. Of questionable value.

Thinger, Robert F., "Lateral Dominance and Reading Achievement", in Claremont Reading Conference Yearbook, Vol. 27, 1963, p. 126-129.

The author referred to his earlier investigation, wherein, among 2,446 sinistral, bilateral, mixed lateral and dextral school children, no consistent differences in achievement with the laterality factor as a variable were revealed. Of moderate value.

-----, "Some Relationships Among Laterality Groups at Three Grade Levels of Performance on the California Achievement Tests", in Toward a Professional Identity in School Psychology, Los Angeles, California Association of School Psychologists and Psychometrists, 1963, p. 70-74.

This study investigated the possibilities of differential achievement in reading, arithmetic, and language among 2,446 sinistral, bilateral and dextral school children to determine changes in interrelationships among these groups in grades three, five, and seven. Lateral preference was not found to be a cogent factor in academic achievement.

Imus, Henry A., John W.M. Rothney and Robert M. Bear, An Evaluation of Visual Factors in Reading, New Hampshire, Dartmouth College Publications, 1938, 144 p.

This was a report of a comprehensive visual survey of 636 college freshmen in 1938, wherein dominance was manifested to be only a minor factor. Contestable identification of handedness.

Jansky, Jeannette, "A Case of Severe Dyslexia with Aphasia-like Symptoms", in Reading Teacher, Vol. 15, No. 2, November 1961, p. 110-113.

A case study of a twelve and one-half year old boy referred to the Language Disorder Clinic, Columbia-Presbyterian Medical Center was imparted. It was revealed that laterality was not firmly established. Of minor value to this investigation.

Jenkins, D.L., Andrew W. Bacon and Laura Elemendorf, "Mixed Dominance and Reading Disability", in American Journal of Orthopsychiatry, Vol. 7, No. 1, January 1937, p. 72-81.

This was a consideration of two sets of girl twins referred to the Institute for Juvenile Research, Chicago. The evidence indicated that confusion of right and left orientation with mixed dominance may present something of an obstacle to learning to read. Contestable value.

Johnston, Philip W., The Relationship of Certain Anomalies of Vision and Lateral Dominance to Reading Disability, Monograph of the Society for Research in Child Development, Vol. 2, No. 2, Serial No. 32, Washington, Society for Research in Child Development, 1942, 147 p.

The investigator reported the reliability of comprehensive tests of handedness and eyedness administered to better than one hundred public school children. He disclosed that dominance and reading were not related. Of worth to this study.

Jones, A.W., "Issues in Beginning Reading", in Claremont Reading Conference Yearbook, Vol. 28, 1964, p.107-113.

The consideration was presented that if ambiguous dominance does exist, problems with spatial and directional orientation are present in some degree and are reflected in language development. Not a statistical evaluation.

Jones, Mary M. Wilcox, "Relationship Between Reading Deficiencies and Left-Handedness", in School and Society, Vol. 60, No. 1554, October 7, 1944, p. 238-239.

Evidence suggests that there was no significant difference in reading ability between clearly left-handed and clearly right-handed children. Dubious determination of handedness and no control for intelligence.

Joynt, R.J. and A.L. Benton, "The Memoir of Marc Dax on Aphasia", in Neurology, Vol. 14, No. 9, September 1964, p. 851-854.

Presented testimony of Dax's memoir and was of esteem to the project because it contained the first mention of the role of the left cerebral hemisphere in the function of speech.

Kennard, Margaret A., Ralph Rabinovitch and Donald Wexler, "The Abnormal Electroencephalogram as Related to Reading Disability in Children with Disorders of Behavior", in The Canadian Medical Association Journal, Vol. 67, October 1952, p. 330-333.

This report connoted no difference between the electroencephalograms of normal readers clinically compared with those of disabled readers.

Kennedy, Helen, "Reversals, Reversals, Reversals", in Journal of Experimental Education, Vol. 23, No. 2, December 1954, p. 161-170.

There was presented a developed test instrument the use of which evidenced an almost complete disappearance of reversal tendency in the work of the average or superior child as he progressed through the first several grades. Of note.

Ketchum, E.G., "Neurological and Psychological Trends in Reading Diagnosis", in Reading Teacher, Vol. 17, No. 8, May 1964, p. 589-593.

The author supported his concern that the term dominance is altogether too loosely used by professionals and others who hold a sadly oversimplified view of the intra- and inter-hemispheric complexities of man's cerebral cortex. Of esteem to this work.

Kirk, Samuel A., "A Study of the Relationship of Ocular and Manual Preferences to Mirror Reading", in Journal of General Psychology, Vol. 44, 1934, p. 192-205.

The administration of both Gray Oral Reading Paragraphs and the Gray Oral Reading Check Tests offered evidence that there existed no significant difference between pure and mixed eye-hand dominance among sixty-one "high grade" mental defectives. Atypical subjects. The tests are of particular interest.

Kirk, Winnifred Day and Samuel A. Kirk, "The Influence of the Teacher's Handedness on Children's Reversal Tendencies in Writing", in Journal of Genetic Psychology, Vol. 47, No. 2, December 1935, p. 473-477.

From an evaluation of the reversal tendencies of fifty-one mental retardates and thirty-seven normal to superior children, the authors suggested that correct orientation in writing was based on maturation or experiential factors or both.

Koch, H.L. et al., "A Study of the Nature, Measurement, and Determination of Hand Preference", in Genetic Psychology Monographs, Vol. 13, No. 2, 1933, p. 117-218.

In examining 201 college students, the authors found that laterality was quantitative and distributed bimodally with about six per cent of the subjects falling within the range of the left mode. Of great interest.

Kravitz, Daniel, "Visual-Field Interpretations in Chiasmal Lesions", in American Journal of Ophthalmology, Vol. 31, No. 4, April 1948, p. 415-426.

This paper, read to the New York Society for Clinical Ophthalmology in 1946, referred to the failure of the temporal

retinal fibers to cross at the optic chiasma but instead to proceed posteriorly to form the lower and upper temporal halves of the optic tracts. Not so of the nasal retinal fibers. Of special note.

Krise, Morely, "An Experimental Investigation of Theories of Reversals in Reading", in Journal of Educational Psychology, Vol. 43, November 1952, p. 408-422.

An investigation of the laterality and reading level of twenty adults suggested that the tendency to reversals is present in varying degrees in all people at all ages. Supports a theory that reversals in reading are due to difficulty in space relations and confusion of figure-and-ground relationships. Impeachable because of small sample.

-----, "Reversals in Reading: A Problem in Space Perception", in Elementary School Journal, Vol. 49, January 1949, p. 278-284.

The author presented a provocative hypothesis regarding reversals which suggested that certain individuals experience reversals because of an inability to differentiate between symbols that look similar rather than because of a mixed dominance condition.

LaGrone, Cyrus W., Jr., "An Experimental Study of the Relationship of Peripheral Perception to Factors in Reading", in Journal of Experimental Education, Vol. 11, No. 1, September 1942, p. 37-49.

Data was presented which indicated that inferior readers excel superior readers in accuracy of perception in the right peripheral field while superior readers excel in accuracy of perception in the left peripheral field. Of value to this study.

LaGrone, Cyrus W. and E.S. Barrett, "Accuracy of Perception in Peripheral Vision in Relation to Intellectual Abilities Among Students Selected on the Basis of Dextrality", in Journal of Psychology, Vol. 28, Second Half, October 1949, p. 255-264.

The interpretation of laterality tests administered to seventy-nine college freshmen specify that the relationships noted between accuracy of perception in peripheral vision and intellectual ability are partially a function of dextrality and are not explicable solely on experience with reading or habitual tendencies. Relevant.

LaGrone, Cyrus W., Jr. and B.F. Holland, "Accuracy of Perception in Peripheral Vision in Relation to Dextrality", in American Journal of Psychology, Vol. 56, October 1943, p. 592-598.

This experiment with fifty-two second-grade children incontestably supported the findings of the author's two studies involving college students reported above.

Leavell, Ullin W., "The Problems of Symbol Reversals and Confusions, Their Frequency and Remediation", in Peabody Journal of Education, Vol. 32, No. 3, November 1954, p. 130-141.

The author presented case studies to support his claim that use of the Hand-Eye Coordinator to remediate pupils' crossed control problems was an effective therapy in the elimination of reversals with resultant improvement in the functional skill of language. An authoritative proposal.

Leavell, Ullin W. and Harry S. Beck, "Ability of Retarded Readers to Recognize Symbols in Association with Lateral Dominance", in Peabody Journal of Education, Vol. 37, No. 1, July 1959, p. 7-14.

Thirty-eight elementary school pupils with reading problems were categorized as to hand-eye dominance and placed into three groups. There were no significant differences in I.Q. or reading ratio between unilateral and mixed dominance groups. Contestable results based on the few subjects in each subgroup.

Leavell, Ullin W. and Florence Chism Falts, "Dominance and Displacement of Visual Imagery in Relation to Reading Achievement", in Peabody Journal of Education, Vol. 21, No. 2, September 1943, p. 103-106.

The purpose of this investigation was to relate lateral dominance to displacement of visual imagery in space, natural tendencies in directional movement, and reading achievement. in 192 subjects from a population of 2,500 used in a related study of lateral dominance. Much attention given these results.

Leavell, U.W., R.W. Waggoner and E.A. Kahn, "Critical Study of a Case of Aphasia", in Archives of Neurology and Psychiatry, Vol. 28, 1932, p. 1178-1181.

The investigators presented evidence from the study of a case of aphasia suggesting that cerebral dominance was related to the most oft-used side and was probably a secondary rather than a causal characteristic.

Lund, Frederick H., "The Dependence of Eye-Hand Coordination upon Eye Dominance", in American Journal of Psychology, Vol. 44, No. 4, October 1932, p. 756-762.

Describing the results of the target or aiming test with 247 high school students, the author revealed a constant advantage in efficiency of binocular vision over either eye alone, although the dominant eye had an advantage over the non-dominant eye. A decisive and authoritative contribution.

McKee, Paul, A Primer for Parents, Chicago, Houghton Mifflin Co., 1957, 37 p.

Although directed to parents, this is a cogent and able delineation of the nature of the reading process with a distinctive and uncommonly fine treatment of early reading development.

Mintz, Alexander, "Reading Reversals and Lateral Preferences in a Group of Intellectually Subnormal Boys", in Journal of Educational Psychology, Vol. 37, No. 8, November 1946, p. 487-501.

This study attempted to verify the theories described by Orton and Monroe regarding the unavoidable effects of the lack of unilateral cerebral dominance. The results were opposed to these earlier theories. Used on an atypical population.

-----, "A Study of Indications of Unstable Unilateral Cerebral Dominance, Reading Disability, and Mental Deficiency", in Psychological Bulletin, Vol. 30, No. 8, 1933, p. 565-566.

A sample of one hundred boys from Letchworth Village for the mentally deficient disclosed that those with indications of unstable unilateral cerebral dominance were not more prone to reversal errors than others at the same reading level. Impeachable because of abnormal sample.

Monroe, Marion, Children Who Cannot Read, Chicago, The University of Chicago Press, 1932, xv-205 p.

One of the highly regarded early studies offering evidence to support a relationship between lack of unilateral dominance and reading difficulty.

-----, "Methods for Diagnosis and Treatment of Cases of Reading Disability", in Genetic Psychology Monographs, Vol. 4, Nos. 4 and 5, October-November 1928, p. 333-454.

One hundred seventy-five retarded readers at the Iowa State Psychopathic Hospital were found to be distinguished from 120 normal readers at each reading level by a greater number of reversals, repetitions, and total errors. Of significant value to this project.

Muehl, S., "Relationship Between Word-Recognition Errors and Hand-Eye Preference in Pre-School Children", in Journal of Educational Psychology, Vol. 54, December 1963, p. 316-321.

A report of data collected from sixty-two preschool children revealed that left laterality in preschoolers was associated with visual or perceptual patterns which could affect word recognition efficiency in later reading. Accepted with reservation.

Orton, Samuel Terry, "An Impediment in Learning to Read: A Neurological Explanation of Reading Disability", in School and Society, Vol. 28, No. 715, September 1928, p. 236-290.

This article was a major contribution to the literature designating a neurological basis for reading deficiency and revealed the author's theory of cerebral dominance.

-----, Reading, Writing and Speech Problems in Children, New York, W.W. Norton and Company, Inc., 1937, vii-215 p.

This was an ingenious early contribution, based exclusively on clinical observations, to a physiological emphasis of laterality. This book offers a discussion of Orton's well-known theory of cerebral dominance.

-----, "Specific Reading Disability-Strephosymbolia", in Journal of American Medical Association, Vol. 90, April 1928, p. 1095-1099.

The author coined the term strephosymbolia as a substitute for word-blindness, a term used earlier. The results of this study, in which a relationship was discovered between mirror reading, reversals, and reading disability in only fifteen of 125 children referred to a mental hygiene clinic, were questionable.

-----, "Word Blindness in School Children", in Archives of Neurology and Psychiatry, Vol. 14, 1925, p. 581-615.

This was the earliest presentation of the author's famed cerebral dominance theory as an explanation of reversals and reading disability. It offered a neurological, physiological etiology. This theory has been discredited in recent years.

Pace, C. Robert, "Handedness and Reading Ability in High School and College Students", in Journal of Educational Research, Vol. 31, No. 3, November 1937, p. 205-210.

Among two hundred high school seniors and college students studied, ambidextrous, left-handed, or shifted subjects exhibited no significant inferiority on a test of reading

ability but appeared to display some inferiority on a test of reading speed. Accepted with reservation because of the limitation of the measuring tools.

Pagel, Walter, "Medieval and Renaissance Contributions to Knowledge of the Brain and Its Functions", in The History and Philosophy of Knowledge of the Brain and Its Function, Springfield, Illinois, Charles C. Thomas, 1958, p. 95-114.

This report was offered to the Anglo-American Symposium, in London, during the month of July 1957. Contributed to the historical basis of this project.

Parson, B.S., Left-Handedness: A New Interpretation, New York, Macmillan, 1924, 185 p.

The author stated that the etiology of handedness is eyedness. He attempted to account for eye-hand disagreement through reason of injury, lack of acuity, or pressure. The method of determining the handedness of his subjects can be seriously questioned.

Penfield, Wilder, "Hippocratic Preamble: The Brain and Intelligence", in The History and Philosophy of Knowledge of the Brain and Its Function, Springfield, Illinois, Charles C. Thomas, 1958, p. 1-14.

This work contributed further to the historical basis for understanding the neurological facet of manual and ocular dominance.

Perkins, F.Theodore, "Problems Arising from Assertion or Assumptions of Delacato", in Claremont Reading Conference Yearbook, Vol. 28, 1964, p. 119-131.

The author presented a series of unequivocal contestations of the contributions of Delacato to laterality and dominance.

Phillips, Albert J., "Relationship of Left-Handedness to Reversals in Reading", in Elementary English Review, Vol. 11, April 1934, p. 97-98 and 116.

The results of this investigation of 126 matched pairs of primary school children revealed no significant correlations between reversals and handedness, although his method of testing handedness was not described.

Potter, Muriel C., Perception of Symbol Orientation and Early Reading Success, Contributions to Education, No. 939, New York, Bureau of Publications, Teachers College, Columbia University, 1949, 43 p.

The author developed a test for reversals and categorized this into the following groups: reversed sequence,

correct sequence but mirrored letters, mixed sequence, and mirrored image. Used with reservation.

Robinson, Helen M., Corrective Reading in Classroom and Clinic, Chicago, The University of Chicago Press, 1953, vii-256 p.

This work was a compilation of reports presented to the Annual Conference on Reading held at the University of Chicago. It contained several very fine reports on reversals and dominance.

-----, "The Study of Disabilities in Reading", in Elementary School Journal, Vol. 38, No. 1, September 1937, p. 15-28.

This article described the method of investigating reading difficulties which was used in the Orthogenic School of the University of Chicago. This school served as a lab for the study of deficiencies in learning and of maladjustments in behavior. A complete discussion of cause of reading disability.

-----, "Visual Efficiency and Reading", in Clinical Studies in Reading. I, Supplementary Educational Monographs, No. 68, Chicago, The University of Chicago Press, June 1949, p. 90-112.

Extensive tests for eye dominance were administered to seventy-five fourth, fifth, and sixth graders. On five tests of eye-preference, sixty-six per cent preferred the right eye.

-----, Why Pupils Fail in Reading, Chicago, University of Chicago Press, 1946, xiii-257 p.

Extremely complete and intensive investigations of thirty retarded readers with normal intellectual endowments. Dominance was not included among the causes of reading disability because specialists were unable to interpret dominance test results.

Robinson, Helen M. and Charles B. Huelaman, "Visual Efficiency and Progress in Learning to Read", in Clinical Studies in Reading. II, Supplementary Educational Monographs, No. 77, Chicago, The University of Chicago Press, January 1953, p. 31-63.

The major purpose of this investigation was to determine the relationship between the visual process and reading progress. Eye preference was found to be unrelated to other aspects of vision. Of good value.

Scheidemann, N.V., "A Simple Test for Ocular Dominance", in American Journal of Psychology, Vol. 43, No. 1, January 1931, p. 126.

This author found the paper-hole test to be the simplest, the most satisfactory, and a very reliable test for ocular dominance. It can be used for close-range as well as distant vision tests. Highly recommended.

Schonell, Fred J., "The Relationship of Reading Disability to Handedness and Certain Ocular Factors", in British Journal of Educational Psychology, Vol. 10, November 1940, p. 227-234; Vol. 9, Part 1, February 1941, p. 20-27.

The writer found evidence that the disability of a few backward readers was in part due to their mixed eyedness and handedness, and that left-handedness, per se, was not a cause of reading disability but could be a contributing factor. Recommended with caution.

Schubert, Delwyn G., The Doctor Eyes the Poor Reader, Springfield, Illinois, Charles C. Thomas, 1957, xv-101 p.

This ophthalmologist devoted a chapter in his book to the neurological basis of reading inefficiency and referred to the unusual pattern of the decussation of the retinal nerve fibers as they pass through the optic chiasma. A fair review of relevant neurology.

Shearer, Robert V., "Eye Findings in Children with Reading Difficulties", in Journal of Pediatric Ophthalmology, Vol. 3, No. 4, November 1966, p. 46-53.

This is a highly recommended and authoritative recent investigation by an ophthalmologist in the area of visual processes, eye-hand dominance and reading ability.

Smith, Josephine M., "The Sensory Function of the Non-Preferred Hand", in Journal of Experimental Psychology, Vol. 16, February 1933, p. 271-282.

Using a sample of 104 adults, this author found that nearly ninety per cent used the non-dominant hand to sense or feel the shape of objects when blindfolded. Impeachable evidence.

Smith, K.U., "The Role of Commissural Systems of the Cerebral Cortex in the Determination of Handedness, Eyedness and Footedness in Man", in Journal of General Psychology, Vol. 32, First Half, January 1945, p. 39-79.

This very fine, comprehensive study of the case studies of surgical procedures on twenty-one epileptics disclosed that, neurologically, ocular and manual or pedal laterality seemed to be unrelated at the cortical level.

Smith, Linda C., "A Study of Laterality Characteristics of Retarded Readers and Reading Achievers", in Journal of Experimental Education, Vol. 18, No. 4, June 1950, p. 321-329.

In her study of fifty male retarded readers and an equal number of male normal readers, the author reported that the retarded readers reversed more often in lower case letters and that they underwent changes of handedness more often.

Snyder, A. and M. Snyder, "Eye Preference Tendencies", in Journal of Educational Psychology, Vol. 19, No. 6, September 1928, p. 431-433.

The authors, using 410 high school and college subjects, revealed that preference for either the right or left eye was implicitly acquired and not natively rooted. Ambocular tendencies were said to increase with age. Of moderate value to this study.

Spache, George D., "Eye Preference, Visual Acuity, and Reading Ability", in Elementary School Journal, Vol. 43, No. 9, May 1943, p. 539-543.

This investigation reveals little relationship between visual acuity and eye preference as measured by sighting tests. Poorly documented statistically.

-----, "Factors Which Produce Defective Reading", in Corrective Reading in Classroom and Clinic, proceedings of the Annual Conference on Reading, Vol. 15, No. 79, December 1953, p. 49-79.

This study summarized the inconclusiveness of and the contradictions in the relationship between vision and reading. It was suggested that most studies have been based on faulty anatomical ideas. Reasonable.

-----, "One-Eyed and Two-Eyed Reading", in Journal of Educational Research, Vol. 37, No. 8, April 1944, p. 616-618.

A sample of twenty-three subjects with marked eye preference and twenty-one with different visual acuity of the two eyes offered data suggesting the best reading was done with the preferred eye, the poorest with both eyes. Questionable because of sample size.

Stevens, H.C. and C.J. Ducasse, "The Retina and Righthandedness", in The Psychological Review, Vol. 19, No. 1, January 1912, p. 1-31.

This was an experimental investigation into the capacity of the retina to estimate spatial extents. A possible developmental cause for right-handedness was suggested. Accepted with caution.

Stevenson, Lillian P., "Poor Readers in the Lower School of the Laboratory Schools", in Clinical Studies in Reading, I, Supplementary Educational Monographs, No. 68, Chicago, The University of Chicago Press, June 1949, p. 7-25.

This study, based on eye-hand dominance and reading tests given to an above-average socio-economic school population, revealed that the two outstanding characteristics of poor readers were mixed eye-hand preference and personal or emotional problems. Suspect because of atypical sample.

Stevenson, Lillian P. and Helen M. Robinson, "Eye-Hand Preference, Reversals, and Reading Progress", in Clinical Studies in Reading, II, Supplementary Educational Monographs, No. 77, Chicago, The University of Chicago Press, January 1953, p. 83-88.

This experiment revealed that pupils who were inconsistent in right preference of hand and eye were not handicapped in learning to read and made no more reversals than those consistent in right preference. Authoritatively presented.

Stromberg, E.L., "Monocular and Binocular Letter-Position Scores of Defective Readers in the 'Range of Attention' Experiment", in Psychological Bulletin, Vol. 31, No. 8, October 1934, p. 589.

The author sought to identify the results, in monocular as opposed to binocular vision, accruing from eye dominance tests of defective readers. He disclosed the presence of left-eye dominance in most defective readers. Accepted with reservation.

Stromberg, Elroy L., "The Relationship of Measures of Visual Acuity and Ametropia to Reading Speed", in Journal of Applied Psychology, Vol. 22, No. 6, December 1938, p. 70-78.

Of some value to this proposed study was the above author's examination of 142 rapid and low readers chosen from among 1,200 University of Minnesota students. The results supported the theory that acuity and ametropia are not important determinants of reading proficiency.

Swanson, D.E. and J. Tiffin, "Bett's Physiologic Approach to Analysis of Reading Disabilities as Applied to the College Level", in Journal of Educational Research, Vol. 29, No. 6, February 1936, p. 433-448.

This survey of 267 freshmen at the Reading Clinic at the University of Iowa made it seem improbable that differences in visual efficiency were causally related to differences in reading ability among college students. Measurement tools could be questioned.

Teegarden, Lorens, "Clinical Identification of the Prospective Non-reader", in Child Development, Vol. 3, No. 4, December 1932, p. 346-358.

This clinical investigation of fifty children, scattered throughout the range of 258 entering first grade, revealed that consistent right or left dominance, or ambidexterity with either eye are conditions most favorable to success in reading.

-----, "Tests for Tendency to Reversal in Reading", in Journal of Educational Research, Vol. 27, No. 2, October 1933, p. 81-97.

The author, from data gained from 262 grade one students, indicated that the strength of reversal tendency bears a positive relation to reading achievement at the end of grade one. A concern for the reliability of her reversal tests.

Travis, Lee Edward and Wendell Johnson, "Stuttering and the Concept of Handedness", in Psychological Review, Vol. 14, No. 6, November 1934, p. 534-562.

In general, this study pointed to the conclusion that in the stutterer the central nervous organization is characterized by a high degree of ambilaterality. Poor statistical documentation.

Twitmeyer, E.B. and Y. Nathanson, "The Determination of Laterality", in Psychological Clinic, Vol. 22, 1935, p. 141-149.

There was no evidence of consistent dominance of ear, eye, and body indicated in this study of two hundred cases. Writing was found to be a poor test of native handedness. The reliability of the adult questionnaire regarding handedness was questionable.

Updegraff, Ruth, "The Correspondence Between Handedness, and Eyedness in Young Children", in Journal of Genetic Psychology, Vol. 42, No. 2, June 1933, p. 490-492.

From a study of seventy-four children, age two to six years, attending preschool labs of the Iowa Child Welfare Research Station, the author declared the most plausible hypothesis of laterality at present was the concept of unilaterality in varying degrees. Of little value.

-----, "Ocular Dominance in Young Children", in The Psychological Bulletin, Vol. 29, No. 9, November 1932, p. 654.

This investigation of 190 children using an adoption of the Miles A-B-C Vision Test, revealed that for many subjects ocular dominance is not established before the age of

three; thereafter it is commonly found. Two-year olds determined unsatisfactory.

Van Ripper, C., "The Quantitative Measurement of Laterality", in Journal of Experimental Psychology, Vol. 18, No. 3, June 1935, p. 372-382.

The author described the Critical Angle Board, occasionally referred to as Van Ripper's Test, for determining laterality free from environmental influences. Recommended.

Warren, Neil and Brant Clark, "A Consideration of Use of the Term Ocular Dominance", in Psychological Bulletin, Vol. 35, No. 5, May 1938, p. 298-304.

These investigators found no justification for the often expressed belief that the sighting eye is preferred, dominates or assumes leadership in normal binocular vision. Of definite value to this proposal.

Wechsler, David and M.L. Pignatelli, "Reversal Errors in Reading: Phenomena of Axial Rotation", in Journal of Educational Psychology, Vol. 28, March 1937, p. 215-221.

This investigation categorizes reversals as to the rotation of the symbol on one of its axes, i.e., vertical axis, horizontal axis, depth axis, and double reverse on two axes. Helpful.

Weisenburg, Theodore and Katherine McBride, Aphasia, A Clinical and Psychological Study, New York, One Commonwealth Fund, 1935, xvi-634 p.

The author's five-year study presented evidence of a generalized effect among patients having brain damage rather than such a specific disability as motor aphasia, word-deafness, agraphia, or alexia. Related to this study.

Weiser, J., "Handedness, Leggedness, Eyedness", in Journal of Experimental Education, Vol. 33, No. 9, Summer 1965, p. 347-350.

Examining hundreds of children ranging in age from fourteen to eighteen, born in twenty-four countries but living in Israel, the author indicated that inborn cases of left-handedness were extremely rare. The reliability of the handedness tests can be doubted.

Wilson, Grace E. and Ullin W. Leavell, A Study of the Relation of Functional Neurological Dominance to Reading Difficulties in Selected Cases of the McGuffey Reading Clinic, unpublished study, School of Education, University of Virginia, 1954, 159 p.

This study of 749 school-age children disclosed that deficiencies in language arts manifested themselves

significantly in more cases where hand-eye confusions or reversals or both were present. Of interest.

Witty, Paul and David Kopel, "Factors Associated with the Etiology of Reading Disability", in Journal of Educational Research, Vol. 29, February 1936, p. 449-459.

The authors in a study of one hundred public school students disclosed data indicating little, if any, relationship between reversal errors and mixed hand-eye dominance. Question reliability of handedness questionnaire.

-----, "Sinistral and Mixed Manual-Ocular Behavior in Reading Disability", in Journal of Educational Psychology, Vol. 27, No. 2, February 1936, p. 119-134.

As was true in their study reported above, the authors questioned the relationship of reading ability with either handedness or eyedness. Right, left, and mixed manual-ocular dominance occurred no more frequently among retarded readers than among non-problem cases.

Wolfe, Lillian S., "Differential Factors in Specific Reading Disability: I. Laterality of Function", in Journal of Genetic Psychology, Vol. 58, First Half, March 1941, p. 45-56.

The author in this study of thirty-six eight- and nine-year old boys connoted that eye dominance, hand dominance, and hand versus eye dominance are not related in a primary way to reading disability. Of refutable value because of small sample.

-----, "An Experimental Study of Reversals in Reading", in American Journal of Psychology, Vol. 52, 1939, p. 533-561.

This data revealed no significant difference between a group of retarded readers and a control group of normal readers in the reversal of geometric designs. Of questionable worth to this project.

Woo, T.L., "Dextrality and Sinistrality of Hand and Eye", in Biometrika, Vol. 20, 1928, p. 79-148.

The author specified no relationship in laterality or its intensity between hand and eye in his statistical study of four hundred students at the University of London. The intercorrelations of both the ocular and manual tests were very variable.

Woody, Clifford and Albert J. Phillips, "The Effects of Handedness on Reversals in Reading", in Journal of Educational Research, Vol. 27, No. 9, May 1934, p. 651-662.

The evidence from a study of 136 pairs of matched right- and left-handed primary pupils presented the conclusion that handedness, per se, had little or no influence on the type of reading response made. Of undoubted value to this project.

Ziets, Sister M. Bernetta, "Relation of Vision and Reading", in Education, Vol. 81, No. 1, September 1960, p. 45-47.

Sister Bernetta in her review of literature expressed her feelings that hyperopia, binocular incoordination, hyperopia astigmatism, and aniseikonia may well have been detrimental in learning to read. No statistical documentation.

APPENDIX 1

GLOSSARY

APPENDIX 1

GLOSSARY

Aniseikonia.- the ocular images are presented unequally either in size or shape so that conflicting impressions arrive at the visual centers in the cortex and present difficulty in fusing the incongruent impressions.

Anisometropia.- the inequality of refractive error in the two eyes. One eye may be myopic and the other eye hyperopic.

Aphasia.- an inability to communicate or to interpret auditory language by persons otherwise normally endowed mentally and without the difficulty of auditory defects. The clinical symptomatology of these persons relative to spoken language is basically the same as the symptomatology of the retarded reader to written language.

Astigmatism.- a refractive error in which there is evidenced an unevenness of focus of the rays of light resulting in the blurring of a part of the image.

Binocular coordination.- the ability to direct the two eyes on the same object at the same time, so that a single impression is obtained.

Dyslexia.- an extreme difficulty in learning to recognize and interpret printed or written language by persons otherwise normally endowed mentally and without the difficulty of ocular defects. This condition in early research was referred to as word-blindness and at other times as alexia and visual aphasia.

Exophoria.- an anomaly of ocular coordination, consisting of a tendency of the visual lines to deviate outward from parallelism when the eyes are at rest.

Fusion.- the blending of two like or somewhat dissimilar (stereoscopic) pictures into a single image.

Hyperopia.- a refractive error occurring when the parallel rays of light entering the eyes do not converge properly, but rather are focused behind the retina. This condition is also referred to as farsightedness.

Myopia.- a refractive error occurring when the converging parallel light rays are focused in front of the retina. This error is also referred to as nearsightedness.

Stereopsis.- depth perception. It is the result of precise binocular coordination brought about by the disparity or unlikeness of the image received by each eye viewing the object from slightly different angles.

Strophosymbolia.- "twisted symbols". A term coined by Samuel Orton to demarcate better the series of cases known as congenital word-blindness. This results in confusions of direction such as can be noted in the failure to differentiate between "p" and "q" and between "was" and "saw". This term is used synonymously with mirror or antitropic reading.

APPENDIX 2

PERCENTAGE OF SUBJECTS IN EACH EYE-HAND DOMINANCE GROUP AS REPORTED IN VARIOUS STUDIES

(The following page represents the percentage of subjects found to be in five various dominance groups by the authors of ten pieces of research.)

APPENDIX 2

Table XXI.-

PERCENTAGE OF SUBJECTS IN EACH EYE-HAND DOMINANCE GROUP
AS REPORTED IN VARIOUS STUDIES

Author and Level of Subjects	Dominance Groups				
	R-R	L-L	R-L	L-R	Mixed
Imus College	56	5	0	12	25
Bennett Elementary	44	8	2	38	8
Cuff Elementary	73	6	0	17	4
Monroe Elementary	59	5	6	21	9
Witty and Kopel Elementary	56	4	4	18	18
Fendrich Grades II-III	42	3	3	41	11
Gates and Bennett Primary	54	0	4	34	8
Hillerich Primary	47	4	3	26	20
Stevenson Grade I	49	6	3	30	12
Updegraff Ages 2-6	52	6	3	21	18
Ranges of Percentages	42-73	0-8	0-6	12-41	4-25

APPENDIX 3

CONNECTING DOTS TEST

(The following page represents the connecting dots test used to determine the handedness of subjects. Each child was given two copies; one to be used with the right hand and one with the left hand.

This page is the actual size of the test as it was administered.)

APPENDIX 3

CONNECTING DOTS TEST

Handedness Test
(45 seconds)

Name _____

Hand _____

Practice:

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Begin:

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APPENDIX 4

FIGURE 1.- VISUAL NERVES WITH RETINAL EXPANSION

(The following is a diagram of the visual nerves with their retinal expansions as viewed from above.

Note is made of the decussation of the optic nerves at the optic chiasma allowing the nasal retinal fibers to cross to each hemisphere while the temporal retinal fibers terminate in the same hemisphere.)

APPENDIX 4

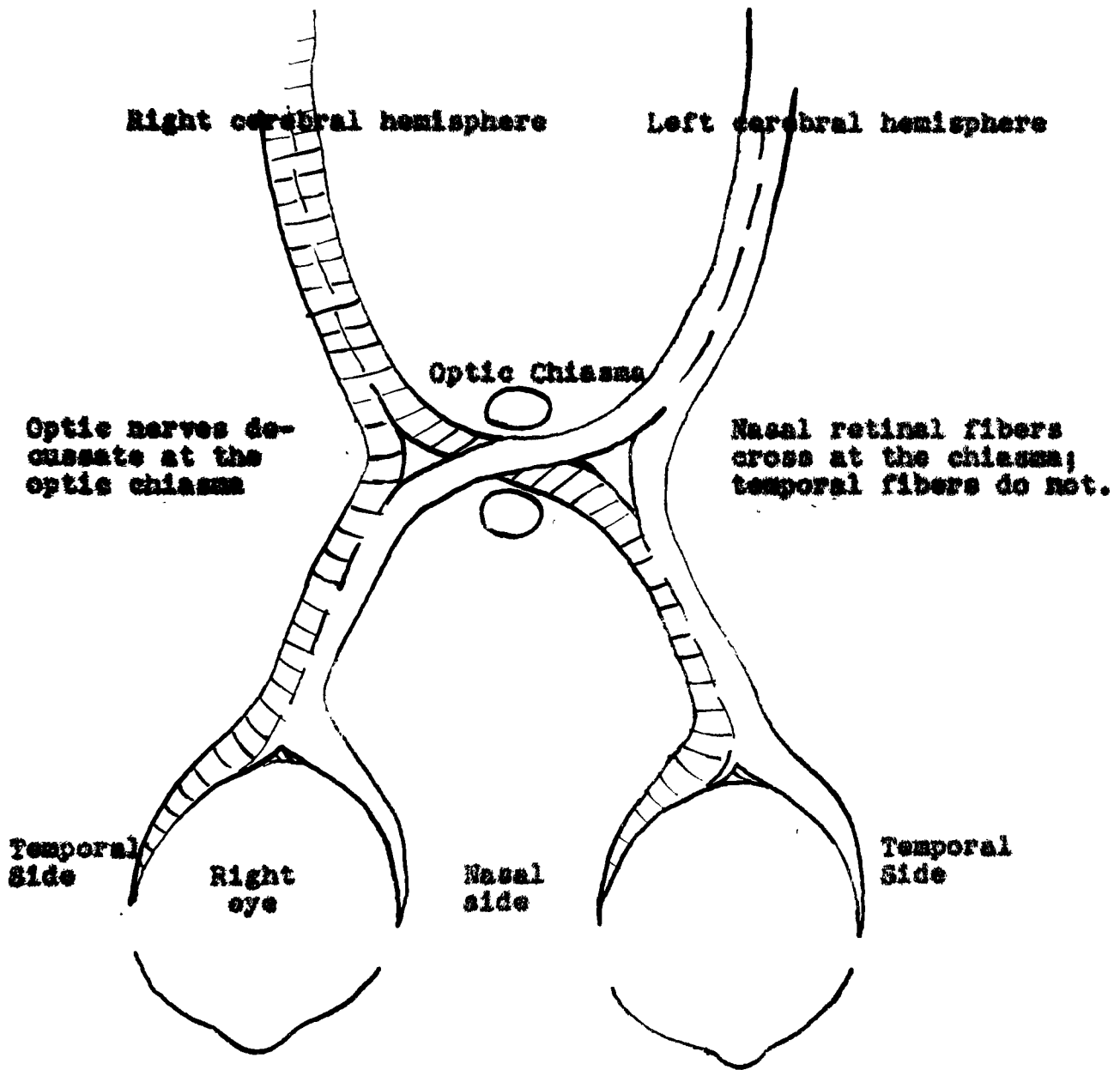


Figure 1.- Visual Nerves with Their Retinal Expansion as viewed from Above.

APPENDIX 5

RECORD SHEET

(This is the record sheet used for this study. The subjects' responses and test scores are noted on this form.)

**APPENDIX 5
RECORD SHEET**

Name _____
 Birth _____
 School & Section _____
 Date _____

Wear Glasses: Always
 Reading Only
 Sometimes

No. _____
 B G

Handedness Tests:

Writing	R	L
Cutting	R	L
Eating	R	L
Hammering	R	L
Batting	R	L
Throwing	R	L
Kicking	R	L

Tapping:

R L

1	_____	_____
2	_____	_____
Total	_____	_____

Dots: _____

Control Far Point

		1	2	3	4	5	6	7	8	9	10
		49	70	84	88	92	96	98	100	103	105
DB-ID Both		L	B	T	L	R	T	L	B	B	R
DB-3D Right	O	T	R	L	T	B	B	L	R	T	R
DB-3D Left	O	B	L	R	R	T	L	B	L	R	T

Control Near Point

	<u>Time</u>	<u>Errors</u>
DG-9 Both	_____	_____
DG-11 Right	_____	_____
DG-10 Left	_____	_____

Dominance

	R	L	<u>Summary</u>
V-Scope	_____	_____	R L
Hole-in-paper	_____	_____	R L

Summary: BERNER TESTS

Hand: R L
 Cont. Eye: R L
 Vision: Problem
 _____ Unilateral Control
 _____ Crossed Control
 _____ Not included (Vis.Problem)

HILLERICH TESTS

Hand:	R	L	M
Dom. Eye	R	L	M
Unilateral Dom.	R-R	L-L	
Crossed Dom.	R-L	L-R	
Mixed Dom.	R-M	L-M	
	M-R	M-L	M-M

	Voc.	Comp.	Total
Reading Ach.	_____	_____	_____
Reading Exp.	_____	_____	_____
Reading Differential			_____

IQ: _____ MA: _____

APPENDIX 6

STATISTICAL FORMULAS

APPENDIX 6

Smith-Satterthwaite Test

t Test

$$\underline{t} = \frac{(\bar{X}_1 - \bar{X}_2) - \alpha}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

Where:

$$\bar{X} = \frac{\sum_{i=1}^n x_i}{n}$$

$$S^2 = \frac{\sum_{i=1}^n (x_i - \bar{X})^2}{n-1}$$

$$\alpha = 0$$

$$Df = \frac{\left(\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}\right)^2}{\frac{(S_1^2/N_1)}{N_1-1} + \frac{(S_2^2/N_2)}{N_2-1}}$$

APPENDIX 7

DATA SHEET

APPENDIX 7

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII									
1	M	R-R	R-R	R-R	16.6	129	11.3	10.6	.7
2	M	R-R	R-R	M-R	14.5	106	8.3	11.3	-3.0
3	M	R-R	R-M	M-R	17.5	132	11.6	11.4	.2
4	M	L-R	L-R	M-R	16.5	122	9.9	10.7	-.8
5	F	R-R	M-R	R-R	16.7	129	10.9	11.7	-.8
6	M	R-R	R-R	M-M	15.4	112	9.2	10.0	-.8
7	F	R-R	R-R	R-R	16.4	119	10.9	10.7	.2
8	F	L-R	L-R	L-M	14.2	103	8.8	9.1	-.2
9	F	R-R	R-M	M-M	15.8	121	10.3	10.1	.2
10	F	R-R	R-R	R-R	14.9	116	9.1	9.4	-.3
11	F	R-L	R-R	R-R	14.6	110	8.8	9.2	-.4
12	F	R-R	R-M	R-M	13.0	96	9.1	8.1	1.0
13	F	R-R	R-R	R-R	14.3	104	9.5	9.1	.4
14	M	R-R	R-R	R-R	17.5	129	12.0	11.5	.5
15	M	R-L	R-R	R-R	18.3	134	11.8	12.1	-.3
16	F	R-R	R-R	R-R	16.2	125	9.5	10.4	-.9
17	M	L-R	L-R	L-M	16.8	125	10.6	10.9	-.3
18	F	L-R	L-R	L-R	17.2	125	11.2	11.3	-.1
19	M	R-R	R-R	R-M	17.9	130	11.7	15.8	-4.1
20	F	R-R	R-R	R-R	16.1	118	11.4	10.5	.9
21	F	L-R	L-R	M-R	13.8	101	8.8	8.7	.1
22	M	R-R	R-M	R-R	14.9	111	9.4	9.5	-.1
23	M	R-R	R-M	M-R	15.1	116	9.6	9.6	0.0
24	M	L-R	R-R	M-R	14.3	109	9.0	9.0	0.0
25	M	L-R	L-M	L-R	19.8	149	11.5	13.1	-1.6
26	M	L-R	L-R	M-R	17.1	133	10.6	11.0	-.4
27	F	R-R	L-R	M-M	16.1	125	11.2	10.3	.9
28	F	R-R	R-R	R-R	16.4	119	10.6	10.7	-.1
29	F	R-R	R-R	R-M	16.5	127	11.6	10.6	1.0
30	F	R-R	L-R	M-R	16.1	123	11.0	10.3	.7

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII (con't)									
31	F	L-R	L-R	R-R	16.6	129	10.4	10.6	-.2
32	F	R-R	L-M	M-M	14.3	112	8.8	8.9	-.1
33	M	R-R	M-R	M-R	15.0	117	9.8	9.4	.4
34	M	L-R	L-R	M-M	16.0	118	10.4	10.4	0.0
35	M	R-R	R-R	R-R	15.8	115	9.3	10.3	-1.0
36	M	R-R	R-M	R-R	15.0	113	11.0	9.5	1.5
37	F	L-R	L-M	M-M	17.2	126	11.8	11.3	.5
38	M	R-R	R-R	R-R	16.3	119	11.6	10.6	-1.0
39	M	L-R	L-M	R-R	10.2	75	6.6	6.0	.6
40	F	L-R	L-R	M-M	12.6	95	9.8	7.7	2.1
41	M	M-R	R-R	L-M	15.7	119	9.8	10.0	-.2
42	F	R-R	R-M	R-R	16.6	128	10.1	10.7	-.6
43	F	R-R	R-R	R-M	17.0	126	12.0	11.1	.9
44	F	L-R	L-R	M-M	17.8	134	12.0	11.6	.4
45	F	L-R	L-R	R-M	11.7	91	6.9	7.0	-.1
46	M	R-R	R-R	R-R	14.1	110	9.4	8.8	.6
47	F	R-R	R-R	R-M	15.8	119	11.1	10.1	1.0
48	M	R-M	R-M	R-M	16.3	123	11.4	10.5	.9
49	F	M-M	L-R	M-M	16.8	126	11.6	10.9	.7
50	M	R-R	R-M	R-M	11.8	89	7.9	7.1	.8
51	M	R-R	R-M	R-R	11.6	91	5.5	6.9	-.4
52	M	L-R	L-M	M-M	15.8	122	11.2	10.1	1.1
53	M	M-R	L-R	L-R	13.2	101	7.7	8.1	-.4
54	F	R-R	R-R	R-M	16.7	131	11.0	10.7	.3
55	F	L-R	L-R	M-M	15.0	113	9.9	9.5	.4
56	M	R-R	R-R	R-R	15.4	120	7.9	9.7	-1.8
57	F	L-R	L-R	L-R	15.2	119	11.4	9.6	1.8
58	F	R-R	R-R	R-R	16.3	123	10.1	10.5	-.4
59	F	R-R	R-R	M-M	16.8	123	11.1	11.0	.1
60	F	L-R	R-R	L-M	16.4	124	10.2	10.6	-.4

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DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII (con't)									
61	F	R-R	R-R	R-R	13.1	101	10.9	8.0	2.9
62	M	R-R	R-R	R-M	15.1	114	8.1	9.6	-1.5
63	F	R-R	R-R	R-M	15.2	115	9.1	9.7	-.6
64	M	R-R	R-R	R-R	15.9	117	10.6	10.3	.3
65	M	R-R	R-R	R-M	16.0	119	9.8	10.3	-.5
66	F	R-L	R-M	R-M	12.7	96	8.0	7.8	.2
67	F	L-M	L-M	L-M	16.0	121	10.9	10.3	.6
68	F	R-R	R-R	M-M	13.9	109	10.0	8.6	1.6
69	M	R-R	L-R	L-R	17.5	137	11.2	11.3	-.1
70	F	L-R	L-R	M-R	16.3	123	10.4	10.5	-.1
71	M	R-R	R-R	R-R	17.9	134	10.6	11.7	-1.1
72	M	R-R	R-R	L-M	17.1	132	11.6	11.0	.6
73	F	R-R	R-M	R-M	16.6	130	11.4	10.6	.8
74	F	L-R	L-R	L-R	16.1	122	11.2	10.3	.9
75	M	R-R	R-M	R-M	15.4	115	10.0	9.9	.1
76	F	R-L	L-R	R-R	17.5	127	11.6	11.5	.1
77	F	R-R	R-R	R-M	15.5	115	9.4	10.0	-.6
78	M	L-L	L-L	L-L	15.3	119	10.4	9.7	.7
79	M	R-R	R-R	R-R	17.2	134	11.6	11.1	.5
80	F	R-R	R-R	R-R	12.7	97	7.8	7.8	0.0
81	F	L-R	L-R	M-M	17.1	129	10.5	11.1	-.6
82	F	R-R	R-M	R-M	15.3	130	11.2	9.4	1.8
83	M	R-R	R-M	R-R	15.1	118	9.5	9.5	0.0
84	F	R-R	M-R	R-M	19.1	140	11.8	12.7	-.9
85	F	R-R	R-R	R-R	12.6	99	9.3	7.6	1.7
86	M	R-R	R-M	R-M	16.0	116	10.8	10.4	.4
87	M	R-R	R-M	R-R	16.2	122	10.7	10.4	.3
88	M	R-R	R-R	R-R	17.6	129	10.8	11.6	-.8
89	M	R-R	R-R	R-M	13.0	105	9.5	7.8	1.7
90	F	L-R	L-R	L-M	14.5	113	9.0	9.1	-.1

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII (con't)									
91	M	R-R	R-R	R-R	15.7	120	9.5	10.0	-.5
92	F	R-R	R-R	R-R	15.8	121	10.9	10.1	.8
93	M	R-R	R-M	R-R	17.1	129	10.9	11.1	-.2
94	M	R-R	R-R	R-R	13.6	107	7.5	8.4	-.9
95	F	R-R	R-R	R-M	18.6	136	12.0	12.3	-.3
96	F	R-R	R-R	R-R	10.8	80	7.1	6.5	.6
97	M	L-R	L-R	L-R	14.9	113	10.6	9.4	1.2
98	F	L-R	L-R	L-R	15.5	117	10.6	9.9	.7
99	F	R-R	R-R	R-R	17.6	133	11.6	11.5	.1
100	F	R-R	R-R	R-R	17.6	128	11.8	11.6	.2
101	M	R-R	R-R	R-M	16.8	127	10.7	10.9	-.2
102	M	R-R	R-M	R-R	13.5	101	7.3	8.4	-1.1
103	M	M-R	L-R	L-M	16.8	125	11.1	10.9	.2
104	F	L-R	L-R	L-R	13.6	103	10.1	8.5	1.6
105	F	R-R	R-R	R-R	15.2	111	9.9	9.8	.1
106	M	R-R	R-R	R-R	12.5	94	9.5	7.7	1.8
107	F	L-R	L-R	M-M	17.6	136	12.0	11.4	.6
108	F	R-R	R-M	R-M	16.3	119	10.7	10.6	.1
109	F	R-M	R-R	R-M	14.3	112	11.3	8.9	2.4
110	M	R-R	R-R	R-R	15.5	115	8.6	10.0	-1.4
111	M	R-R	R-M	R-M	14.6	109	10.8	9.3	1.6
112	M	R-M	R-R	R-M	15.3	119	10.9	9.7	1.2
113	M	R-R	R-R	R-M	16.7	129	9.2	10.7	-.5
114	F	R-R	R-R	R-M	14.3	106	8.9	9.1	-.2
115	F	L-R	L-R	L-M	18.1	124	10.4	12.2	-1.8
116	F	R-M	R-R	R-R	13.9	106	9.0	8.7	.3
117	M	R-R	L-R	M-M	14.2	107	9.4	8.9	.5
118	F	R-R	R-R	R-R	14.2	106	10.9	9.0	1.9
119	M	L-M	L-R	L-R	10.7	78	7.3	6.4	.9
120	F	R-M	R-R	R-R	10.7	83	8.5	6.2	2.3

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII (con't)									
121	F	R-R	R-R	R-M	13.3	100	7.6	8.3	-.7
122	F	L-R	L-R	L-M	14.1	103	9.9	9.0	.9
123	F	L-R	L-R	L-M	15.6	121	10.0	9.9	.1
124	M	L-M	L-R	M-R	15.0	112	10.3	9.6	.7
125	F	R-R	R-R	R-R	13.2	101	8.8	8.1	.7
126	M	R-L	R-R	R-M	15.9	120	11.1	10.2	-1.1
127	M	L-R	L-M	R-R	16.7	126	11.3	10.8	.5
128	F	R-M	R-R	R-M	16.4	119	10.4	10.7	-.3
129	F	R-R	R-R	M-M	16.0	116	10.6	10.4	.2
130	F	R-R	L-R	L-R	13.2	103	9.4	8.1	1.3
131	F	R-R	R-R	R-R	14.4	112	9.7	9.0	.7
132	F	L-R	L-R	L-M	15.2	110	6.9	9.8	-2.9
133	F	R-R	R-R	R-M	13.6	106	9.1	8.4	.7
134	M	R-R	R-R	R-M	17.1	128	11.2	11.1	.1
135	F	R-L	R-R	M-R	15.0	110	10.4	9.6	.8
136	F	L-R	L-R	R-R	14.4	111	7.6	9.0	-1.4
137	M	R-R	R-R	R-R	16.8	126	11.3	10.9	.3
138	F	L-R	L-R	R-R	17.5	132	10.8	11.4	-.6
139	M	L-R	L-R	L-R	16.2	120	10.1	10.5	-.4
140	F	L-R	L-R	M-M	13.9	108	8.9	8.6	.3
141	M	R-R	R-R	R-M	15.4	116	8.1	9.8	-1.7
142	M	R-R	R-R	R-M	17.9	135	10.4	11.7	-1.3
143	F	R-R	R-R	R-R	14.6	106	8.5	9.4	-.9
144	M	R-R	R-R	M-M	16.8	122	8.8	11.0	-2.2
145	F	R-R	R-R	R-R	15.2	112	9.7	9.8	-.1
146	F	M-R	R-R	M-M	13.1	101	8.5	8.0	.5
147	M	R-R	R-R	R-R	16.7	126	11.6	10.8	.8
148	F	R-M	R-R	R-R	15.9	121	11.2	10.2	1.0
149	M	R-R	R-R	R-R	15.5	114	9.1	9.9	-.8
150	F	R-R	R-R	R-R	15.0	122	10.1	10.1	0.0

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Corresponding Control in Grade VIII (con't)									
151	M	R-R	R-M	M-M	15.0	111	11.0	9.6	1.4
152	F	L-L	L-M	L-L	17.1	129	10.0	11.1	-1.1
153	F	L-L	R-L	M-L	13.9	121	9.7	8.7	1.0
154	M	L-L	L-L	M-M	17.1	126	10.5	11.2	-.7
155	F	R-M	R-L	M-M	13.9	108	10.0	8.6	1.4
156	F	L-R	L-L	M-M	15.9	124	10.5	10.1	.4
157	M	M-M	M-M	R-L	14.9	108	9.7	9.6	.1
158	F	L-L	L-M	M-L	16.7	129	11.0	10.7	.3
159	M	R-L	L-L	L-L	16.0	125	10.0	10.2	-.2
160	M	L-L	L-L	L-L	16.1	117	12.0	10.5	1.5
161	F	M-L	L-L	M-L	16.8	128	11.2	10.9	.4
162	M	R-R	R-L	R-L	14.6	108	6.8	9.3	-2.5
163	F	R-L	R-L	L-M	13.7	102	9.0	8.6	.4
164	F	L-L	L-L	M-L	17.8	135	11.8	11.6	.2
165	M	M-L	M-L	L-L	14.1	108	7.3	8.8	-.5
166	F	L-L	L-L	L-M	9.2	63	6.4	5.5	.9
167	F	R-R	R-M	R-M	15.8	116	11.0	10.2	.8
168	F	M-L	M-L	R-L	13.5	102	10.5	8.4	2.1
169	F	R-L	R-M	M-L	16.2	124	11.4	10.4	1.0
170	F	M-L	L-M	M-L	15.6	120	10.2	9.9	.3
171	M	L-R	L-L	R-L	16.5	127	10.4	10.6	-.2
172	F	L-L	L-L	L-L	17.1	134	10.6	11.0	-.4

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Crossed Control in Grade VIII									
173	M	R-R	R-R	R-M	17.8	138	12.0	11.5	.5
174	F	L-R	L-R	L-R	13.1	95	8.9	8.2	.7
175	F	M-R	R-R	M-R	16.1	126	10.3	10.2	.1
176	M	M-M	M-L	M-L	15.7	117	10.2	10.1	.1
177	F	L-R	L-R	M-M	17.9	130	10.2	11.8	-1.6
178	M	R-L	R-R	R-M	14.5	111	10.4	9.1	1.3
179	M	L-R	L-R	L-R	15.5	115	11.6	10.0	1.6
180	F	L-R	R-R	R-M	15.5	115	10.7	10.0	.7
181	F	R-R	R-M	R-R	15.4	112	9.6	10.0	-.4
182	F	R-R	R-R	R-M	14.9	115	8.8	9.4	-.8
183	M	R-R	R-M	R-R	14.7	108	9.9	9.4	.5
184	F	R-R	R-R	R-M	14.3	112	8.8	8.9	-.1
185	F	R-R	R-R	R-M	10.2	78	7.8	5.9	1.9
186	F	R-R	R-M	R-R	15.4	117	9.1	9.8	-.3
187	F	L-R	R-R	R-M	17.4	132	12.0	11.3	.7
188	F	R-R	R-R	R-M	16.5	127	9.0	10.6	-1.6
189	F	L-R	L-R	L-R	16.5	119	10.1	10.8	-.7
190	F	L-L	L-M	L-M	14.4	106	8.5	9.2	-.7
191	M	R-R	R-R	R-M	15.4	113	10.4	9.9	.5
192	F	M-L	L-L	R-L	14.1	107	9.7	8.8	.9
193	M	L-R	L-R	L-M	16.8	125	11.9	10.9	1.0
194	M	M-R	L-R	L-R	16.9	123	10.4	11.1	-.7
195	M	L-L	L-M	M-R	11.9	91	8.4	7.2	1.2
196	F	M-R	R-R	R-R	11.5	88	8.5	6.9	1.6
197	M	L-R	L-R	L-M	15.4	112	11.6	10.0	1.6
198	M	L-R	L-R	L-R	16.3	125	11.3	10.5	.8
199	F	L-R	L-R	L-M	12.7	98	7.5	7.7	-.2
200	M	M-R	L-R	M-M	15.7	119	11.6	10.0	1.6

DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Crossed Control in Grade VIII (con't)									
201	M	L-R	L-R	L-M	15.0	113	10.5	9.5	1.0
202	M	L-R	L-M	L-L	17.8	137	11.3	11.6	-.3
203	F	M-R	R-R	R-M	16.5	125	11.2	10.6	.6
204	M	L-R	L-R	L-R	13.7	101	7.7	8.6	-.9
205	M	R-R	R-R	R-M	14.1	104	8.5	8.9	-.4
206	F	R-L	R-L	R-M	14.8	111	10.1	9.4	.7
207	M	R-R	R-R	R-R	17.5	129	12.0	11.5	.5
208	M	L-R	L-R	R-L	16.6	123	10.1	10.8	-.7
209	M	L-R	L-R	M-R	15.9	119	10.5	10.2	.3
210	F	L-R	L-R	L-R	11.1	89	5.4	6.6	-1.2
211	F	L-R	M-R	L-M	15.3	114	9.8	9.8	0.0
212	M	R-R	R-R	R-M	16.6	125	11.4	10.7	.7
213	M	L-R	L-R	L-M	14.5	111	9.3	9.1	.2
214	F	L-R	L-R	L-M	14.7	115	9.8	9.2	.6
215	F	R-R	R-R	M-M	15.5	116	10.1	9.9	.2
216	M	L-R	L-R	L-M	15.9	119	11.0	10.2	.8
217	F	R-R	R-R	L-R	17.1	125	11.5	11.2	.3
218	F	R-R	R-R	R-R	15.2	111	9.7	9.8	-.1
219	F	R-R	R-R	L-R	14.4	113	10.1	9.0	1.1
220	M	R-R	R-M	R-M	14.7	108	7.3	9.4	-2.1
221	M	R-R	R-R	R-M	15.2	119	7.7	9.6	-1.9
222	F	R-R	R-R	M-R	15.3	118	10.4	9.7	.7
223	M	R-R	R-R	R-R	14.5	111	9.4	9.1	.3
224	F	R-R	R-R	M-R	16.4	122	11.2	10.6	.6
225	F	R-R	R-R	R-M	15.0	116	9.4	9.5	-.1
226	F	R-R	R-R	R-R	16.8	123	11.2	11.0	.2
227	M	L-R	L-M	L-R	12.7	95	8.6	7.8	.8
228	M	R-R	R-R	R-M	15.4	113	10.4	9.9	.5
229	M	M-R	R-R	R-R	16.2	122	11.0	10.4	.6
230	M	R-M	R-M	R-R	12.3	105	8.5	7.1	1.4

APPENDIX 7

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DATA

No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	I.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
Subjects Exhibiting Crossed Control in Grade VIII (con't)									
231	M	L-R	L-R	L-M	13.8	105	9.3	8.6	.7
232	F	L-R	L-R	L-R	12.7	96	8.9	7.8	1.1
233	F	L-R	L-M	L-R	12.8	98	10.1	7.8	2.3
234	F	L-R	L-R	L-M	13.4	102	5.6	8.3	-2.7
235	M	R-R	R-R	R-M	11.6	91	8.8	6.9	1.9
236	M	R-R	R-R	R-M	14.0	107	5.7	8.7	-3.0
237	F	R-R	R-R	R-R	15.4	116	10.4	9.8	.6
238	M	R-R	R-R	M-M	15.4	120	10.8	9.7	1.1
239	F	L-R	L-R	L-M	15.1	110	11.2	9.7	1.5
240	F	R-R	R-R	R-R	13.9	102	10.5	8.8	1.7
241	M	L-R	L-R	L-R	17.0	130	11.4	11.0	.4
242	F	R-M	R-R	R-M	14.7	108	8.5	9.4	-.9
243	M	R-R	R-R	M-M	13.9	102	9.6	8.8	.6
244	M	M-R	R-M	R-R	11.3	89	7.5	6.6	.9
245	M	L-R	L-R	M-M	13.8	105	8.9	8.6	.3
246	F	L-R	R-R	L-L	16.5	127	9.6	10.6	-1.0
247	M	R-R	R-R	R-R	12.3	92	8.5	7.5	1.0
248	F	R-R	R-R	R-M	16.3	122	10.5	10.5	0.0
249	F	R-R	R-R	R-R	15.4	119	9.8	9.8	0.0
250	M	L-M	L-R	L-R	17.2	133	11.2	11.1	.1
251	M	R-M	R-M	R-M	14.8	109	8.8	8.8	-1.1
252	M	L-R	L-R	L-M	16.0	120	10.5	10.3	.2
253	F	L-L	L-R	L-M	14.0	105	9.8	8.8	1.0
254	F	R-R	R-R	R-R	13.4	101	9.0	8.3	.7
255	M	R-R	R-R	R-M	15.3	111	9.4	9.9	-.5
256	F	R-R	R-R	L-R	13.4	103	8.7	8.3	.4
257	F	R-R	M-R	M-M	12.1	89	8.4	7.2	1.2
258	F	M-R	R-R	R-R	12.7	96	8.7	7.8	.9
259	F	M-R	R-M	R-M	11.6	87	7.3	7.0	.3
260	F	L-R	L-R	R-M	16.5	122	11.2	10.7	.5

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No.	Sex	Kdgn. Eye- Hand Dom.	Gd. 2 Eye- Hand Dom.	Gd. 8 Eye- Hand Dom.	M.A.	J.Q.	Total Rdg. Ach.	Rdg. Exp.	Rdg. Diff.
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261	F	L-R	L-R	L-R	16.6	130	11.2	10.6	.6
262	F	R-R	R-M	R-M	11.3	84	7.9	6.8	1.1
263	F	R-R	L-R	R-M	13.2	110	8.7	7.9	.8
264	F	L-L	R-R	M-L	15.6	122	10.4	9.9	.5
265	M	M-R	L-R	L-R	16.5	128	9.8	10.6	-.8
266	M	R-M	M-M	R-M	13.6	104	10.0	8.4	1.6
267	F	R-R	R-R	M-M	16.3	120	9.8	10.6	-.8
268	F	R-R	R-M	M-M	15.9	117	11.6	10.3	1.3
269	F	R-M	R-R	L-M	16.5	127	10.3	10.6	-.3
270	M	R-R	R-R	R-M	13.6	106	5.8	8.4	-2.6
271	M	L-R	L-R	R-M	19.0	139	11.9	12.9	-1.0
272	M	L-R	L-R	L-M	17.0	126	12.0	11.1	.9
273	F	R-R	R-R	R-M	13.6	107	9.7	8.4	1.3

[illegible]

APPENDIX 8

ABSTRACT OF

A Study of the Possible Distinction Between "Controlling Eye"
and "Dominant Eye" and the Relation of Both, with Hand
Dominance, to Reading Achievement

APPENDIX 8

ABSTRACT OF

A Study of the Possible Distinction Between "Controlling Eye" and "Dominant Eye" and the Relation of Both, with Hand Dominance, to Reading Achievement¹

This report includes a review of the literature related to lateral dominance and reading achievement, the neurological basis of reading disability, the significance of reversal errors in reading, and the problem of testing laterality.

The primary purpose of this study was an attempt to clarify the equivocal research on laterality and reading achievement through the investigation of the possible distinction between the "controlling" eye in binocular vision and the "dominant" eye normally referred to in studies of laterality. Related purposes included the following: an analysis of the relationship of crossed control, crossed dominance, and mixed dominance to reading achievement in a junior high school population wherein eye-hand dominance was earlier found to be unrelated to intelligence, reversals, reading differential, and reading achievement at the primary level; a determination of a possible difference in the dominance patterns of males and females; and an evaluation, at

¹ Robert W. Boes, doctoral thesis presented to the Faculty of Education of the University of Ottawa, Ontario, 1968, xv-20⁺ p.

this age level, of a developmental trend away from mixed dominance as reported in an earlier study which followed this same population from kindergarten to mid-third grade.

Subjects were 263 eighth-grade and ten seventh-grade students who remained from the earlier study. Subjects were tested for the controlling eye in binocular vision, using cards DB-2, DB-3, and Gray's Oral Reading Paragraphs with the Keystone Telebinocular. They were retested for the dominant eye used in sighting with the V-Scope and hole-in-paper test, for hand dominance determined by tests of cutting, writing, throwing, eating, tapping, and connecting dots, and for reading achievement using the California Achievement Test, Form W, Level 7 - 9.

Chi square was used to ascertain differences between the controlling eye and the sighting eye, and between the dominance patterns of males and females. Chi square was also used to identify changes in eye-hand dominance from second to eighth grade, and in dominance configuration of subjects below grade level in reading as compared with those at and above grade level. The t test was used to determine significance of differences in reading achievement between crossed and mixed dominant groups as compared with the unilaterally dominant group and between the crossed control group compared with the unilateral control group.

This investigation did reveal a distinction between the "controlling" eye and the "dominant" eye. On the other hand, there was no significant difference in mean reading achievement or mean reading differential among children exhibiting unilateral, crossed, or mixed dominance; nor was there a significant difference in mean reading achievement or mean reading differential between groups exhibiting crossed control as compared with those having unilateral control. While no significant difference was found in dominance characteristics between male and female subjects, a definite trend was observed toward increased amblyedness and ambidexterity from grade two to grade eight in the same subjects.

Although it was concluded that neither dominance nor control characteristics was a significant factor in reading achievement in the group examined, the fact that there was a significant distinction between the "controlling" eye and the "dominant" eye suggested several possibilities for future research. Among these were a longitudinal study of control characteristics, and an investigation of controlling eye discrepancies at varied distances, and the role of visual acuity in determining control.

