A STATISTICAL STUDY OF SPECIFIC DYSLEXIA--
CHARACTERISTICS AND SYNDROME PATTERNS

A Dissertation

Presented to

The Faculty of the Department of Psychology

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

Clifton W. Wolf

June, 1968

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AN ABSTRACT

Clinically significant variables reported in the literature on specific dyslexia were experimentally studied in matched group design. The experimental and control groups consisted of 32 and 23 third and fourth grade children respectively. The children came from families in the middle to above average socioeconomic classification. They were free of medical problems and personality-emotional disturbances, and they had above average intelligence. Selection variables, 10 in all, were statistically held constant with the exception of reading and spelling. The experimental group was one or more years below grade level on reading and spelling and the control group was at or above grade level on reading and spelling.

The two groups were compared on 197 variables in the following areas: (a) intelligence (WISC); (b) education--reading, writing, spelling, and arithmetic; (c) visual perception; (d) auditory perception; (e) speech; (f) psychoneurological; (g) neurological; (h) EEG; (i) medical history; and (j) familial history of language disability.

The data were analyzed by means of simple analysis of variance, intercorrelation of significant variables, factor

analysis, hierarchical grouping analysis, and analysis of variance of variables used in the hierarchical grouping analysis. These procedures produced 43 significant variables, 14 factors, and three syndrome patterns of specific dyslexia.

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CHAPTER I

THE PROBLEM

The child or adult with a reading disability is a disadvantaged person in our highly literate and technological society. This disability can affect him educationally, psychologically, socially, and economically. The person who reads poorly is at an educational disadvantage, as ability to read adequately is the prime requisite and basic foundation for most academic learning, whether it be at the elementary level or the graduate level. Psychologically, the poor reader learns early in life that he is different from others, a difference that is significant to him as it often forms the basis for ridicule and rejection. Even though the disabled reader may have adequate to even superior intelligence, his placement in the low reading group at school marks him as an inferior person. As the child progresses through school a poor self-concept develops, with concommitant feelings of inferiority, inadequacy, and worthlessness. These attitudes toward the self begin to influence his social behavior and his style of interpersonal relations. Economically, this person as an adult probably will not realize his full potential, for he may drop out of school. Or, he may not go on to college, even though his level of intelligence would warrant such.

The following references in the literature are presented, therefore, as justification for the contention that reading disability presents a serious problem to many individuals in particular and to society as a whole.

Prevalence of Reading Disability

A number of authorities in education, psychology, and medicine have estimated the prevalence of school children who have a reading disability. Their information came from clinical experience, per cent of children with reading problems evaluated at child guidance centers, and school surveys. The following estimates concern only the prevalence or extent of reading problems; they do not refer to any particular type of reading disability.

Preston (1940) and Hallgren (1950) both were of the opinion that the incidence of children with poor reading ability was 20%. Betts (1946) wrote that 40% of school pupils could not read text books written for use at grade level. Robinson (1953) wrote, "Authorities estimate that 10 to 20% of pupils in grades 2-6 fall in the category of poor readers (p. 562)." Conant (1959), after an extensive survey of American education, concluded that approximately 10 to 15% of children entering high school had a reading disability at the fourth to sixth grade level, and they were not mentally retarded. Bakwin and Bakwin (1960) stated that 10% of all school children were below grade level in reading ability. Schiffman (1962) reported that various authorities had estimated that 20 to 40% of school children read considerably below capacity level. Mrs. Sally Childs (1965), past president of the Orton Society, concluded that 20 to 30% of students were deficient in reading ability, irrespective of etiology. Cronin (1965), remarked, "Reliable authorities estimate that retarded readers make up 24% of the school population (p. 108)."

The above-mentioned estimates on the prevalence of reading disability vary from 10 to 40%. A median score of these estimates is roughly 20%. To illustrate concretely the extent of reading disability, Gillingham and Stillman (1956) compared the number of children with a reading disability with the number of children in other disability categories. They wrote:

> If ten per cent of them (number of children in the United States in 1953) are children whose reading and spelling are so poor as to demand special

> training, then those in need of remedial instruction must approximate 3,411,340 compared with the 85,000 blind, the 513,000 deaf and the 513,000 crippled children of school age (pp. 16-17).

Other sources in the literature indicated the prevalence of reading disability based on surveys. Durrell (1940) studied 1,130 sixth grade students who were one or more years below grade level in reading. He found that 27% were of average to superior intelligence. Newbrough and Kelly (1962) evaluated all sixth graders (3,946 students) in one school system and found that 14% of them were two or more years below their grade level.

Prevalence of Dyslexia

Dyslexia (specific language disability) is one type of reading disability that has received considerable attention in recent years. It stands in contrast to other types of reading problems associated with, for example, mental retardation, brain damage, and lack of adequate sensory stimulation and cultural exposure. A number of authorities have estimated that the prevalence of dyslexia is approximately 10% of the entire population of school children (e.g., Bryant & Patterson, 1962; Gallagher, 1960; Gillingham & Stillman, 1956; Ketchum, 1959; Rabinovitch, Drew, De Jong, Ingram, & Withey, 1954).

A few investigators have studied the exact incidence of dyslexia. Their findings, therefore, are more reliable when considering the prevalence of this form of reading disability. Malmquist (1960) studied reading disability among first graders (399 children) and found 8.5% were dyslexic. Faigel (1965) evaluated 256 children in grades two through six in one elementary school and found that 13% were dyslexic. Of this 13%, 80% were boys. Walker and Cole (1965) studied 225 children in a school population consisting of families from the above-average socioeconomic classification. They found that 25% of the children had dyslexia.

Personal Adjustment Problems

Prevalence is only one aspect of poor reading. There is the experiential part that involves real life consequences for the child or adult who suffers from a reading disability. Rabinovitch, et al. (1954), in a strongly worded statement, indicated the severity of the life adjustment problems associated with a reading disability:

> Although the reported statistics of incidence vary a good deal, it is likely that at least 10 per cent of children of average intelligence at school in the

> United States are reading so inadequately for their grade placement as to impair their total adjustment (p. 363).

Gallagher (1960) was more specific in describing the impact of a reading disability (dyslexia) on personal adjustment:

> If the difficulty of these young people is not then recognized and remedied, not only will there be failure in school but also excessive anxiety, loss of confidence, and family discord, following which any one of a number of psychosomatic symptoms may develop (p. 4).

Other references in the literature discussed the deleterious influence of poor reading ability on the development of the emotional and personal life of children. Bender (1963) wrote:

> Experience with the problem children at Bellevue Hospital led to the early recognition that more than 50 per cent of boys with the kinds of problems that sent them there were nonreaders or severely retarded in reading . . . . It was also recognized that this is one of the most common causes of social or emotional maladjustment, behavior disorders, delinquencies, etc., in our young people (pp. 25-26).

Dozier (1963) stated:

> the child with a specific reading disability (dyslexia) has a true inferiority, and this engenders in the majority of cases a personality reaction which is likely to be a problem (p. 20).

Saunders (1963), in an address to the Orton Society, was very direct in referring to the experiential world of the child who has a reading problem (dyslexia). He remarked:

> For you to help a fourth grade child advance from a first grade reader to a fourth grade reader is of tremendous importance in the fourth grade, but to grow from feeling like a first grader to feeling like a fourth grader is probably even more important to the fourth grader . . . . We are all familiar with the surprised parental comment, 'Why, he is a changed boy!', often after a few sessions with his reading therapist (pp. 83-84).

In comparing problems of reading with medical problems, Wright (1963) stated:

> the severity of emotional disturbances and the educational failure that might result from this syndrome are as serious a handicap to the individuals as are many medical and surgical problems for which appropriate help is given (p. 143).

A quote from Tompkins (1963) in The New Yorker indicates the scope of reading disability and its impact on children:

> In 1961, the National Council of Teachers of English estimated that out of the thirty-three million children then in elementary school, nearly four million were seriously retarded in reading . . . . (This reflects) an increasingly ominous social dilemma. In our highly literate, technological

> society, the child who cannot learn to read soon realizes that he is disinherited, economically as well as socially . . . (p. 134).

In view of the estimates concerning reading disability and the degree to which poor reading affects the emotional life, the personal growth and development, and the self-concept of the child, it is little wonder that many people from various professional and lay groups are vitally concerned with this problem. It is reasonable to assume, therefore, that the pervasive degree of reading disability and its pernicious influence on children and adults constitute adequate justification for research involvement by the social and behavioral scientists.

Proliferation of Labels Regarding Dyslexia

The literature abounds in statements explaining why people cannot read adequately. Some individuals are mentally retarded and are incapable of learning the symbolic significance of the printed word. Others are brain damaged or suffer from assumed minimal brain impairment. Still others are emotionally disturbed and do not have appropriate attention, concentration, and interest for learning to read. Cultural and educational deprivation are also indicated as causes of reading difficulty. Some individuals have peripheral sensory defects that interfere in learning. Specific dyslexia is also reported in the literature as a basis for reading disability. About this condition much controversy exists. Terms with similar meaning are dyslexia, developmental dyslexia, and specific language disability. Hereafter, the terms dyslexia and specific dyslexia are used synonymously. No distinction is made between them and the terms developmental dyslexia and specific language disability.

Some of the terms with similar meaning to dyslexia are presented in Table 1. The abundance of these terms, some of which no longer appear in the literature, is symptomatic of the confusion concerning the meaning of dyslexia.

Additional terms, related to but not necessarily synonomous with dyslexia, are acquired dyslexia, acquired specific dyslexia, agnosic dyslexia, dyslexia-dysgraphia, occipital dyslexia, parietal dyslexia, subcortical alexia (Benton, 1962b); specific developmental dyslexia (Franklin, 1962); pure congenital visual aphasia (Cohn, 1964); and agnosic alexia, aphasic alexia, pure alexia, visual object agnosia, and symbolia (Critchley, 1964). Some do not give credence to the theoretical basis assumed by the term dyslexia and instead prefer to use the term "backward readers" (Vernon, 1958).

TABLE 1

Terms Similar in Meaning to the Term "Dyslexia"

Term	Source of reference
Word-blindness	Kussman (1877)
Congenital word-blindness	Morgan (1896)
Congenital symbol-amblyopia	Claiborne (1906)
Congenital typholexia	Variot and Lecomte (1906)
Congenital alexia	Stephenson (1907)
Amnesia visualis verbalis	Witmer (1907)
Congenital dyslexia	Rutherford (1909)
Developmental alexia	Chance (1913)
Analfabetia partialis	Wolff (1916)
Bradylexia	Claparede (1917)
Strephosymbolia	Orton (1928)
Specific reading disability	Orton (1928)
Constitutional dyslexia	Skysgaard (1942)

Note.— Terms listed by Drew (1956).

TABLE 1, continued

Term	Source of reference
Specific dyslexia	Hallgren (1950)
Primary reading retardation	Rabinovitch, et al. (1954)
Familial dyslexia	Drew (1956)
Familial congenital word-blindness	Drew (1956)

The various terminology in the above paragraph raises the question whether dyslexia is related to disorders of aphasia or agnosia, whether it is part of a more general language or visuoperceptive deficit, whether it is an aspect of a general psychoneurological learning disability, or whether it is a separate disorder. The answers to these questions depend on what groups or types of patients an investigator studies and the definition he holds for dyslexia. To some degree it also depends on the investigator's professional identification; people in the various professions of medicine, psychology, and education sometimes use different conceptual frames of reference and different language systems. Therefore, one may view dyslexia from a biochemical, anatomical, neurophysiological, psychoneurological, psychophysical, behavioral, psycholinguistic, or educational perspective. Newbrough and Kelly (1962) commented about the complexities involved in conceptualizing dyslexia:

> One of the most challenging problems in regarding research is the definition and relative meaning of reading retardation. Our recent searches of the literature have failed to disclose any very comprehensive discussion of the concept (p. 67).

Definitions of Dyslexia

In general, the term dyslexia, when not restricted in meaning to specific dyslexia or developmental dyslexia, simply means an inability to read or a disability of reading, regardless of the assumed etiology. Benton (1962b), in discussing dyslexia in a general sense, presented a "two-factor" etiological theory of dyslexia by comparing acquired dyslexia with developmental dyslexia. Briefly, acquired dyslexia is associated with focal neuropathology of the dominant hemisphere resulting from some form of brain damage or brain disease, which is not demonstrable in developmental dyslexia. Benton (1964) indicated that with the exception of the EEG patterns, neurological variables do not contribute to understanding developmental dyslexia. In a personal communication, Birch (1964a) held a similar opinion: "I am unaware of any well established set of neurological criteria that may be applied to this issue."

Money's (1962) classification of dyslexia is similar to Benton's (1962b) in that he spoke of traumatic dyslexia and developmental dyslexia. For example:

> Dyslexia means defective reading. The reading defect may represent loss of competency following brain injury or degeneration; or it may represent a developmental failure to profit from reading instruction (p. 9).

In reference to developmental dyslexia, Money said, "But it is usually the case that developmental dyslexia appears without demonstrable early brain injury (p. 14)." Myklebust and Johnson (1962) indicated a similar two-fold genesis.

Geschwind (1962) also used dyslexia in a generic sense to mean an inability to read normally, then subsequently classified the disorder in two major categories. He stated, "it is therefore common practice among neurologists to distinguish acquired dyslexia or alexia from their congenital counterparts (p. 115)."

Prechtl (1962) discussed two categories of reading disability involving brain damage. He wrote:

> From the neurological point of view, we may divide reading disabilities into two groups: a first group with lesions in specific cerebral structures which deal with the function of reading, e.g., the brain areas 17, 18 and 19, which subserve a visual but non-language function, and area 39, which combines both visual and language functions; and a second group with nonspecific lesions of the central nervous system in which the performance of reading is impaired in general, more or less as a side effect (p. 187).

A condition of brain damage is basic to these two groups, but as Prechtl stated, they stand in contract to disordered reading related to hereditary factors.

The aforementioned definitions of dyslexia involve two major types: the first results from brain damage, brain injury or brain disease. This represents an exogenous assault to the brain that results in some form of tissue damage. The second implies a nonfocal neuropathological problem resulting from an inherited, genetic, familial condition or a delay in neurophysiological maturation.

A two-factor theory of learning difficulty which is related to reading problems in adolescents was proposed by de Hirsch (1963c). Although her theory is not specifically about dyslexia, her point of view does offer two broad categories of learning disabilities, one involving psychodynamic factors, the other, psychoneurological factors. The adolescents in the psychodynamic learning disability group tended to be physically small and physiologically immature; intelligence was above average and academic achievement was good in the early school years, however, performance was poor during the adolescent years. The personality structure included passive and infantile traits, poor ego strength, and a superficially charming and compliant style of relating with others. These children were under-achievers and their academic difficulties were related to ego impairment and were manifestations of a severe character disorder.

The characteristics of the psychoneurological learning group were: (a) Verbal Scale lower than Performance Scale on the WISC; (b) speech deficiencies; (c) poor reading; (d) hyperkinesis; and (e) immaturities in the perceptual, motor, and visuomotor areas during the early school years. When these children reached adolescence, a residual language disability was indicated by: inarticulate use of language; poor spelling; poor auditory discrimination; poor writing; poor performance in perceptual, visuomotor, and motor patterning activities; and overt hostility. As de Hirsch (1963c) stated, "What begins with a reading disorder turns into a learning disability (p. 90)."

The two-factor theory of dyslexia may be expanded into a three-factor theory. This is demonstrated by the work of Rabinovitch (1951, 1962), Rabinovitch and Ingram (1962), and Rabinovitch et al. (1954). As Rabinovitch (1962) said, his group has avoided using the term dyslexia, "Because its usage has become so ambiguous . . . (p. 75)." Their research has produced three classifications of dyslexia, related to: (a) brain damage; (b) a nonfocal neuropathological condition; and (c) an emotional disturbance.

The three-factor theory of the Rabinovitch group apparently has been a stimulus for research, as others have reported studies within this frame of reference (Fuller, 1964; Fuller & Laird, 1963a, 1963b; Silver, 1961; Silver & Hagin, 1960). For example, the Minnesota Percepto-Diagnostic Test (MPD) developed by Fuller and Laird (1963b) significantly categorizes children with a reading disability in three groups: (a) primary reading retardation (no evidence of brain damage); (b) secondary reading retardation (capacity to read is intact but interference is present due to emotional factors); and (c) organic reading retardation (evidence of brain damage). Silver and Hagin uncovered three groups of children with similar reading disabilities.

Gallagher (1962) is another who subscribed to a three-factor theory of reading disability. He believes children with dyslexia may be classified in the following three groups: (a) emotional disturbance; (b) brain damage; and (c) specific language disability. His last group is similar to specific or developmental dyslexia and to primary reading retardation.

Another approach to the definition of dyslexia may be termed the multi-factor theory. This theory is more expansive than the two-factor theory and may include any number of etiological factors: poor reading readiness; irregular school attendance: defective teaching; physical handicaps; speech retardation, subnormal intelligence; and social and cultural deprivation. Monroe (1932) listed 15 factors that can produce reading problems. Jackson (1944) wrote about the intertwining of psychological, social, and environmental factors as responsible for reading disability. Robinson (1946) listed the following seven factors as basic to a disturbance in reading: visual difficulties; intellectual and maturational status; neurological and dominance factors; auditory, speech, and language factors; physical difficulties; emotional adjustment; and social and environmental variables. The lack of preciseness in conceptualizing the problem of reading disability tends to be present in the writings of some multi-factor theorists as evidenced by the following quote from Witty and Kopel (1939):

> reading disability is a complex condition involving the interaction of multitudinous phases of physical and mental growth. In every case, causation should be sought not in single factors

> but in the complex patterns whose interrelated elements, in proper balance, are essential to maximum efficiency (p. 218).

Much of what is contained in the multi-factor theory is unrelated to cerebral function as found in the two-factor and three-factor theories, and there is little relevance to the concept of dyslexia as found in the medical and psychological literature. Partly, this is due to the fact that multi-factor theorists are educators or researchers attached to educational-type institutions rather than to clinical and medical settings. Additionally, educators have looked at the problem of reading retardation from a limited point of view (e.g., reading test scores) and generally they have not worked intensively with severe cases of reading disability. Neurologists, pediatricians, and psychologists associated with clinical and medical settings have considered reading disability from a broader perspective--educational test performance together with neurological, psychoneurological, and psychological behavior.

Reversing our field for the moment, we may now consider single-factor theories of reading disability. The first and foremost single-factor theory is based on emotional and personality disturbances. Much has been written concerning emotional problems as the etiological basis for reading disability (e.g., Blanchard, 1946; Blau, 1946; Fabin, 1951; Gann, 1945; Gates, 1922, 1941; Meyer, 1953; Vorhaus, 1952). Here reading disability is discussed in relation to such concepts as feelings of guilt or dread of castration, ego impoverishment, educational impotence, lack of rapport with the environment, neurotic symptomatology, dynamic aspects of personal adjustment, and unfavorable home influence. The following quotation from Pearson (1952) illustrates how personality variables are utilized in understanding learning and reading problems:

> Essentially a diminished capacity to learn is a problem of ego psychology and therefore I intend to discuss the various factors which hinder the ego in its ability to learn. These factors may occur in the ego itself, as a result of the influence of the external world on the ego or as the result of influence which may emanate from the superego or the id (p. 323).

Blanchard's (1946) approach was psychoanalytical and he believed reading disability was not a primary disturbance; rather it was a secondary phenomenon or a neurotic symptom.

Stewart (1950) related reading disability to personality problems such as poor motivation due to an insecure relationship with parents or as an expression of hostility against a parent or parents with ambivalent feelings toward the child. Some have criticized the use of personality as a causative factor in reading disability. Thus, Smith and Carrigan (1959) stated:

> Personality structure, narrowly conceived, will probably prove sterile as a focus. For example, with regard to anxiety, clinical experience has shown that many anxious children can be made sufficiently comfortable to allow learning to occur (p. 14).

A similar view was expressed by Jastak (1946) who disavowed the pernicious influence of anxiety on reading. He remarked that,"high reading and low arithmetic scores tend to occur in abnormal states of a developmental nature and of long standing as in neurosis and schizophrenia . . . (p. 2)." He further stated that, "The neurotic and disorganized child is usually more proficient in reading than in arithmetic (p. 14)."

A statement by Kass (1962) placed the hypothesis of an emotional basis to reading disability in proper perspective: "At present, there is no convincing evidence which differentiates between cause and effect in emotional disturbance and reading disability (p. 11)."

In summary, decisive experimental research on emotional disturbance and reading disability is yet to be done. Those who have emphasized the emotional basis to reading problems have not adequately investigated or controlled the relevant variables that appear in the research of those who have postulated a developmental, psychoneurological, or genetic basis to reading disability. Emotional factors may be correlated with or antecedent to disturbed reading, but adequate experimental research has not yet validated this hypothesis. The law of parsimony would suggest that investigators look for less complicated or more simplified hypotheses as found, for example, in Birch's work (Birch, 1962; Birch & Belmont, 1964).

There are several other single-factor theories that might be placed in the category of "miscellaneous one-factor theories." Reference is made to the following investigators and their major points of emphasis: Cole (1951), Goody and Reinhold (1961)--lack of cerebral dominance due to heredity; Drew (1956)--defect in figure-ground recognition or configuration; Hallgren (1950)--genetic inheritance; Hermann (1959)--constitutional factors (heredity); Hinshlewood (1895)--familial, de Hirsch (1961)--poor perceptual integration due to inherited generalized Gestalt deficiency; Bender (1957), Olson (1940)--maturational lag; Orton (1925, 1926)--ambiguous occipital dominance; and Smith and Carrigan (1959)--disturbance in endocrine functioning resulting in chemical imbalance at the point of synaptic transmission.

In summarizing the dyslexic research concerning the one-factor theory, one theoretical concept appears to be most prominent; it is variously referred to as hereditary, familial, constitutional, or genetic. The study by Hallgren (1950), which is perhaps the best documented one indicating a specific genetic factor responsible for dyslexia, implied a monohybrid autosomal dominant mode of inheritance.

There is another approach to defining dyslexia which is worthy of careful attention; reference is made to the work at the Institute for Research on Exceptional Children, University of Illinois (e.g., Kirk, 1963). It is difficult to place this approach within the aforementioned factor categories as emphasis is placed on the correlates of reading disability rather than etiology. The Illinois group is primarily concerned with the psycholinguistic correlates of learning disabilities, of which reading disability is only one aspect (Bateman, 1964a, 1964b; Kass, 1963; Kirk & Bateman, 1962; Sievers, McCarthy, Olson, Bateman, & Kass, 1963).

The conceptual frame of reference for this work was Osgood's model of psycholinguistic functions (Osgood, 1957a, 1957b; Osgood & Miron, 1963). Kirk (1963) and his co-workers (McCarthy & Kirk, 1961, 1963) have utilized the Illinois Test of Psycholinguistic Abilities (ITPA) in studying various learning disability groups. They are concerned primarily with assessment of behavioral symptoms and in developing remedial programs for various learning disabilities. They are not interested in diagnosing antecedent etiological factors. Concerning dyslexia, Kirk and Bateman (1962) wrote:

> Dyslexia is a label meaning that the person has difficulty learning to read. A dyslexic may have a lesion in the angular gyrus, or had his handedness changed, or perhaps his father rejected him. But none of these kinds of analyses tells us what to do to improve the reading of our particular subject. Our interest is in the kind and extent of diagnosis of learning problems that lead directly to a formulation of what should be done about the disability (p. 73).

One may assume from the foregoing that the Illinois group does not view specific dyslexia as a special subcategory of reading disability, or at least concern themselves with this problem, as do Benton (1962b), Childs

(1965), Cole (1951), Critchley (1961), Drew (1956), Eisenberg (1962), Fuller (1964), Gallagher (1950), Hallgren (1950), Hermann (1959), de Hirsch (1952), Rabinovitch (1959), Orton (1937), and Silver and Hagin (1960). All of these writers view specific or developmental dyslexia as a discrete subcategory of reading disability involving problems of psychoneurological organization and integration. In addition to these writers, there are many others who share a similar point of view.

A concluding statement by Benton and Bird (1963) summarizes present knowledge about the etiology of reading disability:

> There is agreement that it is useful to think of reading disability as a symptom which may appear as the result of diverse antecedent conditions. It may occur as an expression of a general visuoperceptive deficit in a brain-damaged child. It may reflect a slow rate of cerebral development, which is also shown in motor and speech retardation. It may appear as an expression of long-standing emotional disturbances. It may present as a relatively specific language disturbance without note-worthy associated deficits. Children of the last type, who are dyslexic but whose neurological, intellectual and emotional status are within normal limits, form a fairly sizable group (p. 531).

The literature itself, and those who review the literature, frankly indicate that considerable disagreement in Europe and in the United States has been present for several decades concerning etiological factors and clinical symptoms of reading disability in general and dyslexia in particular. That this conflict is still present is indicated by the following statement by Gallagher and Locke in their introduction to Hermann's (1959) book:

> we have become concerned lest the present-day tendency to blame one or another teaching method, or some emotional experience or environmental factor, obscure the fact that in many individuals a variation in the working of brain itself constitutes fundamental difficulty (pp. 5-6).

If one is allowed the privilege of presenting a "line-up," it seems that educators and educational psychologists emphasize emotional, personality, environmental, and educational instructional methods as major causative factors in reading disability. On the other hand, neurologists and related medical specialists, and clinical and experimental psychologists, indicate that psychoneurological variables unrelated to personality-emotional and environmental factors are the primary antecedent variables associated with a large number of children with reading problems, particularly those with dyslexia. There are a number of reasons why this conflict continues. The following 11 categories, or points of view which represent sources of confusion, are presented in an effort to clarify the basis of this theoretical and scientific conflict.

Problems Associated with Dyslexic Research

Age of Subjects Evaluated

The samples of subjects evaluated in reading disability research range from pre-school to adult ages. Generalizations about dyslexia in regard to the population at large are based on the age norms of the samples studied; a longitudinal consideration is therefore obscured. Many phenomena in dyslexia are developmental: right-left orientation (Benton & Kemble, 1960; Belmont & Birch, 1963; Harris, 1957); peripheral lateral dominance (Belmont & Birch, 1963; Zangwill, 1962); intersensory integration (Birch & Belmont, 1965; Birch & Lefford, 1963); finger localization (Benton, 1959b); visual-motor performance (Bender, 1938); hierarchical organization of sensory systems (Birch, 1962): and lag in development (Bender, 1957; Eisenberg, 1962; Money, 1962; Olson, 1940). Depending on the age level of the children, investigators have reported various results on the above-mentioned variables. The conclusions drawn from studies using different age norms tended therefore to conflict one with another in regard to the degree these developmental factors were present or absent in the subjects studied. In discussing present research findings, one should make specific reference to the age level of the subjects evaluated when attempting to generalize to the population of dyslexic readers.

Clinical-Observational vs. Experimental Research

Much of our knowledge on dyslexia has come from clinical studies. As is the case in this type of research, replication is most difficult. It is not known, therefore, whether the clinical findings correctly represent the phenomena of dyslexia or whether they are artifacts of the methodological procedures and techniques used by the clinician. A report by Bryant, Mirlin, and Patterson (1964) is pertinent to this consideration. In a review of the literature on the association of impaired motor development and dyslexia, they stated:

> few quantitative studies appear to have been made . . . . None of the references . . . give experimental and quantitative verification to the association of poor motor development with reading disability (p. 1).

Other problems concern variability and reliability in observational techniques used by various investigators. This is readily recognized in psychiatric research wherein reliance is placed on the psychiatric interview as a diagnostic instrument. Part of the problem in dyslexic research is related to the skill and training of the investigator, his "built-in" norms of normal and abnormal behavior, and his conceptual frame of reference, whether it is psychological, behavioral, neurological, or educational.

The clinical-observational approach has produced much knowledge about dyslexia, but it is surprising that few investigators have not gone further by employing the hypothetico-deductive or the empirical-correlational approach. The absence of these methods in the literature is remarkable, particularly in view of the voluminous studies on causes of reading disability. By way of illustration, the hypothetico-deductive method of analysis is seen in Benton's work (Benton, 1959a, 1959b; Benton & Kemble, 1960; Benton & Menefee, 1957) and in Birch's work (Belmont & Birch, 1963; Birch, 1962; Birch & Belmont, 1964; Birch & Lefford, 1963). The empirical-correlational method is illustrated in Kass' 1962 dissertation.

Reliability and Validity of Standard Measurement Instruments

A number of references were made to the use of well-known reading tests which were employed in determining the degree and nature of reading disability. The reliability and validity of some of these instruments may be questioned in view of the reviews in Buros (1953, 1959). The selection of measurement instruments for educational achievement also presents problems, particularly the results in arithmetic computation and spelling, two measurement operations often reported in the dyslexic literature. For example, various achievement tests measure different aspects of arithmetic; some measure arithmetic computation and some emphasize reasoning and conceptual factors. In regard to spelling, some research papers reported results based on spelling tests developed as early as the 1920's, tests that have been criticized as being unreliable and invalid. Measurement of handwriting, another factor reported in the literature, also needs careful scrutiny. Gross and bizarre handwriting is easily recognized. However, there is the problem of refined measurement and reliability in judging handwriting. This difficulty will remain until more adequate instruments are utilized in research, unless of course one considers handwriting on a discrete good-poor continuum.

Use of Different Instruments to Measure the Same Function

It would be well if all investigators used the same "yardstick" in assessing factors associated with dyslexia; however, this has not been the case. Nevertheless, there is some agreement concerning the various phenomena correlated with dyslexia, but the problem is that different researchers go through different operations to arrive at their conclusions. These operations may or may not be measuring the same (assumed) process, or they may be measuring different aspects of the same process. A case in point is auditory discrimination which has been reported to be correlated with poor reading. A study by Goetzinger, Dirks, and Baer (1960) employed three tests of auditory discrimination: the Rush Hughes recording of the Harvard PB (phonetically balanced) word lists, the C.I.D. W-22 records, and the Wepman Test of Auditory Discrimination. They found that the C.I.D. W-22 test did not differentiate good and poor readers, whereas the Rush Hughes recordings and the Wepman Test did. Even though these latter two tests differentiated the two groups of readers, they were not significantly correlated with each other.

Another example may illustrate this problem. Difficulty in right-left discrimination has been reported by some writers as characteristic of dyslexic children. Most studies have utilized clinical-observational techniques only. Others, however, have used standardized instruments such as the Harris Tests of Lateral Dominance (Harris, 1958), the Benton Right-Left Discrimination Battery (Benton, 1959b), and Belmont and Birch's (1963) Right-Left Awareness Items adapted from Piaget (1928). The Benton test is by far the most complete and thorough in its analysis of right-left discrimination. The Harris test is only a three item test, but age norms and degree of discrimination âre provided. The Belmont and Birch test was developed to demonstrate growth and development in right-left discrimination in children.

The difficulty in interpreting the relevant correlation of right-left discrimination with dyslexia is that much of the research was not reported in relation to normative data or methods of assessment. Very few studies used, for example, right-left discrimination tests developed by Benton (1959b), Birch (Belmont & Birch, 1963), and Harris (1958). One cannot be sure, therefore, that the results from various studies can be equated.

Until it can be justifiably assumed that various tests, formal or informal, measure the same function, confusion will exist concerning the degree to which a function is normal or impaired.

Neurological Evaluation and Classification of Children with Dyslexia

Reitan (1962) and Reed (1963) indicated there is a problem involved in the measurement of the independent variables in brain-behavior research. In regard to collaborative research with neurologists, Reitan stated that psychologists should be familiar with independent neurological variables that form the basis for assignment of subjects to research groups. Furthermore, psychologists must be aware of problems of standardization involved in the neurological examination.

Cohn (1964), a neurologist, indicated a theoretical problem associated with the neurological examination of dyslexic children. He wrote:

> From the recent literature . . . it is evident that many neurologists believe that there are a number of minimal, or "soft," neurological signs in individuals who have difficulty in acquiring verbal language functions necessary for information transfer. It is implied that these minimal neurological findings can be equated with minimal brain damage, and that this minimal brain damage retards the organizational capacity of the child to synthesize and

> classify incoming data. This writer takes exception to the equating of minimal brain damage with minimal neurological signs . . . (p. 180).

This point of view was also expressed by Benton (1962a) and Birch (1964b).

Theoretical disagreement is present concerning neurological factors in dyslexia, but what is important to the establishment of empirical findings is contained in Cohn's (1964) comment about the methods of the neurological examination itself, as he remarked:

> In a number of reported instances, neurological study consisted only of a standard initial physical examination performed by the neurologist . . . (p. 180).

This is essentially a reiteration of Drew's (1956) criticism concerning incomplete neurological examinations as sometimes reported in the literature.

The EEG has also been used in dyslexic research. Benton and Bird (1963) reviewed some of this literature and concluded:

> The trend of results indicates a higher-than-expected incidence of EEG abnormality in dyslexic children. The observed incidence of abnormality has varied widely--from 88 to 28 per cent. Two major factors contributing to this discrepancy are employment of

> different criteria of EEG abnormality and the selection of cases for study. Failure to include control cases in these studies is regrettable, since such normative data might resolve some of the discrepant findings on the incidence of EEG abnormality in dyslexic children (p. 531).

Conflicting reports on the neurological basis of dyslexia will continue to exist until clinical neurological examinations and EEG interpretations are improved, in terms of reliability and validity.

Assumed Extraneous Variables--Early Child-Rearing Practices, Sensory Deprivation, Impoverished Cultural and Educational Background, and Emotional-Personality Factors

Little attention has been given by investigators concerning the control of these variables in dyslexic research. A number of investigators who postulate a familial, heredity, congenital, or genetic basis to underlying neurological disorganization or dysfunction do not adequately assess the above-mentioned variables. Although the following statement by Reinhold (1962) is rather extreme, it does, nevertheless, indicate the tendency to gloss over nonmedical factors in the background history of children with reading problems. She wrote:

> A short conversation with the child on general topics will help him to relax and will help the examiner to judge

> whether the child is normally intelligent, whether he is likely to be severely disturbed emotionally, whether he sees and hears normally, and whether his education has been adequate (p. 72).

Another problem encountered is the practice of screening out children with assumed neurological problems and assigning the remaining children to a so-called what's-left-over category. Generally speaking, the what's-left-over category is considered the one containing the children with emotional problems.

Neglect of Relevant Research

Since the publication of Birch's work (Birch 1962; Birch & Belmont 1964, 1965; Birch & Lefford 1963), this writer has been unable to find studies that are concerned with his three principles of development (sensory hierarchy organization, intersensory equivalence, and levels of perceptual function). Birch and Lefford indicated the importance of intersensory equivalency in the development of normal children, and Birch and Belmont demonstrated its relevance in poor reading.

In regard to the ITPA developed by McCarthy and Kirk (1963) at the University of Illinois, an instrument of considerable importance in diagnosing learning disabilities, this writer noted only one reference in the literature to its use with dyslexic children (Kass, 1962). A review of this dissertation is presented in Chapter II. It is worth noting here that Kass discovered several significant correlations between various ITPA subtests and dyslexia. Interestingly, this instrument has not been extensively used in dyslexic research in the light of comments like this one by Money (1962)·

> There is a need for new tests that are more accurate and valid in the differential diagnosis of dyslexia. Experiment and clinical study is a prerequisite for the development of these tests (p. 33).

The people at the University of Illinois do appear to have met these two criteria admirably in the construction of the ITPA.

Longitudinal Studies

Reports of longitudinal studies on dyslexic children are not found in the literature. The importance of this research is indicated by Benton and Bird (1963):

> A meaningful system of diagnostic classification is a prerequisite for the rational treatment of dyslexic children. It seems that the basic investigative work which will disclose the relationships on which such a classification must rest has still to be done . . . . Critically designed, longitudinal studies of dyslexic children are required (p. 531).

De Hirsch (1964) did, however, provide information derived from predictive studies of reading success and failure. Benton and Bird's (1963) suggestion on the importance of longitudinal research is presently valid, and until such time as these studies are conducted, confusion on what constitutes dyslexia will continue to exist.

Confusion in Terminology

As previously indicated, some 30 terms or labels have been used to designate dyslexia. To a considerable degree, these terms refer to various etiological variables, different psychoneurological factors, and various symptoms. All of these labels are not currently in use; however, enough are used that precise communication is not possible. It is little wonder that research in dyslexia and reading disability appears, at times, contradictory, ambiguous, and unstructured. Nevertheless, it is necessary to acknowledge the existence of the hypothesis that some children suffer from a reading problem related to psychoneurological disorganization or dysfunction.

Limited Scope of Measurement

Sophisticated statistical treatment of dyslexic variables, which may uncover a unique pattern of signs, has not been published in the literature for, as Money (1962) remarked:

> no one has yet uncovered any tell-tale sign or group of signs that are exclusive to the syndrome of specific dyslexia and are not found in other conditions of reading retardation. It is not at all rare . . . that a disease should have no unique identifying sign, that uniqueness being in the pattern of signs that appear in contiguity. Out of context, each sign might also be encountered in other diseases, or, in different intensities, in the healthy (p. 16).

The few experimental-statistical studies reported have been concerned primarily with mean differences between groups. From the abundance of clinical-observational studies, we now have considerable information on assumed relevant patterns of variables. Further studies of this nature will not add greatly to our understanding of dyslexia.

To achieve the magnitude suggested by Money (1962)--uncovering the uniqueness in the pattern of signs that appear in contiguity--more elaborate statistical treatment of data is necessary. When this occurs, the unique pattern of signs will be discovered. This will occur when the researcher elaborates or extends his scope of measurement of dyslexia and treats the data with procedures such as factor analysis, linear regression analysis, or some other form of multivariant analysis. The investigator who views dyslexia from a limited measurement frame of reference may be correct in his conclusions; however, an incomplete Gestalt of dyslexia will persist until more relevant variables are studied and included in the statistical analysis.

Inadequate or Incomplete Diagnostic Criteria

The category of incomplete diagnostic criteria is dependent upon the other 10 categories concerning the confusion in dyslexic research. For example, it is similar to Money's (1962) comment on the lack of tell-tale signs associated with dyslexia. It is also related to the problem of multiple labels of disordered reading. It is relevant to the problem of separating developmental factors from nondevelopmental factors. In commenting on diagnostic criteria in dyslexic research, Drew (1956) wrote:

> The diagnosis of congenital dyslexia presents many difficulties. There is no unanimity of opinion regarding diagnostic criteria . . . . It is little wonder that some authors tend to deny the existence of specific dyslexia (p. 450).

In summary, the aforementioned 11 categories were presented in an effort to clarify some of the confusion in dyslexic research. Furthermore, they constituted reference points for the design of this dissertation in order to avoid errors found in some studies of the past.

Methodological Approaches to the Study of Dyslexia

As has been indicated, much of our knowledge about dyslexia has come from designs involving fragmented research. Schiffman (1962) believed this has led to conceptual confusion and that the answer lies in an interdisciplinary approach to reading problems. Clemens (1961) stated that research workers have not cultivated adequate inter-professional communication which is necessary for understanding complex problems in which psychological, educational, and medical variables are related. Rabinovitch (1962) also supported the interdisciplinary approach to the study of dyslexia.

Clements and Peters (1962), in their paper on the evaluation of children with minimal brain dysfunction, emphasized the above views. Myklebust (1963) also stressed a combined psychological-neurological research approach to the study of children with psychoneurological learning disorders. There is little doubt in his view, as he stated:

> The validity of the concept of psychoneurological learning disorders (aphasia,

> dyslexia, dysgraphia, and non-verbal disorders) is dependent on ascertaining precisely and specifically the exact deviation in learning which is present, and the exact neurological dysfunction to which it relates (pp. 27-28).

Benton and Bird (1963) also were of the opinion that an interdisciplinary, multidimensional evaluative approach to the study of dyslexia is needed. They wrote:

> Analysis of the interrelations among neurological findings, life history factors, psychological test performance, speech and motor development, emotional status and EEG findings should provide the empirical data on which a classification consonant with the facts can be formulated (p. 531).

Drew (1964) suggested that a comprehensive study of dyslexia should involve a careful delineation of the type and degree of the impairment and an investigation of variables associated with auditory imperception, apraxia, and neurological history and examination.

In summary, several authorities have stressed the value of a comprehensive, cross disciplinary approach to dyslexic research. Dyslexia is so complex that a narrowly conceived and fragmented evaluation approach cannot lead to an appreciation of the relevant variables.

Need for New Measurement Instruments

In order that advancement may continue in dyslexic research, several investigators stressed the need for new diagnostic tests. Money (1962) commented that, "There is a need for new tests that are more accurate and valid in the differential diagnosis of dyslexia (p. 33)." Myklebust (1963) stated a similar view in regard to learning disorders associated with neurological dysfunctions, particularly nonverbal psychoneurological learning disorders. He wrote:

> A limitation in the study of these concomitants (dyschronometria, dyscalculia, disturbance in orientation, in social perception, in body image and in spatial perception) of neurological dysfunction is the few standardized procedures available for their measurement. The development of such tests is an urgent need (p. 27).

Some researchers have developed experimental tests in general and specific areas related to dyslexia (e.g., Benton, 1959b; Birch, 1962; Birch & Belmont, 1964; McCarthy & Kirk, 1961; Myklebust, 1963; Wepman, 1960, 1962). In a conference on children with minimal brain impairment, Becker (1963) summarized participants' views on new areas of measurement.

He stated that the views of Birch focused

> our attention on exploration of the importance of testing for intersensory equivalence in diagnostic testing, in contrast to the current focus on input-output equivalences. The ease with which a child can move from a visual stimulus to a haptic equivalent, etc., appears to have considerable significance for methods of remedial training (p. 123).

In summary, some experimental advances in new fields of measurement are currently being reported. Hopefully, these may represent real breakthroughs in resolving the riddle of why some children cannot read.

CHAPTER II

REVIEW OF THE LITERATURE

As previously indicated, few experimental studies have been reported on specific dyslexia, in contrast to the vast amount of literature on reading disability. Myklebust and Johnson (1962) commented:

> Despite the pioneering work of Morgan (1896), Thomas (1905), Hinshelwood (1900), Orton (1937), Hallgren (1950), and Hermann (1959), only minor attention has been given to the problem of dyslexia in children. Reading specialists to a great extent have ignored this condition as a causative factor in children's reading disabilities. Nevertheless, gradually there is a growing awareness of its importance, not only in terms of the need for appropriate diagnosis and specialized training, but because of the opportunities for expanding our knowledge of the processes whereby all children learn to read (pp. 15-16).

There is, however, limited knowledge about dyslexia, and it is presented in this chapter in the following sequence: (a) basic conceptions of dyslexia; (b) experimental studies; (c) cerebral dominance; (d) dyslexia, minimal brain damage, and motor incoordination; (e) auditory variables· (f) speech; and (g) opthalmological problems.

Basic Conceptions of Dyslexia

Several writers have discussed dyslexia in such terms as perception (figure-ground relationships, form perception, directional sense), association, cognition, psycholinguistics, etc. Benton (1962b) wrote about the perceptual and linguistic deficits in dyslexia. Rabinovitch and Ingram (1962) discussed the problem the dyslexic child experiences in translating perceptions and concepts into meaningful symbols. Money (1962) considered the possibility that the dyslexic child may be a "nonvisile cognitional" type, a person weak in visual imagery and visual memory of all types.

Kass (1963) studied psycholinguistic factors in a group of dyslexic children and reported:

> this sample of children with reading disability tended to have more deficiencies at the integrational level than at the representational level of psycholinguistic functioning . . . . This may mean that reading requires more perceptual and memory type abilities than conceptual abilities. This sample of children was not able to integrate elements into meaningful wholes (p. 94).

Kass' use of the term integrational level (automatic and sequential memory aspects of communication) refers to such activities as: (a) auditory memory, as in the WISC Digit Span subtest; (b) visual-motor sequencing (visual memory of pictures and geometric figures arranged in sequence); (c) knowledge of grammar (ability to verbally reproduce plural nouns, various verbal tenses, and comparative and superlative adjectives); and (d) visual closure tasks. In summary, Kass indicated memory and perceptual dysfunctions in dyslexia.

Benton (1962b), Rabinovitch (1962), and Birch and Belmont (1965) did not deny the relation of perceptual variables to dyslexia, as they acknowledged the prominent role they play during the early developmental years. Conceptual or intellectual variables, however, assume a more prominent role during later childhood years. Perceptual and conceptual factors are relevant to dyslexia, but at different points in the developmental history of the child.

Fuller (1964) believed that dyslexia is a disturbance in association rather than perception as he wrote:

> In hypothesizing about the defect in primary reading disability, it would seem that we must turn to the associative instead of the perceptual processes. When perceiving a word or letter perception per se is intact, while the ability to deal with the words and letters as symbols is impaired. This defect appears to reflect a biologic or inherent disturbed pattern of neural organization (p. 316).

Principles of Gestalt psychology have been used to explain basic problems of dyslexia (Drew, 1956; de Hirsch, 1952, 1961, 1963a, 1963b). Others have related Gestalt psychology to reading disabilities in general and to normal visual function in reading. Specific tests have been designed to measure certain Gestalt factors in reading (Bender & Schilder, 1951; Fuller & Laird, 1963a; Goetzinger et al., 1960; Krise, 1949, 1952). Interestingly, in 1937, Wechsler and Pignatelli (1937) wrote about reading reversal errors in terms of figure-ground relationships. Few studies since then have treated the matter so systematically.

Three examples illustrate how Gestalt psychology has been used conceptually in dyslexia. Bender and Schilder (1951) discussed the problem of relating parts to the whole configuration in children with specific dyslexia:

> Reading disability represents a clear-cut defect in the visual motor field . . . . In addition such children always show a special incapacity to relate the visual structure of a word to its auditory structure. This is probably due to the gestalt of the word as a sign (p. 147).

Drew (1956) subsumed a number of the signal dyslexic symptoms under the concept of a disturbance in Gestalten formation when he stated·

> The assumption that the fundamental defect in hereditary dyslexia is a disturbance in Gestalten formation not only permits the explanation of the numerous variations and inconsistencies which appear in the literature, but so suggests a theoretical basis for the monohybrid dominant type of inheritance in hereditary dyslexia (p. 657).

Referring to a previous publication which he co-authored (Rabinovitch et al., 1954), Drew (1956) stated that the nonfamilial cases of congenital dyslexia he studied exhibited, in addition to the reading disability, disturbance in directional selection, mixed hand-eye preference, abnormal face-hand responses, auditory-visual phonetic disintegration, and spatial disorientation. He wrote:

> No constant neurological sign is present, but if these various findings are interpreted as Gestalten disturbances then the entire symptom complex becomes a coherent entity (p. 457).

Drew (1956) indicated in his review of the literature that others have applied the Gestalt psychology frame of reference to diagnostic categories related to specific dyslexia; e.g., right-left disorientation, agraphia, acalculia, and finger agnosia in the Gerstmann syndrome expressed a disturbance in Gestalt formation. Critchley (1964) had the same opinion, and wrote that the configurational approach promised the best understanding of the Gerstmann syndrome.

Drew (1956)[1] reported the views of Duensing (1952), who considered three stages of visual-gnosis: (a) Gestalt seeing, (b) Gestalt recognition, and (c) object comprehension. Duensing believed that the problem of visual agnosia was a defect in Gestalt recognition rather than perception. In regard to Orton's (1925) views, Drew thought that:

> Orton's concept of three cortical levels of integration of vision can be adapted to Gestaltic terminology. Orton believed that 'word-blindness' was the result of a deficit at the third level of cortical visual function, the level of visual association or Duensing's third stage, object comprehension (p. 456).

Though some writers considered specific dyslexia to be a manifestation of a basic defect in Gestalt formation or figure-ground relationships, other writers have been concerned with the relation of specific dyslexia to other diagnostic categories. Ingram and Reid (1956) viewed specific dyslexia in the context of developmental aphasia

[1] Drew's review of the article by Duensing (1952) contained incomplete bibliographic information and therefore this author was not listed under Reference in this dissertation.

and Wallin (1921) considered it an expression of visual aphasia. Critchley (1964), however, denied that developmental dyslexia (specific dyslexia) results from an aphasic disorder.

In a review of the literature, Benton (1962b) stated that some writers have considered dyslexia as one manifestation of visual agnosia. He does not, however, agree with this position. Herman and Norrie (1958) suggested that dyslexia is a congenital type of Gerstmann's syndrome.

Orton's (1966) views on the lack of cerebral dominance as fundamental to dyslexia have held a prominent position in our theoretical thinking. He stated:

> I believe that this disability rests largely if not entirely on the failure to acquire the physiological habit of leading exclusively from either cerebral hemisphere and that the confusions which exist and which block progress in reading skill are due to an inadequate elision of the engrams in the non-dominant side of the brain. This view . . . implies a physiological rather than a pathological basis for the disability . . . . The physiological view seems well supported by the striking improvement in these children when taught by methods properly adapted to their needs (p. 141).

Thus, there is some uncertainty about (a) the relation of specific dyslexia to aphasia and agnosia, (b) whether or not specific dyslexia is a true language disorder, (c) whether it is a relatively isolated condition independent of more general language or visuoperceptive disorders, and (d) whether the lack of cerebral dominance is basic to disturbed language function.

Experimental Studies

Most of our knowledge about dyslexia has come from clinical studies rather than from controlled experimental research. However, clinical knowledge is sufficiently adequate that it is now possible to conduct meaningful experimental research. The studies reviewed in this section were selected for one of the following reasons: (a) relevant clinical variables were measured; (b) control groups were used; (c) multiple variables were studied; and (d) careful and sophisticated experimental designs were used.

Rabinovitch et al. (1954) reported the results of their comprehensive studies on poor readers. They categorized reading retardation into: (a) primary reading retardation (specific dyslexia); (b) secondary reading retardation (emotional disturbance); and (c) brain injury with reading retardation. In one of their studies on 20 primary and 20 secondary reading cases, they found a significant difference between the WISC mean Verbal Scale IQ and Performance Scale IQ. The primary readers achieved a mean verbal IQ of 82.0, and the secondary readers achieved a mean verbal IQ of 90.9. In comparing the mean difference between the verbal and performance IQ within each group, they found the mean difference for the primary group was 22.1 and the secondary group was 8.8, a difference significant to the .001 level. The primary group, in addition to being significantly deficient on two measures of reading, was also significantly below the secondary group in arithmetic computation. Rabinovitch commented that the latter finding was contrary to what was often reported.

On the neurological findings of the primary reading group, Rabinovitch et al. (1954) observed a characteristic pattern: (a) right-left confusion; (b) various extinction or inattention phenomena; (c) cortical sensory disturbances; (d) mixed hand-eye preferences; (e) nonspecific motor awkwardness; (f) dissociated dysgraphia; (g) speech difficulties; and (h) poor spelling. These symptoms were variously combined, but rarely were all of them present in a given person.

Silver and Hagin (1960) reported results similar to those by Rabinovitch et al. (1954). They studied 150 children referred primarily for behavior problems and concomitant reading disability, and 30 matched control children. Three reading-disability categories were uncovered: (a) a syndrome indicating incomplete cerebral dominance (71 percent of the experimental group); (b) a group with incomplete cerebral dominance together with structural organic defects (21 percent of the experimental group); and (c) an assumed "emotional" group, since the subjects presented no evidence of incomplete cerebral dominance nor structural organic defects (8 percent of the experimental group). Neither the Rabinovitch et al. study nor the Silver and Hagin study adequately controlled the problem of behavior disturbance in its samples. Benton (1962b) suggested that the experimental group in the Silver and Hagin study was contaminated with behavior problems, disturbances in praxis, and a variety of visuoperceptive difficulties. As he said, "one cannot help but wonder whether the background reading in their cases was simply a part expression of a gross behavioral disturbance (p. 100)." Nevertheless, these two studies are worthy of attention since few studies reported in the literature are as comprehensive and systematic in research design.

Following the diagnostic classification of Rabinovitch et al. (1954), Fuller and Laird (1963a, 1963b) and Fuller (1964) reported the results of studies utilizing the Minnesota Percepto-Diagnostic test (MPD), a visual perceptual test developed by Fuller and Laird (1963b). All three studies indicated that children could be differentiated into three groups: (a) primary reading retardation (specific dyslexia); (b) secondary reading disability (associated with emotional disturbances); and (c) organic reading retardation (associated with brain damage).

Fuller (1964), in a study on dyslexic children with a mean age of 10.61, focused attention on associative processes rather than perceptual processes. He studied three groups of children with reading disabilities and one group of children without reading disabilities. The children were classified by a team of psychologists, psychiatrists, reading specialists, and social workers. Following the classification, 287 children ranging in age from eight to 15 were given the MPD test. The children in the secondary and organic groups produced significant rotations of their figure drawings. There was no significant difference between the normal and the primary reading groups.

The MPD test measures visual perception with respect to directional orientation. It was so designed since Fuller (1964) stated that directional disorientation was the most frequently mentioned type of deficit associated with reading disability. Directional orientation is measured in degrees of rotation on two Bender-Gestalt designs (cards A and 3), each presented on three different background cards: a vertical rectangle, a horizontal rectangle, and a diamond. This test was developed in the context of Gestalt psychology. Its construction and the authors' studies employing the test displayed careful and sophisticated experimentation, a procedure conspicuous by its absence in dyslexic research. It represents a major advancement in the classification of children into various reading disability groups.

Benton (1962b) presented an excellent review of the dyslexic research pertaining to directional sense and form perception. About the former, he stated:

> Investigation of the role of directional sense as a factor in dyslexia has proceeded along two lines. First, the ability to discriminate between different orientations of identical figures, and tendencies to reverse the conventional left-to-right orientation as well as temporal orientation in

> sequential stimulation have been assessed. Secondly, since directional sense has been related to the development of the body schema, the right-left orientation of normal and dyslexic children, with respect to their own and to those of other persons, has been examined (p. 96).

In a series of well designed experiments, Benton carefully investigated right-left orientation and reading disability (Benton 1959b; Benton & Kemble 1960; Benton & Menefee 1957). In view of his own studies and after reviewing some major studies of directional orientation, Benton (1962b) concluded tentatively that the importance of this variable in reading disability has been rather exaggerated. He believed that directional orientation might be significant in the early school years, while a child is learning to read, but that it was attentuated in the older dyslexic children. Although Benton believed that directional orientation should be investigated in younger children, he held the opinion that it accounted for only a small portion of severe dyslexia presented by older school children.

Benton (1962b) concluded his review by stating that, if dyslexia persisted in older children, directional orientation might play a significant role "when the task requires implicit verbal mediation for optimal performance (p. 102)." He was implying that directional disorientation in the older child might be more of a conceptual problem than one of lateral confusion about the body schema.

According to Benton (1962b), form perception was most often mentioned as associated with specific dyslexia, as well as with acquired dyslexia resulting from specific neuropathology. In his review of the literature, he examined the thesis that dyslexia was "an attentuated form of visual agnosia, i.e., a more or less direct consequence of expression of impairment in form discrimination (p. 87)." He noted that much controversy existed in the literature on the significance of form perception. He held that inconsistent or contradictory findings in a number of the studies might be explained on the basis of poor research designs, the failure to control such relevant variables as intelligence, sample composition, and age. After reviewing the many studies on perception, Benton stated:

> My conclusion is that deficiency in visual form perception is not an important correlate of developmental dyslexia. By this I mean that, while it may be a determinant of the language disability in some cases, it is <u>not</u> a significant factor in the majority of cases. Thus, I should guess (and it is only a guess) that transient reading disability is often conditioned by a retardation in the development of higher-level visuoperceptive skills (pp. 94-95).

Cerebral Dominance

The hypothesis relating cerebral dominance to reading disability, particularly specific dyslexia or specific language disability, has long been controversial in the literature. Orton's (1937) name is most prominently associated with the idea that the neurological basis underlying incomplete cerebral dominance is primary to specific language disability, or strephosymbolia (his term). Zangwill (1962) presented a comprehensive and critical review of the literature relating dyslexia to cerebral dominance. He wrote:

> It has been pointed out over and over again that many backward readers are left-handed, ill-lateralized, or exhibit inconsistency of preference as between hand, foot, and eye . . . . Yet opinion differs greatly as regards both the incidence and the significance of such anomalies and a few investigators have denied outright that there is any correlation between atypical laterality and backwardness in reading . . . . At all events, it is obvious that not all backward readers are ill-lateralized and that many individuals with odd or inconsistent lateral preferences learn to read normally (p. 109).

According to Zangwill (1962), the available evidence on laterality and dyslexia indicated that an appreciable proportion of children with dyslexia manifested poorly developed laterality. He did, however, indicate that it was difficult to understand why some ill-lateralized children were poor readers and others--almost certainly the majority--were not poor readers. Though ill-lateralization seemed to be related to dyslexia, there was a theoretical problem concerning ill-lateralized children who were not poor readers.

Although Zangwill (1962) did not furnish a solution to this problem, he did offer two suggestions. First, he believed that it would be expedient to study the differences between ill-lateralized dyslexics and fully lateralized dyslexics. As far as he was aware, no systematic investigation had been done on these differences. Secondly, his clinical experience suggested that ill-lateralized dyslexics manifested retarded speech development, spatial perception defects, motor clumsiness, and defective maturation, whereas the fully lateralized dextral dyslexics were more "pure," or specific, in symptomatology. About this second group he postulated a specific genetic factor as adduced by Hallgren (1950) and Hermann (1959).

The research findings of other investigators tended to confirm Zangwill's (1962) conclusions. Galifret-Granjon and Ajuriaguerra (1951), Harris (1957), Ingram (1959, 1960), Macmeeken (1939), Orton (1937), Silver and Hagin (1960), and Silver (1961) suggested that weak, mixed or inconsistent lateral preferences were present in children with reading difficulties. Zangwill believed these studies suggested that delayed or incomplete lateral specialization of cerebral function was closely linked with problems of reading. In a personal communication, however, Zangwill (1964) wrote, "I do not think cerebral dominance can be measured It is possible to measure the strength and consistency of peripheral lateral preferences in a rough way . . . ." The question may be raised, therefore, about the relations between methods of measurement and the psychoneurological process measured. Zangwill (1964) implied that conventional methods of measurement assessed peripheral dominance rather than cerebral dominance.

Zangwill (1962) offered three possible explanations for the correlation of ill-lateralization with dyslexia. First, an acute cerebral lesion might be present. This hypothesis was supported by the work of Ettlinger and Jackson (1955) who found evidence of focal left hemisphere EEG abnormality or minimal neurological lateralizing signs in a small portion of dyslexic children. The second explanation was that some children with ill-defined laterality had, in addition, a constitutional weakness in maturation. This constitutional weakness in maturation was suggested by the occasional incidence in dyslexia of nonspecific EEG abnormality (Statten, 1953), or minimal signs of diffuse neurological dysfunction (Cohn, 1961; Rabinovitch et al., 1954). The third explanation was that children who lacked strong and consistent lateral preferences were particularly vulnerable to the effects of stress (Zangwill, 1960). This hypothesis assumed that minimal brain injury at birth might more severely affect those who showed no strong tendency toward lateral specialization. This contention was supported by Naidoo (1961), who observed that children with ambiguous handedness had had many complications at birth, and had come from families with a high degree of sinistrality. In addition, Zangwill (1960) stated that a history of early brain illness or minor epilepsy was not uncommon in ill-lateralized dyslexic children.

Relation of Dyslexia and General Reading Disability to Minimal Brain Damage and Motor Incoordination

Considerable controversy exists in the literature on the relation between reading disability in general and minimal brain damage. Some of the previously mentioned studies of motor incoordination and nonspecific awkwardness and ill-lateralization were suggestive of this correlation. A high correlation between reading disability and minimal brain damage was also noted in a few studies based upon medical case histories. Eames (1955), Eustis (1947), and Kawi and Pasamanick (1958), all reported a high incidence of pre- or paranatal complications in the history of children with reading problems. Kawi and Pasamanick (1959) studied 372 children between the ages of 10 and 14 and noted toxemia and bleeding during pregnancy in mothers of children with reading disorders. These same pregnancy complications also were noted in cases involving still-births, neonatal deaths, cerebral palsy, epilepsy, and behavior disorders. They wrote:

> Such findings have led to the formulation of a hypothesis that there is a continuum of reproductive casualty with a lethal component consisting of abortions, stillbirths and neonatal deaths and a substantial component consisting of cerebral palsy, epilepsy, mental deficiency, and behavior disorders in children. This investigation suggests that some of the reading disorders in childhood constitute a component of this continuum (p. 61).

In Prechtl's (1962) investigation of mothers' whose children manifested choreiform movements, 50% of the pregnancies had been complicated by toxemia and severe bleeding. Neonatal disturbances were noted in 46% of the children--26% had experienced severe asphyxia; 14% had had difficulties in sucking and had had a low body temperature; and in 8% the delivery had been premature. Additionally, 60% of the children in the total sample had experiences postnatal difficulties.

There was a number of other reports in the literature indicating brain damage as an antecedent to reading disability, e.g., Benton and Bird (1963) and Shankweiler (1962). Most writers did, however, distinguish this form of reading disability from specific or developmental dyslexia which does not result from brain damage, for as Critchley (1964) wrote, "No brain pathology has indeed ever been demonstrated in a case of developmental dyslexia (p. 75)."

Although attention has been given to visual motor problems associated with reading disability, few experimental studies have focused on problems of motor coordination. The studies done in The Netherlands by Prechtl (1962) are relevant to this association. Prechtl's contribution was his discovery of the choreiform syndrome. He studied a select group of children between the ages of nine and 12 with choreiform movements. These movements were chorealike twitchings--slight jerky movements occurring quite irregularly and arhythmically in different muscles--of the extremities and of the head. These movements occurred suddenly and were of short duration. In 96%

of the children, the choreiform movements were observed in the eye muscles and caused disturbances of conjugate movement and difficulties in fixation and reading. In some cases Prechtl was able to correlate errors in word recognition with the occurrence of involuntary eye movements. In addition, most of the children had difficulties in right and left discrimination. Ambilaterality was also observed in 58% of the cases.

Prechtl (1962) reported an unpublished study by a colleague who found that children with the choreiform syndrome, when compared with a control group, were poor readers and showed a significantly lower performance in their schoolwork. Prechtl provided additional data about children who had the choreiform syndrome. The majority of the patients manifested, even at an early age, unrestrained and wild behavior, clumsiness, inability to concentrate, and very labile mood fluctuations from timidity to outbursts of agression. At school, these behavior patterns became increasingly more obvious. Prechtl considered that most of these children, however, had adequate intelligence. In another publication, Prechtl and Stemmer (1962) reported:

> The choreiform syndrome seems to be
> a form of minimal brain damage and

> falls, by definition into the category of cerebral palsy. No successful form of drug therapy has yet been discovered (p. 126).

In summary, Prechtl (1962) uncovered a neurological syndrome involving motor incoordination which suggested the presence of minimal brain damage in a group of children with learning difficulties. He did not assume that all children with reading problems would manifest the choreiform syndrome. Rather, this type of neurological dysfunction was only one of several antecedents to reading disability.

Other workers have reported correlations between motor problems and reading disability. Rabinovitch et al. (1954) observed problems in the following areas: (a) gait; (b) performance of motor acts, such as opening and closing doors; (c) handling of psychological test material; and (d) right-left discrimination. These activities suggested a non-specific awkwardness and clumsiness in motor function. Bakwin and Bakwin (1960) uncovered similar findings. They observed that a number of children with reading disabilities were abnormally clumsy. Their movements were jerky and uncoordinated. Cohn (1961) compared a group of children with reading-writing difficulties with a control group who were normal in schoolwork and who did not overtly manifest motor problems. Differences between the two groups were observed on the following variables: (a) right-left orientation (b) evaluation of double simultaneous tactile stimuli; (c) the knee-jerk reflexes; (d) the Babinski sign; (e) motor coordination; (f) mechanics of speech; and (g) the EEG.

Bryant et al. (1964) reported the results of an experimental investigation of motor behavior in dyslexic children; however, they did not relate their findings to the presence of minimal brain damage. Using the Lincoln Oseretsky Motor Development Scale, they compared the behavior of a sample of reading disability cases with a sample of normal readers. Both groups were evaluated on the accuracy subtest of the Gilmore Oral Reading Test. The experimental group was one or more years below grade level in reading and the control group was at grade level or above. All children were average or above average in intelligence as measured by the WISC. The control group was not significantly different from the norms of the Lincoln Scale, whereas the experimental group was significantly (.01 level) below the norms of the Lincoln Scale. The authors concluded from their study:

> It is apparent from the analysis given above that reading disability cases usually show impairment in their motor development as reflected by a standardized scale . . . . The fact that the majority

> of items of the Lincoln Scale reflect the impairment suggests that this is a general impairment in motor development rather than extreme difficulty in some specific aspect of coordination of motor function (p. 4).

A few other studies have been reported on the association of nonspecific awkwardness and reading disability. Jensen (1943) characterized 22 cases of poor readers as manifesting motor incoordination, clumsy gait, and speech defects. Although Orton (1937) rejected the association of motor problems with strephosymbolia, his wife (Orton, 1957), indicated that clumsiness in handwriting and disability in other motor acts were characteristic of some children with strephosymbolia.

Auditory Variables

In view of the voluminous literature on reading disability, it is surprising that little attention has been given to the relation of multiple auditory variables and poor reading. A few writers, however, did mention the association of one or two auditory variables and disorder reading (Benton, 1963; Birch & Belmont, 1964; Boshes & Myklebust, 1964; Critchley, 1964: de Hirsch, 1961; Ingram, 1959; Kass, 1962; Monroe, 1932; Rabinovitch, 1962; Schilder, 1944. Silver & Hagin, 1960; Wepman, 1962). For the most part, it has been educators and educational psychologists who have investigated the relation between auditory variables and general reading retardation, whereas neurologists and clinical and experimental psychologists have studied the relation between auditory variables and specific dyslexia.

Auditory Discrimination

From the early part of the twentieth century to the present time, a few investigators have postulated a relationship between auditory discrimination and proficiency in reading. One of the early reports was by Bronner (1917), who explained a case of poor reading as resulting from poor auditory discrimination and memory. Monroe (1932), in a classic investigation, studied 32 nonreaders and 32 randomly selected children of elementary school age. She noted that the nonreaders produced significantly more auditory discrimination errors than did the control group. Bond (1935) evaluated good and poor readers and found good readers significantly superior in auditory discrimination Hester (1942) noted that 58% of a group of children (194 children of all ages) evidenced an inadequate knowledge of letter names, sounds, and blends. Schonell (1942) observed that 38% of a group of backward readers did poorly on auditory discrimination of speech sounds. Poling

(1953) and Reynolds (1953), however, did not find significant differences between good and poor readers. Wheeler and Wheeler (1954) obtained a nonsignificant low correlation between reading test scores and scores on the Seashore test of pitch discrimination. It is possible that these last investigators did not uncover significant correlations because their sample children were not severely deficient in reading.

Artley's (1948) review of the literature indicated that auditory discrimination may be significantly related to reading disability. Later studies by Goetzinger et al. (1960), Rabinovitch (1962), Silver and Hagin (1960), and Wepman (1962) suggested a relation between auditory discrimination and poor reading. Findings from Wepman's study revealed that 27% of 80 first-grade children had inadequate auditory discrimination, with reading scores significantly poorer than those of the children with adequate auditory discrimination. In the second grade, he found the same evidence in 19% of the children.

Goetzinger et al. (1960), indicated the problems involved in auditory discrimination research by stating:

> It is apparent, therefore, that the research relative to auditory discrimination and reading ability is in conflict.

> That variables such as the influence of speech reading were not always adequately controlled was apparent from the review of the literature. Furthermore, test materials, varying in difficulty, could account for discrepancies in the results. It would appear, therefore, that further research is needed in the area of auditory discrimination and reading problems (p. 122).

<u>Auditory Memory</u>

Several publications suggested that poor readers were deficient in auditory memory. Fields (1921) was one of the first to present experimental evidence on this association. In a study of good and poor readers, each group having relatively low intelligence, she found that backward readers had more difficulty in remembering numbers and words presented auditorily than those classified as good readers. Hincks (1926), Lichtenstein (1938), Rizzo (1939), Wolfe (1941), and Raymond (1955) reported similar results. Johnson (1955) studied a wide age range (7½ to 18 years) of poor readers and concluded that 70% of them had deficient auditory memory spans. A study by Bond (1935) indicated small differences in auditory memory between good and poor readers. Artley's (1948) review of the literature supported the hypothesis of a relation between poor auditory memory span and reading disability. More recently, Schiffman (1962) suggested that in auditory memory span tests, memory for digits forward was better than memory for digits backward, and that the span for oral direction was usually very low for dyslexic children.

Auditory Blending

Monroe (1932) produced evidence suggesting that poor readers had more trouble blending sounds in response to visually presented words than did normal readers. Although poor readers were inadequate in producing sounds of single letters, their blending ability was even more inadequate. Bond (1935) compared poor and normal readers and found that the poor readers had more difficulty in blending sounds into words than did normal readers. Reynolds (1953), who worked with a less severely deficient group of readers than did Bond, did not find a significant correlation between reading ability and sound blending. Silver and Hagin (1960), in a study of normal and below average readers, found the below average readers were significantly poorer in auditory blending than the normal readers. Kass (1962), utilizing the ITPA, noted that a sample of dyslexic children was deficient in auditory blending.

Auditory Attention

Very little can be said about the problem of auditory attention and its relevance to language function as this association has not been studied, for the most part. Only a few reports have been published. Burt (1937), in addition to studying auditory perception and immediate memory defects, noted that poor readers of both sexes experienced difficulty in auditory attention. In a paper on developmental aphasia and brain damage, Benton (1963) related auditory inattention to auditory imperception, a form of developmental aphasia; and he referred to Myklebust's (1956) statement that the child is able to hear but cannot listen.

In reviewing the literature, this writer found no studies on the relation between auditory attention and specific dyslexia. This may be an area needing exploration.

Auditory Intersensory Functions

Several investigators have studied the inter-relations among the several sensory modalities. Schilder (1944) discussed auditory-vocal-visual intersensory functions of children with congenital reading disabilities. He reported:

> But in all cases one difficulty was outstanding and that was the difficulty of

> coordinating the sound which is more or less correctly connected with the single letter, with the sequence of letters in the re-write word. This inability was especially evident in short words such as, ME, UP, WAS, BAT, and HEN (p. 85).

Schilder (1944) further stated that congenital reading disability:

> is due to an incomplete function of the hearing center. It is the inability of the patient to differentiate the spoken word into its sounds, andto put sounds together into a word (p. 85).

Vernon (1958), who presented a comprehensive review of the literature in England and the United States, discussed auditory discrimination, auditory memory, and auditory-visual assocation. His review concerned children who were slow or backward readers, not those with specific dyslexia, since he did not recognize the existence of specific dyslexia. He wrote that the backward reader was unable to hear some phonetic sounds clearly (letters, letter combinations, and words) and to recall them with sufficient accuracy to reproduce them in association with the corresponding printed letters and words. He wrote:

> the normal reader acquires his skills in enunciating phonetic sounds correctly and systematically as he learns to read; but the backward reader re-

> mains in a state of confusion over the whole process (pp. 62-63).

Kass (1962), in a study of dyslexic readers, ages 7-0 to 9-11, found that the children were significantly deficient in auditory-vocal association as measured by the ITPA. The auditory-vocal association subtest measures the ability to draw relationships from what is heard. The subject is tested by means of an analogies test (e.g., the examiner says, "Soup is hot; ice cream is _________.") Kass also found that this group of readers was deficient on the auditory-vocal automatic subtest. In the examiner's manual, McCarthy and Kirk (1961) described this subtest as follows:

> Auditory-vocal automatic ability permits one to predict future linguistic events from past experience It is called 'automatic' because it is usually done without conscious effort. In listening to a speech, for example, we develop an expectation for what will be said which is based on what has already been said. In the present test, the subject must supply the last word to a test statement, invariably requiring inflection (e.g., the examiner says, 'Father is opening the can. Now the can has been _________.') (pp.6-7).

Birch (1962) and Birch and Belmont (1964) have focused attention on auditory-visual integration. They found that this form of intersensory organization was less well-developed in poor readers than in normal readers; however, they did not believe that this was the only factor underlying poor reading ability.

Speech

Few investigators in dyslexic research have considered the relation between specific dyslexia and speech problems. Cole and Walker (1964), de Hirsch (1963), Hardy (1962), Ingram (1959), Rabinovitch et al. (1954), Orton (1928) did, however, indicate an association between these two variables. The types of speech problems they referred to were stuttering, hesitation, repeating words, oral speech deficiencies, cluttering, and motor speech delay. Quantitative and controlled experimental studies, however, do not appear in the literature on the relation between dyslexia and speech disorders.

The relation of speech disorders to the general field of reading disability also has been relatively neglected, particularly when compared to the amount of attention given visual perceptual functions. One of the first to call attention to this possible association was Monroe (1932). She noted that poor readers had many more speech defects than good readers. In particular, she hypothesized dysarticulation as a relevant factor in reading disability. Others have more or less supported her general views and some have produced corroborating data (Bennett, 1938; Betts, 1946; Hildreth, 1946: Moss, 1938; Witty & Kopel, 1939). Jones (1951) produced experimental evidence suggesting that speech training accelerated the reading achievement of an experimental group compared with a control group.

Bond (1935) did not find significant differences in speech defects between good and poor readers. He considered skill in oral and silent reading separately and observed that 35% of those children who were poor in silent reading had speech defects. Those poor in silent reading but good in oral reading showed no speech defects. A study by Everhart (1953) indicated some tendency for boys with normal articulation to have higher reading achievement than boys with articulatory difficulties. In regard to silent reading, Hall (1938) and Moore (1947) both found subjects with dysarticulation equal to normal speakers in silent reading. Robinson (1946), after a careful review of the literature on possible causes of reading disability, concluded that, "On the basis of the evidence available, articulatory defects may be concluded to be important in oral reading but of little significance in silent reading (p. 99)." Although she concluded that speech defects may be causal factors in poor reading, the mere presence of a speech defect did not necessarily imply that it was causally related to reading retardation. Artley (1948) arrived at a similar point of view after his review of the literature on some of the factors presumed to be associated with reading and speech difficulties. He concluded that speech defects might: (a) cause reading defects; (b) be the results of reading defects; or (c) that speech and reading defects might result from some common variable.

These studies and reviews indicated that it is feasible to hypothesize a significant correlation between reading disability and speech defects. From an empirical point of view, it seems advisable that a research design of comprehensive scope ought to be employed to measure the correlation between these two factors.

Ophthalmological Problems

Considerable attention has been given to ophthalmological problems as they relate to reading skill. Most authorities have agreed that there was no causal connection between peripheral vision, types of eye movements--as measured by the frequency and duration of fixations and the number of regressive movements--and skill in reading. The following brief review, derived primarily from the medical literature, illustrates this point of view. One of the earlier reports in this area was by Orton (1937), who made the statement that reading disability was not attributable to poor function of the visual aperture. Schilder (1944) believed that the optic functions were intact for poor readers and stated:

> Certainly the optic mistakes concerning the letters cannot be taken as the cause of the reading disability. They are merely an indication that we deal with the primary disturbance in the perceptual optic sphere . . . (p. 83).

Cole (1951) stated that vision was adequate in the large majority of reading disability cases and that it was not considered by the ophthalmologist to be the cause of failure in learning. In a review of the literature on peripheral vision subsequent to Orton's (1928) early work, Cole and Walker (1964) reported that disturbance in the following factors were not found to be related to poor reading: (a) binocular vision; (b) stereoscopic vision; (c) fusion of images; and (d) possible variation of size of the images in the two eyes.

Smith and Carrigan (1959) believed that visual problems were an unlikely basis for reading disability, as many children with very poor vision were successful readers. Critchley (1961) remarked that developmental dyslexia (specific dyslexia) was independent of muscular imbalance, errors of refraction, imperfect binocular fusion; and that there was no evidence that the reception of visual sense data was disturbed. Gallagher (1962) said that children with specific dyslexia did not have visual defects as the primary cause.

Vernon's (1958) review of the literature revealed no significant correlation between poor reading and irregular eye movements. He stated that it was the failure to attend to and to comprehend what was read that caused irregular eye movements and regressions. Those with irregular eye movements needed training in understanding rather than training in eye movements. Gallagher (1962) stated that slow eye movements, length of fixation on words, regressions, or eye muscle incoordination, were not the cause of poor reading. Ineffective eye movements were caused by faulty understanding of what was read. He referred to a statement by Hermann (1959) that it was the brain, not the eye, that learned to read. And de Hirsch (1963b) said research had indicated no significant difference in the number of eye fixations between good and poor readers.

The above-mentioned statements and reviews of the research literature do not give credence to the notion that poor reading results from faulty eye movement patterns or other peripheral visual defects.

Summary

A condensation of the material contained in this chapter suggests that some of our knowledge about specific dyslexia is well-defined, that certain specific facts have been observed by many clinicians and, to some degree, verified by research. There are some variables, on the other hand, regarding which clinicians and researchers are not in complete agreement. A summary on the general state of our understanding of specific dyslexia is presented in Table 2. An inspection of this table reveals one glaring gap in our knowledge: there is no experimentally identifiable pattern or syndrome associated with specific dyslexia. Some clinicians have described symptom patterns, but consensus is lacking.

All authorities agree that poor reading ability, i.e., when considered generically, is caused by a number of different factors: low intelligence; brain damage; limited reading instruction· poor teaching methods; cultural deprivation; and heredity. Many authorities believe that specific dyslexia is a familial or hereditary condition and not related to brain damage. There is some agreement, as

TABLE 2

Some Characteristics of Specific Dyslexia as Reported in the Literature by Various but not All Authorities

Measurement Area	Description
Intelligence	Level of intelligence is adequate and may range from average to very superior.
General Education	1. Emotional-attitudinal problems associated with early school experiences are absent.
	2. Generally early success in learning arithmetic. When reading is involved, grades in arithmetic drop.
	3. Reading and spelling ability are below grade level or the child's level of intelligence.
	4. Writing may be poorly formed and organized.
Reading	1. Learning to read by the whole-word method produces poor results in comparison with a decoding system such as an alphabetic-phonic approach.
	2. Rate in oral reading is slow.
	3. A wide variety of accuracy errors are produced in oral reading, particularly substitution errors (e.g., "was" for "saw").

TABLE 2 continued

Measurement Area	Description
Reading (cont.)	4. Reading level is considerably below the achievement level in arithmetic and science.
	5. Letter reversal and/or word rotation is present in the early school grades.
	6. Mirror reading may be present in the early grades.
	7. Tendency to ignore details within words and to base word recognition on insufficient cues such as initial letter and length of word.
Sense Organs	Peripheral vision and hearing are intact.
Sensory	1. Visual and auditory sensory modalities may not be hierarchically dominant over other modalities.
	2. Poor intersensory integration.
Visual Perception	1. Problems associated with object agnosia are not present.
	2. Distortion in visual perception is present in the early school years, e.g., form perception and directional sense. These problems are attenuated

TABLE 2 continued

Measurement Area		Description
Visual Perception (cont.)		or eliminated in the latter grade school years.
	3.	Poor visual memory.
	4.	Problems in form constancy, spatial relations, and figure-ground relationships are present in the early school years, but generally are absent in the latter grade school years.
	5.	Visual-motor sequencing difficulty in younger children.
	6.	Slow perceptual speed in younger children.
	7.	Poor perceptual-motor planning ability.
Auditory Perception	1.	Poor auditory discrimination.
	2.	Poor auditory memory.
	3.	Poor auditory comprehension.
	4.	Poor ability in blending sounds (inability in blending parts into wholes).
	5.	Difficulty in associating sounds with the equivalent printed visual symbols.

TABLE 2 continued

Measurement Area	Description
Speech	1. Dysarticulation may be present.
	2. Diadochokinetic ability may be poorly developed.
Neurological	1. Examination reveals no gross neurological signs.
	2. Percent of children reported with abnormal EEG varies from 28 to 88 per cent. Interpretation of these findings is difficult since the nature of the samples studied is not always clearly defined.
	3. Nonspecific awkwardness is present in some cases, indicating poor motor development and coordination.
	4. Directional confusion (right-left discrimination) may be present, particularly in younger children.
	5. Lack of clearly developed peripheral dominance is present in some cases.
	6. Confusion in double simultaneous tactile stimuli may be present.

TABLE 2 continued

Measurement Area	Description
Familial	1. Specific dyslexia occurs much more frequently in males.
	2. A familial history of poor reading, writing, spelling, particularly in paternal relatives.
	3. A familial history of il-lateralization, poor dir-ectional orientation, and poor motor coordination.
Emotional	Minor emotional problems are present. They are secondary to specific dyslexia and are associated with poor academic success, parental pressure for need of achievement, and peer rejection. Occasionally, severe secondary emotional problems are reported.
General Comments	The following variables are not assumed to be antecedent factors:
	1. Below average intelligence.
	2. Brain damage.
	3. Severe emotional problems.

TABLE 2 continued

Measurement Area	Description
General Comments (cont.)	4. Educational problems of poor instructional methods and irregular school attendance.
	5. Cultural and ethnic deprivation.
	6. Poor motivation
Theoretical	Specific dyslexia is assumed to result from some form of psychoneurological dysfunction or dysorganization. Some authorities claim this is familial in nature.

well as dispute, concerning the characteristics of this disability. Most authorities agree that perceptual difficulties are present in younger children (ages 5, 6, 7, and perhaps 8), but that cognitive, conceptual, or associational difficulties of a verbal nature are the sine qua non of the older children. Fundamental to both the perceptual and conceptual consideration is an auditory-visual disturbance, i.e., a problem of establishing the correct sounds with the equivalent visual symbols. It is for this reason that most programs have emphasized training in phonemic-visual symbol association. There is agreement also concerning certain psychoneurological variables: right-left discrimination, finger agnosia, directional disorientation, and incomplete cerebral dominance. Some of these variables in varying degree may be present in younger children, but not necessarily present in older children. Carefully planned experimental research and comprehensive longitudinal studies are needed before adequate understanding can be achieved concerning the complexities of dyslexia. Benton and Bird's (1963) comment on the value of this research is well justified.

CHAPTER III

METHODS AND PROCEDURES

This dissertation posed two major questions· (a) what are the quantitative characteristics that distinguish children with specific dyslexia from normal readers?; and (b) what are the subpatterns or clinical syndromes within the category of specific dyslexia? The beginning approach to these questions was a review of the literature to ascertain the relevant variables in specific dyslexia. A number of research clinicians were contacted both in the United States and in England concerning current published and unpublished research findings. Also, note was made of the various measurement instruments used in the assessment of the behavior studied.

Selection of a general experimental design was governed by the nature of the two questions and the kinds of research designs reported by others. A clinical-observational approach was excluded since another study of this type would add little to the existing knowledge. As indicated in Chapter I, an experimental approach was the preferred method, since many hypotheses based on clinical observations have been offered with little attention to testing these hypotheses.

To answer the question, "How do children with specific dyslexia differ from normal readers?", it was necessary to use a matched group design.

Selection of Subjects and Criterion Variables

The experimental dyslexic group was selected from the files in the Pediatric Neurology Study Center, Bradford Memorial Hospital, Dallas, Texas.[2] Records were available on approximately 250 previously diagnosed dyslexic children, collected through the years 1963 to 1965. These children, in grades one through 12, were referred by pediatricians and other medical specialists for evaluation of academic problems particularly in reading, spelling, and writing. The majority of the children came from the middle to above middle socioeconomic geographic sections of Dallas. The referring physicians had seen these children in private practice. They indicated that the children were free of incapacitating medical problems, such as organic brain damage or systemic disease.

[2] This unit was under the direction of Dr. Lucius Waites, Pediatric Neurologist, Department of Pediatrics, University of Texas Southwestern Medical School. The Pediatric Neurology Study Center was an autonomous unit housed in Bradford Memorial Hospital.

The following information and test scores, collected by the staff of the Pediatric Neurology Study Center, were available on all children referred by the physicians:

1. Sex and age of the child, and socio-economic classification of the parents.

2. Grade level, grades repeated, and school attended.

3. Test results on the Peabody Picture Vocabulary Test, Gilmore Oral Reading Test (accuracy, comprehension, and rate), Durrell Analysis of Reading Difficulty (accuracy, comprehension, and composite score), Bender Gestalt, Raven's Progressive Matrices (1956), Wepman Auditory Discrimination Test, an informal speech-sound discrimination test, Morrison-McCall Spelling Scale, Paragraph Copy Test, The American Handwriting Scale, and oral and written reproduction of the alphabet.

The experimental group, selected from the hospital files, consisted of 32 children who met the following criteria:

1. Average to above average intelligence, as measured by the Peabody Picture Vocabulary Test (Dunn, 1959).

2. One or more years below grade level in reading, as measured by the accuracy subtest on the Gilmore Oral Reading Test (Gilmore, 1952).

3. One or more years below grade level in spelling, as measured by the Morrison-McCall Spelling Test (Morrison & McCall, 1923).

4. Currently enrolled in the third or fourth grade, regardless of age.

5. Pure tone auditory threshold within normal limits.

6. No known medical or physical problems that would contribute to problems of reading.

7. Parents of the children were in the middle to above middle socioeconomic classification.

8. No evidence of serious emotion-personality disturbances or family conflicts, as determined by school officials and the pediatric neurologist and psychologist participating in this study.

9. Diagnosis of specific dyslexia by the pediatric neurologist and his staff.

Practical and theoretical reasons restricted the selection of subjects to the third and fourth grades. The majority of the 250 previously diagnosed children were in these grades. Being younger, it was more convenient for these children to participate in a research project, since they were less involved in extra-curricular activities than were older children. Children in the first and second grades were not considered, since several developmental variables might have been present that could have confounded the diagnostic picture of specific dyslexia; e.g., right-left discrimination, incompletely developed lateralization, intersensory equivalence problems, and problems associated with motor development and physical immaturity. The small sample size necessitated the selection of children from a restricted age range or grade range. Another governing factor for selecting children in these grades was that specific dyslexia is clearly manifested at this period in the educational history of the child. Knowledge about the early discernible signs of specific dyslexia can result in accurate detection of the problem and can lead to appropriate language retraining. Consequently, a study of children at these grade levels may be beneficial to various professions working with dyslexic children.

The control group consisted of 23 subjects matched with the experimental group on intelligence, grade, audition, medical status, socioeconomic level, and family problems. These children differed from the experimental group in that they showed no deficiency in reading or spelling, and were not diagnosed "specific dyslexic." The specific criteria for selection of the control group were:

1. Average to above average intelligence, as measured by school tests.

2. At or above grade level in reading, as measured by school tests.

3. At or above grade level in spelling, as measured by school tests.

4. Currently enrolled in the third or fourth grade, regardless of age.

5. Pure tone auditory threshold within normal limits.

6. No known medical or physical problems.

7. Parents of the children in the middle to above middle socioeconomic classification.

8. No evidence of serious emotion-personality disturbances or family conflicts, as determined by school officials, the pediatric neurologist, and the author.

Fifty percent of the children in the experimental group attended private schools; the remainder attended public schools in either Northeast Dallas or the Highland Park School District, an incorporated city within Northeast Dallas which contains Southern Methodist University. Children in the control group were selected from the same schools as those in the experimental group, on a prorated basis.

To further limit the differences between the groups, with the exception of reading and spelling ability, the control group was administered the same criterion tests as given the experimental children: (a) Gilmore Oral Reading Test; (b) the Morrison-McCall Spelling Test; and (c)

Peabody Picture Vocabulary Test. Information from these tests is presented in Table 3. It is evident that the two groups did not differ significantly in mean grade level and mean IQ. Further evidence of nonsignificant difference in IQ is presented in Table 4. Although the WISC Full Scale IQ was not a criterion measure, the results on this measure did corroborate the results of IQ measures in Table 3.

Consideration was given to the socioecononic classification of the parents of both groups. It is well known in education that many variables contribute to poor performance or underachievement in reading; namely, cultural deprivation, limited sensory-motor experiences, erratic educational experiences due to sporadic school attendance, poor teaching, and family background evidencing low interest in academic learning. To control for these variables, only children from middle to above middle socioeconomic classifications were selected. The Hollingshead Index of Social Position (Hollingshead & Redlich, 1958) did not reveal a significant difference between the experimental and control groups.

Personality-emotional disturbance and family conflicts were not considered relevant by the referring physicians of the experimental group. The pediatric neurologist and psychologist participating in this study did not detect

Table 3

Comparison of Experimental and Control Groups on Certain Criterion Variables

Group	Mean grade level	Mean IQ[a]	Mean reading level (accuracy)	Mean spelling level
Control	4.28	113.9	5.6	6.8
Experimental	4.31	112.5	3.7	4.0

[a] Peabody Picture Vocabulary Test (Dunn, 1959).

TABLE 4

Comparison of Experimental and Control Groups
on the WISC Full Scale IQ

Group	Mean IQ	*F* ratio	Probability level
Control	114.00	1.834	.1814*
Experimental	110.56		

* Not significant.

serious personality-emotional disturbances in the children during the initial screening evaluation nor during any phase of the project. The interview session with the mothers also failed to elicit significant intra-family disturbances or emotional disturbances in the children. Because of these facts, pernicious family environmental factors and personality-emotional factors were ruled out as having significant influence on reading ability in the experimental group.

Data on the criterion variables were accepted as evidence that the groups were equated except on reading and spelling. By definition, the experimental group was composed of children with specific dyslexia, manifested primarily by poor performance on the reading and spelling tests. The control group was composed of normal children with no reading or spelling problems. It was reasonable to assume, therefore, that significant differences found between the two groups on the prediction variables could be attributed to some theoretical consideration of specific dyslexia.

Test Battery and Testing Procedures

Testing was of two types: individual and group. Each child was given four individual testing sessions and one group testing session.[3] The types of tests administered in the individual sessions were:

Language Evaluation

1. Gilmore Oral Reading Test, Form A (accuracy, comprehension, and rate)
2. Wide Range Achievement Test (reading)
3. Alphabet (verbal recitation)
4. Auditory Blending
5. Auditory Intrasensory Integration Test
6. Letter Recognition Test
7. Benton's Revised Visual Retention Test (Administration C, A, and D)
8. Minnesota Percepto-Diagnostic Test
9. Benton Right-Left Discrimination Test (verbal and behavioral forms)
10. Harris Tests of Lateral Dominance (hand dominance and foot dominance forms)
11. The A-B-C Vision Test for Ocular Dominance
12. Benton's Finger Localization Test (single and double stimulation)

Intellectual Evaluation (WISC)

1. Information
2. Comprehension
3. Arithmetic
4. Similarities

[3] Testing was done at the Dean Memorial Pediatric Neurology Division, Texas Scottish Rite Hospital for Crippled Children, Dallas, Texas. The Pediatric Neurology Study Center, where the experimental groups had been selected, was moved to the latter facility.

5. Vocabulary
6. Digit Span (not used in computing Verbal Scale IQ)
7. Picture Completion
8. Picture Arrangement
9. Block Design
10. Coding
11. Mazes (not used in computing Performance Scale IQ)

<u>Neurological Evaluation</u>

1. Clinical Examination
2. EEG, wake and sleep

<u>Auditory and Speech Evaluation</u>

1. Seashore Measures of Musical Talents (Pitch, Loudness, Rhythm, Time, Timbre, and Tonal Memory)
2. Sound Localization
3. Signal to Noise Ratio Test
4. Wepman Auditory Discrimination Test
5. Templin-Darley Screening Test of Articulation
6. Diadochokinesias (speed and rhythm in lateral alternating tongue movement)

The following tests were given in the group session:

1. Iowa Silent Reading
2. SRA Primary Mental Abilities (Perceptual Speed, Spatial Relations, and Figure Grouping)
3. Coloured Progressive Matrices, revised order, 1956
4. Wide Range Achievement Test (spelling)
5. Wide Range Achievement Test (arithmetic)
6. Alphabet (written)
7. Handwriting

Individual interviews with mothers of both groups were conducted to obtain information for the Medical History Inventory and for the Familial History of Language Disability.

Selection of standard tests was governed by: (a) the literature reporting tests currently in use; (b) Buros' Mental Measurements Yearbook (1953, 1959); (c) correspondence with various clinicians engaged in research; and (d) need for new tests not reported in the literature. Two new tests, Auditory Intrasensory Integration Test and Letter Recognition Test, were developed by this author to explore more specifically auditory and visual perception functions.

After the initial battery of tests was selected in consultation with the pediatric neurologist, copies of the battery were sent to a number of clinicians and researchers for their opinions. Based upon their suggestions, a few tests were dropped from the battery and several were added.

Description of Measurement Instruments

The following is a brief description of the instruments employed in this study. More complete information may be obtained from the original sources and from Buros' Mental Measurements Yearbook (1953, 1959). Copies of some of these instruments are presented in the appendices. Designation of the types of evaluations within this study, such as language, psychological, neurological, etc., were somewhat arbitrary, in terms of the tests they subsume. These classificatory titles were as much for the convenience of organizing blocks of tests per testing situation as they were for indicating the internal relatedness of the tests within each category.

General Remarks about the Language Evaluation

This evaluation took place within one testing period of approximately one hour and 15 minutes. Testing was done by the staff psychometrist who was familiar with all the tests and who had several years of experience evaluating children with language problems. Typical testing procedures were maintained throughout the evaluation. The order of presentation of tests was arranged in a predetermined sequence, the same sequence being used for all children of both groups. Tests with dissimilar performance requirements were intermixed to present novelty and to maintain the interest of the children. A short rest period was provided midway in the testing situation.

Gilmore Oral Reading Test (*Form A*). This test by Gilmore (1952) measures four aspects of oral reading: accuracy, comprehension (immediate recall of factual information), rate or speed in reading, and types of reading errors. In addition, qualitative evaluation of voice is provided. As an adjunct to this test, an additional category for miscellaneous errors was included for purposes of this study. The types of reading errors were:

1. Substitution. A sensible or real word is substituted for the word in the reading paragraph.

2. Mispronunciation. Instead of reading the correct word, the subject produces a nonsense word in one of the following manners: (a) false accentuation, (b) wrong pronunciation of letters, or (c) omission or addition of letters.

3. Words pronounced by examiner. If the child is unable to pronounce the word within five seconds, the examiner pronounces it for him.

4. Disregard of punctuation. The child fails to observe punctuation.

5. Insertions (including additions). The child inserts one or more words not present in the reading material.

6. Hesitation. The child pauses at least two seconds before pronouncing a word.

7. Repetition. The child repeats a word, part of a word, or a group of words.

8. Omission. The child omits one or more words that appear in the reading material.

Evaluation of voice quality involved:

1. Word-by-word reading.

2. Reading in a monotone voice.

3. Poor enunciation.

4. Strained pitch.

5. Volume too loud or too soft.

Miscellaneous errors were·

1. Child loses place in reading.

2. Child is a "finger pointer."

Wide Range Achievement Test (reading). The Wide Range Achievement Test by Jastak and Bijou (1946) is a three part test measuring ability in spelling, arithmetic computation, and reading. In the reading section, the child is presented a list of 128 words. He is asked to pronounce the words one after the other. There is no syntactical relationship among the words as they are not arranged in sentences or paragraphs. Types of reading errors are disregarded in scoring; the child either passes or fails each word. The child may make one or more errors in pronouncing the words, but it is his last pronunciation that is scored as passed or failed. Since this test is a measure of word attack skill, initial mispronunciations are disregarded if the final production is correct. The ceiling is reached when the child makes eight successive errors. The total number of words correctly pronounced constituted the score.

Alphabet (verbal recitation). The child is asked to recite the alphabet in sequence. If he omits one or more letters or recites one or more letters in incorrect sequence, the child fails the test.

Auditory Blending Test. This test, developed by Gates and McKillop (1962), contains 15 words. The examiner pronounces each word, syllable by syllable, with a half-second pause between syllables. The child is asked to say the word. There is only one trial for each word. The score consisted of the total number of words correctly identified.

Auditory Intrasensory Integration Test. This test, clinically developed by the author, was based on the observation that children and adults with specific dyslexia seem to have much difficulty in recognizing simple words spelled to them. It contains 25 words each spelled out with a half-second pause between letters. The words were selected from the Morrison-McCall Spelling Scale (Morrison & McCall, 1923). The range or level of spelling difficulty was between grades 1.0 and 1.9. This test was included in the battery because the psychological processes involved in integrating letter names into a meaningful whole appear to be different from the processes involved in a regular spelling test. Of course, if there is a very high correlation between the two procedures within a factoral matrix then this assumption will prove to be unwarranted.

This test was scored in two ways; total number of words correctly identified, and the cumulative reaction time in producing responses. The reaction time was the interval between the last letter of the word announced by the examiner and the time the subject made a response. If the child did not make a response within 10 seconds, timing was discontinued.

Letter Recognition Test. Many studies have reported that children with specific dyslexia exhibited visual-perceptual confusion in letter recognition. Bryant (1964), for example, noted that spatial confusion was frequently present in reverse image letters, such as "b," "d," and "p." The Letter Recognition Test was developed for the present study in an effort to quantify this behavior. The test consists of 12 rows with 22 letters in each row. The 12 letters are randomly presented in each row. Many of these letters are commonly confused by children with specific dyslexia. One row of letters is revealed at a time. The examiner announces only one letter within each row; the child is to circle this letter. He may, however, circle an incorrect letter. Scoring consisted of the total number of letters correctly identified and the total reaction time. Reaction time was the cumulative time interval between the announced letter and the time the child started to circle a letter, regardless of the letter circled.

Benton's Revised Visual Retention Test. This test, developed by Benton (1955), consists of three sets of 10 cards. Each card contains one or more geometric designs. In Administration "C," the child copies on a separate sheet of paper the 10 designs. This procedure is similar to that of the Bender Gestalt. In Administration "A," the child is shown each design for 10 seconds. He then reproduces it. This administration is similar to the visual reproduction subtest of the Wechsler Memory Scale (Wechsler & Stone, 1945). In Administration "D," the child is shown each design for 10 seconds. Following a 15 second delay or waiting period, the child reproduces the design. This is a delayed visual memory test. In all three separate administrations, scoring consisted of the total number of correct reproductions, and the total number of errors. Scoring was governed by instructions in the manual. No breakdown was made for the types of errors.

Minnesota Percepto-Diagnostic Test. This test was developed by Fuller and Laird (1963b). It consists of six cards, three cards containing Figure "A" and three cards containing Figure "3" derived from the Bender Gestalt. The directional orientation of each Gestalt figure, in relation to the card, constitutes the difference among the six designs. (See illustration in Appendix C.) The cards are presented in sequence and the child views the design while he draws it. He is given one sheet of paper and he is not allowed to rotate the paper or the cards. Scoring is in terms of degrees of rotation of the figure in relation to a base line. Administration and scoring followed the instructions in the manual.

Benton's Right-Left Discrimination Test. Benton (1959a) has developed a systematic series of tests to measure right-left discrimination. In Part I, the child is asked to touch one part of his body (either ear, knee, eye or shoulder) with his right or left hand. There are seven of these commands. In Part II, the child is shown eight pictures, each depicting either the right or left hand on either the right or left body part (eye or ear). The child is asked which hand is on which body part. Correct responses are in terms of the body schema of the pictures, not the body schema of the child. Benton (1959b) indicated that some children made consistent reversals on this part of the test, i.e., if the picture showed the right hand on the left ear, the child would indicate that the left hand was on the right ear. If this occurred, Benton scored the responses as correct but took note of the fact that consistent reversals were made. The same procedure was adopted in this study and a dichotomous yes-no scoring system was used. A separate scoring system was employed to record whether or not the child made consistent reversals on Part II.

Part I and Part II were scored separately and in terms of the total number of correct responses for each part. For the purposes of this study, an additional grand total (Part I plus Part II) was obtained. Also, a recording of whether or not the child reversed all of his responses on Part II--a dichotomous yes-no-system--was made.

Harris Tests of Lateral Dominance. Only two subtests, Hand Dominance and Foot Dominance, were used from a series of dominance tests developed by Harris (1958). In the Hand Dominance test, the examiner asks the child to demonstrate, in pantomime form, 10 separate activities involving the use of a hand; for example, throwing a ball, winding a watch, hammering a nail, etc. Note is made of which hand is used. In the Foot Dominance test, Harris has two items; kicking a football and stomping out a fire. A third item, hopping on one foot, was added to increase reliability. An extended version of the Harris system of classifying dominance was developed by the author for computer analysis, as follows:

1. Eye (left = _0_, right = _1_). If the majority of sightings were done by one eye, it was scored as the dominant eye.

2. Hand (left = _0_, right = _1_). If the majority of pantomime activities were done with one hand, it was scored as the dominant hand.

3. Foot (left = _0_, right = _1_). If the majority of activities were done by one foot, it was scored as the dominant foot.

4. Right lateralization (no = _0_, yes = _1_). If the child used his right eye, hand, and foot the majority of times, he was classified as right-lateralization.

5. Left lateralization (no = _0_, yes = _1_). If the child used his left eye, hand, and foot the majority of times, he was classified as left-lateralization.

6. Incomplete eye (yes = _0_, no = _1_). If one eye, whether right or left, was not used in _all_ the sightings, the classification was incomplete eye dominance.

7. Incomplete hand (yes = _0_, no = _1_). If one hand, whether right or left, was not used in _all_ the pantomime activities, the classification was incomplete hand dominance.

8. Incomplete foot (yes = _0_, no = _1_). If one foot, whether right or left,

was not used in all the activities, the classification was incomplete foot dominance.

9. Cross dominance (yes = 0, no = 1). If a child was right-eyed and left-handed or left-eyed and right-handed, he was classified as cross-dominant.

10. Complete lateralization (no = 0, yes = 1). To be classified as completely lateralized, a child could be either right-dominant (eye, hand, and foot) or left-dominant (eye, hand, and foot).

The A-B-C Vision Test for Ocular Dominance. This test, developed by Miles (1946), forms one part of the binocular tests in the Harris Tests of Lateral Dominance (Harris 1958). The child is asked to sight through a cone, open at both ends. The examiner presents eight cards successively, each containing two circles of different size and different degrees of shading. The examiner, who is 10 feet away, asks the child to look through the cone and indicate which circle is larger or which is darker. The examiner attends only to which eye is used in sighting and disregards the verbal responses. The eye used in sighting was recorded.

Benton's Finger Localization Test. Instructions for administering and scoring this test were obtained in private communication from Benton (1964). The test is briefly described in Benton (1959a). A 12-X-16-inch box with slanting top, open at both ends, was constructed for use in administering this test. A curtain at the front of the box prevented the child from seeing what the examiner was doing. The test consists of two parts; single stimulation of the fingers of both hands (10 trials for each hand) and double simultaneous stimulation of the fingers of both hands (10 trials for each hand). A tracing of the hand to be stimulated was placed on top of the box with the numerals 1 through 5 recorded on the finger tips. Scoring consisted of three parts: total score for single stimulation, total score for double simultaneous stimulation, and a grand total for both tests. Only correct responses were scored.

<u>Intellectual</u> <u>Evaluation</u> (<u>WISC</u>)

This evaluation was done by the author within one testing period. Wechsler's (1949) manual was followed for administration and scoring of the subtests selected for this study. Subtests administered were: Information, Comprehension, Arithmetic, Similarities, Vocabulary, Digit Span, Picture Completion, Picture Arrangement, Block Design, Coding, and Mazes. The Object Assembly subtest was omitted. The Digit Span subtest was not used in computing the Verbal Scale IQ. The Performance Scale IQ was computed on a prorated basis of the subtests administered with Mazes excluded. For computer analysis, the Digit Span subtest was additionally scored in terms of the magnitude of the difference between digits recited forward and digits recited backwards. As it turned out the direction of the difference was in favor of more digits recited forward than backwards for all children in both groups.

Neurological Evaluation

Clinical Neurological Examination. The neurological evaluation was developed by Dr. Lucius Waites, pediatric neurologist, and for the most part was derived from procedures previously used in examination of children with specific dyslexia, learning disabilities in general, and neuropathological disorders. A few modifications of his established procedure resulted from a review of the literature regarding neurological tests of children with specific dyslexia and from the work of Zedler (1965) in particular.

EEG. EEG tracings were obtained from a Grass Model 6-16CH6B electroencephalograph by a trained EEG technician under standardized conditions. The EEG procedure included wake, sleep, hyperventilation, and photic stimulation tracings. Each subject was assigned to one or more of nine categories. He could, for example, be assigned to the "14 and 6 cycles per second" and the "Fast" categories, if both were observed on the tracing. The "Abnormal-Other" classification was employed for subjects with an abnormal tracing not specified by the other categories. As it turned out, none of the children in either group was assigned to this category. The following EEG categories were used:

1. Slow
2. Fast
3. Mixed (diffuse)
4. Paroxysmal bursts
5. Focal
6. Immature tracing
7. 14 and 6 cycles per second
8. Abnormal-Other
9. Normal

Auditory Evaluation

Auditory testing was done by a fourth-year speech and hearing major under the supervision of Mrs. Louise Helton, registered audiologist of the Callier Hearing and Speech Center, Dallas, Texas. Subjects were evaluated in a sound room under standard conditions. The Seashore Measures of

Musical Talent, the Signal to Noise Ratio Test, and the Wepman Auditory Discrimination Test were presented to the children on tape. A Beltone audiometer was used for the Sound Localization Test.

Seashore Measures of Musical Talents. This test, developed by Seashore, Lewis, and Saetveit (1960), measures auditory discrimination in the following areas: pitch, loudness, rhythm, time, timbre, and tonal memory. Although the test was designed for group administration, slight modifications in the instructions to the examinees enabled it to be used individually. Scoring consisted of the total number of correct responses for each subtest.

Sound Localization Test. This test measures the ability of a person to localize sound in a three dimension field. In this study the stimulus was a 1000 cycles per second signal, 40 dbs above the pure tone auditory threshold of each child. The signal was presented to the child in a sound room for a duration of one second. The child had five directional choices to make concerning where he thought the sound originated: right, right-oblique, center (front), left-oblique, and left. A practice session to familiarize the child with the problem preceded the testing and consisted of one signal for each of the five directions. Whether or not he guessed correctly, the examiner demonstrated the correct localization response. The five directional signals were randomized. Testing consisted of 20 trials and correct responses were scored.

Signal to Noise Ratio Test. Silver and Hagin (1964) employed this type of test in research on children with specific dyslexia. The test is similar to a visual figure-ground test in that the child attempts to differentiate an auditory figure from an auditory background. The figure or auditory signal was 50 words presented on record W-22 from the Central Institute for the Deaf. The background was white noise. The signal and noise were reproduced on tape at 55 to 45 db level respectively. The signal consisted of an announcer saying, "Say the word ______." (See Signal to Noise Ratio Test, Appendix D, for the list of 50 stimulus words.) This was repeated 50 times, once each for the 50 different words. Each time the announcer gave a stimulus word, the child, who was in the sound room, repeated through his microphone the word he heard. The score was the total number of words correctly reproduced.

Wepman Auditory Discrimination Test. This test by Wepman (1958) consists of 40 pairs of words, 30 of which are different, but similar in phonetic structure, and 10 of which are the same. When each pair of words is presented, the child responds by saying "same" or "different." The 10 pairs of words that are the same constitute a validity scale. If the child misses four or more, the test is invalid. The total number of words misidentified out of the 30-pair word-list was the score.

Speech Evaluation

The examiner conducting the auditory evaluation also examined all children for speech. This was conducted under the supervision of Mrs. Louise Helton, Callier Hearing and Speech Center.

Templin-Darley Screening Test of Articulation. This test, developed by Templin and Darley (1960), consists of 50 stimulus pictures that are used to elicit certain initial, medial, and final speech sounds. Scoring involves the total number of sounds correctly reproduced. Jordan (1960) developed another scoring system. He found 24 sounds in the Templin-Darley test that significantly differentiated children with good speech from those with poor speech. In his study, the 24 sounds proved more effective than the complete Templin-Darley Screening Test of Articulation. Both scoring systems were used in the present study.

Diadochokinesis. This is a commonly used informal tongue movement test employed by speech therapists. There are several measures involved: the saying of "tuh;" total number of jaw movements in clicking of teeth together over a short time span; total number of left-right lateral tongue movements; and rhythm of left-right lateral tongue movements. In consultation with several speech therapists, it was arbitrarily decided to use total number of left-right lateral tongue movements, over a 10 second period of time, and to use the quality of tongue rhythm in left-right lateral movements.

The examiner demonstrated the test and allowed several practice sessions for the child in order to assure adequate understanding of the tasks. Following the practice sessions, the examiner counted the total number of lateral tongue movements. A tongue movement consisted of a sweep of the tongue from one corner of the mouth to the other and back to the starting point. If there was any doubt concerning the quality of tongue rhythm, the test was repeated. The classification of rhythm was in two degrees: good and poor coordination.

Group Testing

Normally six to eight children were present for group testing. At no time did this number exceed 10. Individual desks were spaced to make copying impossible. The author administered all group tests. Standardized testing procedures were followed.

Iowa Silent Reading Test (Form 4). This test is one section of the Iowa Tests of Basic Skills developed under the editorship of Lindquist and Hieronymus (1964). It is 55 minutes long and measures the following areas:

1. Recognition and understanding of stated or implied factual details and relationships.
2. Discernment of the main idea.
3. Organization of ideas.
4. Evaluation of what is read.

Reading sections are followed by questions with multiple-choice answers.

SRA Primary Mental Abilities. Three visual perception sections were selected from the Primary Mental Abilities, revised edition (Thurstone & Thurstone, 1962) as follows: Spatial Relations, Figure Grouping, and Perceptual Speed.

Coloured Progressive Matrices (1956). This test by Raven (1956) was administered to measure cognitive nonverbal visual perception since uncertainty concerning its relevance to dyslexia is present in the literature.

Wide Range Achievement Test (spelling). In this examination, the examiner states the word to be spelled, uses the word in a sentence provided by the manual, and restates the word. Scoring consisted of the total number of words correctly spelled.

Wide Range Achievement Test (arithmetic). This is a computational test. The ceiling is reached when the child makes 10 consecutive errors. The score was the total number of problems correctly solved.

Alphabet (written reproduction). This test simply involves writing the alphabet in sequence. The manner of reproducing the alphabet is of no consequence, whether manuscript, cursive, upper or lower case. The test was scored as passed or failed. The test was failed if one of the following errors were made: omission of letters; improper sequence of letters; and reversals of letters such as "z."

Handwriting. Each child was presented a printed paragraph on a sheet of paper. The children were asked to copy the paragraph on the paper in cursive writing. Children in the third grade copied a third-grade passage and those in the fourth grade copied a fourth-grade passage. These paragraphs were from the American Handwriting Scale (West, 1957).

The written material was classified by three judges into four divisions: very poor, poor, good, and very good. The three judges (the author, the staff psychometrist, and a Ph.D. language disability specialist) collaborated in judging the qualitative characteristics of the handwriting.

An informal scale for analysis of handwriting difficulties was developed by the author and the psychometrist as a guide in judging the specimens, as follows:

1. Inconsistency in slanting of letters.

2. Malformation of letters
   a. Unclosed letters such as "o" and "a"
   b. Misformed letters (bizarre formation of letters)
   c. Spacing of letters (too little or too much spacing)
   d. Height of letters in relation one to another (disregard of the relative height of "f," "h," "k," "l" in relation to "a," "c," "e," "i," etc.)
   e. Inconsistency in formation of identical letters

3. Irregular line formation (sentence not written in a straight line)

4. Letters retraced

5. Erasing of letters

6. Incomplete letters ("t" not crossed, "i" not dotted, etc.).

Each child was assigned to one of four groups, ranging from best to worst in quality of writing. Specimens within each category were then assigned a group number: _0_ = very poor; _1_ = poor; _2_ = good; and _3_ = very good.

Interview Schedules

Two interview schedules were employed, the Medical History Inventory and the Familial History of Language Disability. A staff registered nurse interviewed mothers of both groups. She was conversant with medical and familial history information contained in both schedules, and she was trained in interviewing techniques.

Medical History Inventory. This inventory was adapted from Zedler (1965) by the pediatric neurologist. Items were presented as nontechnical questions. When necessary, examples were given to explicate the items.

Familial History of Language Disability. This inventory, which was given to the mothers of both groups, was developed by the author to explore familial factors in specific dyslexia. The ideal approach would have been an evaluation of the siblings and parents of both groups of children. Such a task was too involved for this study.

The nine items in this inventory are reading, spelling, handwriting, laterality, directional orientation, motor coordination, speech, overall judgment, and siblings. The first eight items are divided into two categories: father and mother. The ninth item is divided into two categories: brothers and sisters. Subdividing the items allowed for statistical analysis of a sex linked basis for specific dyslexia.

Each item is briefly described in the schedule and was used by the nurse in interviewing the mothers. The nurse's qualitative judgment was the basis for deciding the presence or absence of parental or sibling involvement on each item.

Statistical Analysis of Data

Information on each child was recorded on individual test forms and transferred to a master data collection sheet. Scores for each child were then punched on Fortran cards. The data were analyzed on a CDC 1604 computer at the University of Texas Computation Center. A total of 197 variables and/or measurement operations were studied.

Analysis of Variance

The statistical measurement of significant difference between the experimental and control groups was by simple analysis of variance. This method was chosen over the *t* test as the latter method was not in the program library of the statistician consultant to this research project. Of the 197 variables analyzed, 42 were significant at the .05 level or less. Two variables at the .06 level were arbitrarily considered significant for clinical reasons so they could be included in additional analyses. Thus, the total number of significant variables was 44. This number was reduced to 43 as one variable, Neonatal Respiratory Difficulty (variable 42, Table 5), was excluded from additional statistical analysis. Since the control group has shown more respiratory difficulties than the experimental group, further analysis would not add to our understanding of the experimental group.

Intercorrelation of Significant Variables

An intercorrelation matrix was computed on 43 significant variables derived from the analysis of variance for the experimental group.

Principal Axis Factor Analysis with Varimax Rotation

This analysis was made only on the 43 significant variables of the experimental group. It was a preliminary step to the hierarchical grouping analysis since interest was in identifying important variables that might differentiate the experimental group into subsyndrome patterns.

Hierarchical Grouping Analysis

Following the factor analysis, the variables within each factor with the highest loading were selected for the hierarchical grouping analysis. This method of analysis was developed by Ward (Ward, 1963; Ward & Hook, 1961). The routine developed by Ward is contained in Veldman's (1965) statistical program library with Veldman's description of the routine as follows:

> This program clusters individual's profiles of test scores by a step-wise procedure which combines subjects (groups) so that total within-groups variation (considering all test variables equally and simultaneously) is minimally increased at each stage. The reduction proceeds from N one-person groups down to two groups. Beginning at an option-controlled stage, all subsequent stages of printout include complete group-membership information as well as the increase in within-group variance and the accumulated total of this error (p. 34).

In this routine, each child in the experimental group was assigned to a group based upon the pattern of his scores on the 14 variables selected from the factor analysis. The routine was programmed to produce two or more mutually exclusive groups, and in the case of this study, syndrome patterns of specific dyslexia.

Analysis of Variance of the Variables Selected from the Factor Analysis for the Groups Identified by Hierarchical Grouping Analysis

A summary of the procedures leading up to the analysis of variance is as follows:

1. Identification of the significant variables distinguishing the experimental and control groups.

2. Factor analysis of the significant variables using only data from the experimental groups.

3. Selection of the variables within each factor with the highest loading.

4. Identifying and categorizing the children of the experimental group into subgroups (hierarchical grouping analysis) in terms of the variables with the highest factor loadings.

5. Analysis of variance of subgroups (hierarchical grouping analysis) X variables (variables with the highest loadings derived from the factor analysis).

The print out of this analysis of variance resulted in the following information: groups $\underline{F}$ ratio; mean scores for the subgroups for the variables with the highest loadings; and probability levels for each $\underline{F}$ ratio for the variables.

CHAPTER IV

RESULTS

The results are presented in the following sequence: (a) significant variables identifying the experimental group; (b) intercorrelations of significant variables; (c) factor analysis of significant variables, (d) hierarchical grouping analysis of the experimental group; and (e) analysis of variance of the important loadings from the factor analysis used in the hierarchical grouping analysis.

Significant Variables Identifying the Experimental Group

The 42 significant variables at the .05 level or less are presented in Table 5 and the two variables arbitrarily considered significant--making a total of 44 significant variables--are shown in Table 6 (variables 1 and 2). Only 43 significant variables, however, were used in later statistical analyses as variable Neonatal Respiratory Difficulty (variable 42, Table 5) was excluded from consideration. This was done because the control group had more involvement than the experimental group on this variable. The following statistical information is contained in both tables: $\underline{F}$ ratios; experimental and control group means;

and probability levels. The variables are arranged in decreasing levels of significance. A scoring system such as the following was used in all cases where a mean value of less than one is found:

0 = the observed variable is not present (or is present)

1 = the observed variable is present (or is not present)

or

0 = the observed variable is not present

1 = the observed variable is mildly present (mild involvement)

2 = the observed variable is moderately present (moderate involvement)

3 = the observed variable is present to a great degree (severe involvement)

These classifatory systems were used for the neurological, alphabet, familial history of language disability, handwriting, medical history variables, and lateral dominance measures.

On all 43 significant variables, the experimental group was at a lower level of performance than the control group, i.e., the experimental group had more difficulty in functioning than the control group, except on Picture Completion, (variable 32, Table 5, page 145). On Picture Completion, the experimental group performed better than the control group. On

Foot-Dominance (variable 29, Table 5), the experimental group was significantly more left footed than the control group. (Tables 5 through 19 appear on pages 139-201).

Table 6 contains the variables that tend toward significance, i.e., between the .06 and the .10 levels. Since few experimental studies have been reported, the 16 variables in this table are presented so that future research may take cognizance of their relative importance in specific dyslexia. This is to guard against Type II error.

The 41 significant variables listed in Table 5, with the exception of Neonatal Respiratory Difficulty, and the two variables arbitrarily classified as significant (Table 6, variables 1 and 2) are listed in Table 7 according to areas of measurement, i.e., language, intellectual, visual memory retention, etc. The variables that tend toward significance are listed in Table 8 according to areas of measurement. Table 9 presents for each area of measurement the number of variables studied, the number of significant variables, and the percentage of significant variables. The area of language contains the largest number of significant variables (13 out of 29), followed by auditory (7 out of 12), familial history (8 out of 18), and intellectual (5 out of 16).

The percentage column in Table 9 gives some idea of the relative contribution of the various measurement areas, in terms of the number of significant variables to the number of variables studied. The importance of the percentages listed is relative only to the total number of variables within any given area of measurement. Areas that contain a fairly high number of variables but few significant variables are as follows: (a) neurological examination (3 out of 41 were significant); (b) medical history (1 out of 27 was significant); (c) EEG (none out of 18 were significant); (d) visual perception (2 out of 13 were significant); and (e) dominance (2 out of 10 were significant).

Referring again to Table 5, it is evident that there is considerable similarity among several of the variables: for example, variable 13, Alphabet-Total (verbal and written scores combined), variable 14, Alphabet-Written, and variable 37, Alphabet-Verbal; and variable 8, Auditory Intrasensory Integration Test (total number right), and variable 12, Auditory Intrasensory Integration Test (total reaction time in seconds). The purpose of such a definitive classification of some of the major variables was to determine the best scoring system that would reflect differences between the experimental and control groups. Although there may be a significant difference between the groups on a given variable, one type of scoring system may be more sensitive to this difference than another type of scoring system.

Intercorrelation of Significant Variables

Table 10 identifies variables by number that appear in Table 11, the table showing the intercorrelations of the 43 significant variables. When noting the significant correlations in Table 11 one refers to Table 10 for the names of the intercorrelated variables. Table 12 lists each variable and the significant variables correlated with it. The level of significance is .05 or less.

The positive and negative intercorrelations in Tables 11 and 12 are interpreted in relation to the particular scoring system used for any given variable. For example, under variable 1 (Verbal Scale IQ) in Table 12, variable 33, Reading-Father (Familial History of Language Disability) is negatively correlated with variable 1. The scoring of variable 33 is, 0 = presence of familial history and 1 = absence of familial history. The interpretation of the correlation between variables 1 and 33 is that a high score on the Verbal Scale is correlated with a familial history of reading disability for the father. The converse is that a low score on the Verbal Scale is correlated with the absence of a familial history of reading disability in the father. A minus sign precedes negatively correlated variables. The variables without the minus sign are positively correlated.

Factor Analysis of Significant Variables

After identifying the 43 significant variables, these variables were factor analyzed. The primary reason for including a factor analysis was to identify the highest loading within each factor in order that these highest loadings could be used in the hierarchical grouping analysis program. Table 13 lists important loadings from the principal axis factor analysis with varimax rotation. The manner of determining the important loading for the 14 factors was as follows: The highest loading for each variable among the 14 factors was determined by inspection and recorded under that factor. This was done for all 43 variables. This resulted in each variable being assigned to only one of the 14 factors. Any given factor may contain more than one important loading; however, the variables assigned to a given factor were not assigned to any other factor.

Table 14 shows the highest loadings for each of the 14 factors. (These variables were used in the hierarchical grouping analysis.) These variables are organized in Table

15 according to areas of measurement. Although the variables are considered as separate factors, Table 15 does indicate the relative contribution of the areas of measurement to the 14 factors. This classification is somewhat arbitrary; e.g., variable 2, Digit Span, is a subtest on the WISC but it is included under the auditory area of measurement because of its high correlation with several auditory measures on the Seashore test. (See Table 12, variable 2).

Table 16 presents descriptive names for the 14 factors. The names of the factors were derived primarily from the variable with the highest loading within each factor and were as follows: (a) familial history of language disability-father; (b) spelling deficiency, (c) finger agnosia; (d) finger-hand dyspraxia (e) auditory memory deficit; (f) incomplete peripheral dominance, (g) visual perception of pictorial details, (h) reproduction of alphabet deficiency; (i) oral reading deficiency; (j) poor visuomotor coordination and planning; (k) letter recognition deficit; (l) familial history of reading disability-mother, (m) auditory discrimination deficit; and (n) verbal mediation deficiency.

Hierarchical Grouping Analysis of the Experimental Group

The hierarchical grouping analysis procedure compared the children in the experimental group on 14 variables as listed in Table 14. These are the variables with the highest loadings selected from the 14 factors as presented in Table 13. The results of the hierarchical grouping analysis is shown in Table 17. As indicated in Chapter III, this procedure identifies subjects according to group patterns, in this case, the variables with the highest loadings from the factor analysis. As seen in Table 17, Group A contains eight children, Group B contains 17 children, and Group C contains seven children. One may say that the children within each group form a mutual pattern on the 14 variables and that the patterns among the three groups are different one from another.

Analysis of Variance of the Important Loadings from the Factor Analysis Used in the Hierarchical Grouping Analysis

In order to reveal the different pattern structures of the three groups resulting from the hierarchical grouping analysis, it was necessary to compute an analysis of variance for the three groups and the 14 variables. This analysis is presented in Table 18 and contains the following information: F ratios; means for the three groups; mean scores transformed into standard scores; and probability level. The means transformed into standard scores are presented in this table since it was impractical to construct a profile of the original means as their values range from .00 to 113.71. The significant F ratios in Table 18 are Verbal Scale IQ (variable 1), Letter Recognition Test (variable 5), Alphabet-Total (variable 6), Foot Dominance (variable 10), Benton's Finger Localization Test (variable 11), Approximation and Abduction (variable 12), and Reading-Mother (variable 14).

Figure 1, page 202, is the profile of the scores for the three groups derived from the analysis of variance in Table 18. A low standard score indicates a low score for any given variable, poor performance, or the presence of a disability. A high standard score indicates a good performance. (It is to be noted that a low score on Foot Dominance, variable 10, indicates left footedness.) In order to maintain this schema it was necessary to present the converse of the standard scores for variable 5, Letter Recognition, and variable 12, Approximation and Abduction of Fingers. The following computations were made to present these converse scores:

> 63 (the highest standard score) minus
> the original standard score plus 36
> (the lowest standard score).

The converse standard scores for groups A, B, and C for variable 5 are 56.0, 44.0, and 53.1 respectively. The converse standard scores for variable 12 are 37.4, 53.6, and 51.7 respectively. The profiles of the standard scores appear in Figures 1 and 2 (see pages 202 and 203).

Due to the number of variables in Figure 1, it is difficult at this time to clinically integrate and understand the three patterns of specific dyslexia. Figure 2 reduces this complexity by presenting only those variables with a significant *F* ratio, with one exception: Overall Judgment-Father, (variable 13, Table 18) which tends toward significance ($P = .0832$) and was therefore included. It was presented to better clarify the role of familial factors associated with the three groups.

It is apparent from Figure 2 that there is a difference among the groups concerning verbal ability. Group A is low on the Verbal Scale IQ, Group C is high, and Group B occupies a somewhat middle-high position.

On Letter Recognition, Group A is high (good in identifying letters), Group B is low, and Group C is middle-high. In regard to Alphabet-Total, Group A is low, Group B is at the middle position, and Group C is high. On Foot Dominance, Group C is low. In terms of the scoring system used, *0* = Left Footed and *1* = Right Footed, Group C is left footed whereas groups A and B are right footed. Concerning Benton's Finger

Localization Test, Group C is low, Group A is middle-low, and Group B is high.

There appears to be a difference among the groups on the two familial history variables. Group C is low on Overall Judgment-Father and high on Reading-Mother. The converse is true for Groups A and B; both tend to be high on Overall Judgment-Father and low on Reading-Mother. This suggests that Group C is associated with fathers who have a familial history of generalized language disability (reading and spelling) and groups A and B are associated with mothers who have a history of reading disability.

Group A appears to be composed of children with the following characteristics: poor verbal abilities; good ability in letter recognition and discrimination; poor ability in reproducing the alphabet; right footedness; average ability in finger localization; no familial history of generalized language disability for the father; and familial history of reading disability for the mother. Group B has the following characteristics: average to high average verbal abilities; poor ability in letter recognition and discrimination; average ability in reproducing the alphabet; right footedness; good ability in finger localization; no familial history of generalized language disability for the father: and a familial history of reading disability for the mother. Group C has the following characteristics: bright normal verbal abilities; average ability in letter recognition and discrimination; good ability in reproducing the alphabet; left footedness; poor ability in finger localization; familial history of generalized language disability indicated for the father; and no familial history of reading disability for the mother. These qualitative characteristics are summarized in Table 19.

TABLE 5

Variables Significant at the .05 Level or Less Derived from Analysis of Variance of Experimental and Control Groups

Variable	Experimental Group Mean	Control Group Mean	*F* Ratio	Probability Level
1. Wide Range Achievement Test-Reading (number of words correctly pronounced)	41.0000	70.1739	109.568	.0000*
2. Wide Range Achievement Test-Spelling (number of words correctly spelled)	33.7813	56.6087	75.409	.0000
3. Iowa Silent Reading Test (number of correct answers)	31.5000	51.3478	62.016	.0000
4. Gilmore Oral Reading Test (number of words read)	179.8750	376.4348	43.842	.0000

* P = .00005

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
5. Gilmore Oral Reading Test (ratio of substitution errors to total words read)	20.9688	5.6957	34.729	.0000
6. Gilmore Oral Reading Test-Accuracy (number of errors)	67.4687	49.9130	31.810	.0000
7. Gilmore Oral Reading Test-Comprehension (number of correct answers)	41.0313	59.6522	24.124	.0000
8. Auditory Intrasensory Integration Test (number right)	20.0313	23.5217	21.039	.0000
9. Rapid Apposition of Thumb and Fingers (neurological rating scale of 0 = no involvement to 3 = severe involvement)[a]	.5313	.0000	20.079	.0000

[a] All neurological measurements in Table 5 are based on this four point rating scale.

TABLE 5, continued

	Variable	Experimental Group Mean	Control Group Mean	$\underline{F}$ Ratio	Probability Level
10.	Mazes (WISC Scaled Score)	9.9063	12.5217	19.218	.0001
11.	Rhythm (number of correct auditory judgments)	39.9688	73.2174	18.601	.0001
12.	Auditory Intrasensory Integration Test (total reaction time in seconds)	83.0625	50.6957	17.999	.0001
13.	Alphabet-Total (verbal and written scores combined where $\underline{0}$ = failed & $\underline{1}$ = passed)	.3750	.8690	17.161	.0001
14.	Alphabet-Written[b]	.4375	.9130	16.533	.0002
15.	Directional Orientation-Mother (Familial History of Language Disability rating scale where $\underline{0}$ =				

[b] Same scale of measurement as variable 13.

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
disability & 1 = no disability)[c]	.2500	.7391	16.261	.0002
16. Gilmore Oral Reading Test-Rate (number of words read per minute)	99.4063	112.0870	16.064	.0002
17. Handwriting (clinical judgment based on 0 = very poor to 3 = very good)	.9063	2.0000	15.506	.0002
18. Approximation and Abduction of Fingers (neurological)	.5938	.0435	14.634	.0003
19. Rapid Supination and Pronation of Hands (neurological)	.3750	.0000	13.298	.0006

[c] All Familial History of Language Disability items in Table 5 are based on this two point rating scale.

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
20. Time (auditory)[d]	36.5625	59.7824	12.189	.0010
21. Digit Span (WISC Scaled Score)	9.1250	11.1304	10.882	.0017
22. Spelling-Father (Familial History of Language Disability)	.4688	.8696	10.772	.0018
23. Crawling (Medical History Inventory rating scale of 0 = not late to 3 = very late in crawling)	.6563	.0435	9.452	.0033
24. Tonal Memory (auditory)[e]	43.5938	66.1304	9.210	.0037
25. Reading-Mother (Familial History of Language Disability)	.5625	.9130	8.984	.0041

[d] Same scale of measurement as variable 11.
[e] Same scale of measurement as variable 11.

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	$\underline{F}$ Ratio	Probability Level
26. Vocabulary (WISC Scaled Score)	10.6250	12.3914	7.819	.0072
27. Auditory Blending (number of words blended correctly)	12.5625	14.0000	7.719	.0075
28. Overall Judgment-Mother (Familial History of Language Disability)	.5938	.9130	7.575	.0081
29. Dominance-Foot ($\underline{0}$ = left foot dominance & $\underline{1}$ = right foot dominance)	.7500	1.0000	7.388	.0089
30. Subjects' Brothers with Specific Dyslexia (familial History of Language Disability)	.4375	.7826	7.166	.0099
31. Overall Judgment-Father				

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
(Familial History of Language Disability)	.5000	.8261	6.671	.0126
32. Picture Completion (WISC Scaled Score)	12.8125	11.1304	6.700	.0124
33. Gilmore Oral Reading Test (ratio of total errors to total words read)	58.1875	47.2174	6.524	.0136
34. Verbal Scale IQ (WISC)	108.5313	115.1304	5.854	.0190
35. Reading-Father (Familial History of Language Disability)	.5313	.8261	5.469	.0232
36. Benton's Visual Retention Test-Delayed Recall (number right)	3.9688	4.9130	5.235	.0261
37. Alphabet-Verbal[f]	.6563	.9130	5.171	.0270

[f] Same rating scale as variable 13.

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	$\underline{F}$ Ratio	Probability Level
38. Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)	31.1250	33.6087	4.336	.0422
39. Loudness (auditory)[g]	33.0000	47.3913	4.269	.0437
40. Benton's Finger Localization Test (correct responses to double simultaneous stimulation)	13.6875	14.5652	4.235	.0445
41. Motor Coordination-Father (Familial History of Language Disability)	.8438	1.0000	4.104	.0478

[g] Same rating scale as variable 11.

TABLE 5, continued

Variable	Experimental Group Mean	Control Group Mean	$\underline{F}$ Ratio	Probability Level
42. Neonatal Respiratory Difficulty (Medical History Inventory rating scale where $\underline{0}$ = no difficulty to $\underline{3}$ = much difficulty	.0000	.1739	4.044	.0494

Note.-Variable 42 was excluded from further statistical analysis as it applies only to the control group, i.e., the control group had more difficulty than the experimental group.

TABLE 6

Variables Significant Between the .06 and .10 Levels Derived from Analysis of Variance of Experimental and Control Groups

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
1. Dominance-Incomplete Handedness[a]	.5313	.7826	3.771	.0575
2. Letter Recognition Test (number correct)	11.6875	11.9565	3.711	.0594
3. Benton's Visual Retention Test-Delayed Recall (number of errors)	9.2813	7.7391	3.597	.0633
4. Benton's Visual Retention Test-Immediate Recall (number of errors)	7.5313	5.8261	3.464	.0683
5. Spelling-Mother (Familial History of Language Disability rating scale of				

[a] Scoring system is 0 = presence of incomplete handedness, whether right or left, and 1 = absence of incomplete handedness, whether right or left.

TABLE 6, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
0 = history of & 1 = no history of disability)	.6563	.8696	3.284	.0756
6. Benton's Visual Retention Test-Immediate Recall (number right)	4.9063	5.8261	3.192	.0797
7. Handwriting-Father (Familial History of Language Disability)[b]	.7188	.9130	3.228	.0781
8. Extra Pyramidal System (neurological rating scale of 0 = no involvement to 3 = severe involvement)[c]	.1250	.0000	3.166	.0809
9. Caesarean Section (Medical History Inventory rating				

[b] Same rating scale as variable 5.

[c] All neurological measurements in Table 6 are based on this four point rating scale.

TABLE 6, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
scale of 0 = Section not done to 3 = emergency Section done)	.3750	.0000	3.166	.0809
10. Dominance-Left Sided (rating scale where 1 = yes: left side of body is dominant & 0 = no)	.1250	.0000	3.1666	.0809
11. Primary Mental Abilities-Perceptual Speed (correct responses)	12.8750	15.3913	3.070	.0856
12. Dominance-Incomplete Footedness[d]	.5625	.7826	2.915	.0936
13. Alternating Flexion and Extension of Fingers (neurological)	.1563	.0000	2.784	.1011

[d] Same scoring system as variable 1.

TABLE 6, continued

Variable	Experimental Group Mean	Control Group Mean	F Ratio	Probability Level
14. Hopping on One Foot (neurological)	.1563	.0000	2.784	.1011
15. Sound Localization (number of correct responses)	14.8438	16.1304	2.764	.1023
16. Pitch (number of correct auditory judgments)	44.6563	56.9565	2.745	.1035

TABLE 7

Significant Variables (.05 Level or Less)

Measurement Area	Variable
Language	
Reading	1. Wide Range Achievement Test-Reading (1)
	~~2. Iowa Silent Reading Test (3)~~
	3. Gilmore Oral Reading Test (number of words read) (4)
	4. Gilmore Oral Reading Test (ratio of substitution errors to total words read) (5)
	5. Gilmore Oral Reading Test-Accuracy (6)
	6. Gilmore Oral Reading Test-Comprehension (7)
	7. Gilmore Oral Reading Test-Rate (16)
	8. Gilmore Oral Reading Test (ratio of total errors to total words read) (33)
Handwriting	1. Handwriting (17)
Spelling	1. Wide Range Achievement Test-Spelling (2)
Alphabet	1. Alphabet-Total (verbal and written scores combined) (13)
	2. Alphabet-Written (14)
	3. Alphabet-Verbal (37)
Intellectual (WISC)	1. Mazes (10)
	2. Digit Span (21)
	3. Vocabulary (26)
	4. Picture Completion (32)
	5. Verbal Scale IQ (34)

Note.-Numbers in brackets refer to the variable numbers listed in Table 5.

TABLE 7, continued

Measurement Area	Variable
Visual Memory	1. Benton's Visual Retention Test-Delayed Recall (number right) (36)
Auditory	1. Auditory Intrasensory Integration Test ~~(number right) (8)~~
	2. Rhythm (11)
	3. Auditory Intrasensory Integration Test (total reaction time in seconds) (12)
	4. Time (20)
	5. Tonal Memory (24)
	6. Auditory Blending (27)
	7. Loudness (39)
Dominance	1. Dominance-Foot (left foot is dominant) (29)
Neuropsychological	1. Benton's Finger Localization Test (combined score of correct responses for single and double simultaneous stimulation) (38)
	2. Benton's Finger Localization Test (double simultaneous stimulation) (40)
Neurological	1. Apposition of Thumb and Fingers (9)
	2. Approximation and Abduction of Fingers (18)
	3. Supination and Pronation of Hands (19)
Medical History	1. Crawling (23)
Familial History of Language Disability	1. Directional Orientation-Mother (15)
	2. Spelling-Father (22)

TABLE 7, continued

Measurement Area	Variable
	3. Reading-Mother (25)
	4. Overall Judgment-Mother (28)
	5. Subjects' Brothers with Specific Dyslexia (30)
	6. Overall Judgment-Father (31)
	7. Reading-Father (35)
	8. Motor Coordination-Father (41)

TABLE 8

Variables Tending Toward Significance
(.06 to .10 Level)

Measurement Area	Variable
Visual Perception Memory	1. Letter Recognition Test (number correct) (2)
	2. Benton's Visual Retention Test-Delayed Recall (number of errors) (3)
	3. Benton's Visual Retention Test-Immediate Recall (number of errors) (4)
	4. Benton's Visual Retention Test-Immediate Recall (number right) (6)
Perceptual Speed	1. Primary Mental Abilities (perceptual speed) (11)
Auditory	1. Sound Localization (15)
	2. Pitch (16)
Dominance	1. Dominance-Incomplete Handedness (1)
	2. Dominance-Left Sided (10)
	3. Dominance-Incomplete Footedness (12)
Neurological	1. Extra Pyramidal System (8)
	2. Alternating Flexion and Extension of Fingers (13)
	3. Hopping on One Foot (14)

Note.-Numbers in brackets refer to the variable numbers in Table 6.

TABLE 8, continued

Measurement Area	Variable
Medical History	1. Caesarean Section (9)
Familial History of Language Disability	~~1. Spelling-Mother (5)~~ 2. Handwriting-Father (7)

TABLE 9

Number and Percent of Significant Variables According to Areas of Measurement

Measurement Area	Number of Variables Studied	Number of Significant Variables	Percent of Variables Significant
Miscellaneous-repeated grade	1	0	.00
Language			
Reading	23	8	
Handwriting	1	1	
Spelling	1	1	
Alphabet	3	3	
Arithmetic	1	0	
(Total)	(29)	(13)	44.83
Intellectual	16	5	31.25
Visual Perception	13	2	15.38
Auditory	12	7	58.33
Speech	4	0	.00
Dominance	10	2	20.00
Right-left discrimination	4	0	.00
Finger Localization	3	2	66.66

Note.-Forty-four variables were found significant, however, one, Neonatal Respiratory Difficulty, is not listed as it applies only to the control group.

TABLE 9, continued

Measurement Area	Number of Variables Studied	Number of Significant Variables	Percent of Variables Significant
Neurological Examination	41	3	7.32
EEG	18	0	.00
Medical history	27	1	3.70
Familial history of language disability	18	8	44.44
Age	1	0	.00
Grand Total	197	43	22.17

TABLE 10

Identification of 43 Significant Variables by Variable Number as They Appear in Table 11

1.	WISC Verbal Scale IQ
2.	WISC Digit Span
3.	WISC Vocabulary
4.	WISC Picture Completion
5.	WISC Mazes
~~6.~~	~~Letter Recognition Test (number correct)~~
7.	Benton's Visual Retention Test-Delayed Recall (number right)
8.	Alphabet-Verbal (rating scale: 0 = failed, 1 = passed)
9.	Alphabet-Written (same scale as variable 8)
10.	Alphabet-Total (verbal and written scores combined)
11.	Wide Range Achievement Test-Spelling (number right)
12.	Wide Range Achievement Test-Reading (number of words correctly pronounced)
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
14.	Gilmore Oral Reading Test-Accuracy (number of errors)
15.	Gilmore Oral Reading Test-Comprehension (number of correct answers)
16.	Iowa Silent Reading Test (number of correct answers)
17.	Handwriting (rating scale: 0 = very poor to 3 = very good)
18.	Loudness (auditory) (variables 18, 19, 20, and 21 involve correct responses)
19.	Rhythm (auditory)
20.	Time (auditory)
21.	Tonal Memory (auditory)
22.	Auditory Blending (number right)
23.	Auditory Intrasensory Integration Test (number right)
24.	Auditory Intrasensory Integration Test (total reaction time in seconds)
25.	Dominance-Foot (experimental group is left footed)
26.	Dominance-Incomplete Handedness (rating scale: 0 = presence of incomplete handedness & 1 = absence of incomplete handedness whether right or left)

TABLE 10, continued

27.	Benton's Finger Localization Test (correct responses to double simultaneous stimulation)
28.	Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)
29.	Approximation and Abduction (neurological) (rating scale: 0 = poor performance to 3 = good performance)
30.	Apposition of Thumb (neurological) (rating scale: 0 = poor performance to 3 = good performance)
31.	Supination and Pronation of Hands (neurological) (rating scale: 0 = poor performance to 3 = good performance)
32.	Crawling (Medical History Inventory) (rating scale: 0 = poor performance to 3 = good performance)
33.	Reading-Father (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
34.	Reading-Mother (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
35.	Spelling-Father (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
36.	Directional Orientation-Mother (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
37.	Motor Coordination-Father (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
38.	Overall Judgment-Father (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
39.	Overall Judgment-Mother (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)
40.	Subjects' Brothers with Specific Dyslexia (Familial History of Language Disability) (rating scale: 0 = presence of familial history, 1 = absence of familial history)

TABLE 10, continued

41. Gilmore Oral Reading Test (ratio of substitution errors to total words read)
42. Gilmore Oral Reading Test (number of words read)
43. Gilmore Oral Reading Test (ratio of total errors to total words read)

TABLE 11

Intercorrelation of Significant Variables Derived from Analysis of Variance
(See Table 10 for identification of variables by numbers)

	1	2	3	4	5	6	7	8	9
1.									
2.	.0251								
3.	.8335**	-.1630							
4.	.1509	-.0015	.1477						
5.	-.0802	-.0856	.0386	-.2270					
6.	.1242	-.0177	-.1420	-.1605	-.0860				
7.	.0533	.0314	-.1109	.0765	.0985	.0558			
8.	.2086	.2954	.1932	.0800	.0379	-.0454	.2499		
9.	.1227	.0377	.2219	-.0358	.1239	.0372	.0608	.3730*	
10.	.2225	.1700	.2894	-.0200	.0048	-.0254	.0163	.5606**	.8783**
11.	-.0478	.2459	-.1499	.0030	.2104	-.0013	.2421	.2622	.3254
12.	.3690*	.1783	.2728	-.0858	.3467*	.1534	.1222	.2405	.1961
13.	.0943	.1858	.0811	-.0561	.3407	.2037	.0461	.1241	-.2090
14.	-.2563	-.0905	-.2170	-.0189	.1421	.0139	.2280	-.1437	-.0195
15.	-.0582	.0945	.0183	-.0083	-.0802	.1002	.1702	.0025	.1788
16.	-.0426	.0858	-.0626	.2925	.2389	-.0411	.2526	.0240	-.1657

*-P $<$.05
** P $<$.01

TABLE 11, continued

	1	2	3	4	5	6	7	8	9
17.	-.1894	.0341	-.2194	-.0691	.2088	-.1389	.3003	.1875	.2608
18.	-.1666	-.0339	-.1129	-.0685	.1745	-.1453	.0224	-.0366	-.1158
19.	-.1714	.3722*	-.3264	-.1254	.0399	.0104	.1409	-.3904*	-.3064
20.	-.0671	.5854**	-.1654	-.2083	.1010	-.2448	.1027	.0640	-.2747
21.	.1876	.4118*	-.0574	-.0674	-.0689	.0508	.3121	-.0034	.0240
22.	.2605	-.0281	.3052	-.1236	-.2978	-.0299	.1814	.4706**	.2540
23.	.0305	.0040	-.0670	-.2570	.1574	.1534	.0952	.0267	.2960
24.	.0846	-.0505	-.0009	.3491*	-.0323	.1504	.0617	-.1599	-.1194
25.	.0449	.0000	.0308	-.2538	-.0321	.1707	.3271	-.1140	-.2182
26.	-.1249	.1462	-.1504	.0826	.1337	.0309	.2326	-.1524	-.1815
27.	.1046	.1729	-.2166	-.0347	-.2351	.3701*	.2262	-.2074	-.1641
28.	.0992	.2136	-.2054	-.1054	-.1236	.2353	.2128	-.0388	-.1097
29.	-.2523	-.1914	-.1197	-.1666	.1072	-.0047	-.0771	-.1476	-.3187
30.	-.2566	-.0838	-.0867	-.1578	-.0800	-.3255	-.3560*	-.0184	-.2751
31.	.0619	.0155	.1516	-.3139	-.1102	.0763	-.2438	.0170	-.4229*
32.	-.0579	-.3023	.1284	.2375	-.2421	-.0768	-.0533	-.0557	-.4226*
33.	-.3930	-.0037	-.3376	-.2802	.0593	.1296	-.1038	-.0206	-.1815
34.	.4731**	.0226	.3968*	.1922	.1380	-.2359	.2776	.2901	.2698
35.	-.4612**	.1537	-.4379*	-.2381	.0151	.0679	.1038	-.1112	-.0710
36.	.1850	-.0346	.2157	.0149	.2036	-.0569	.1090	-.0380	.2182
37.	.0485	-.0155	.2619	-.0690	.2316	-.2120	.0488	.4134*	.2060

TABLE 11, continued

	1	2	3	4	5	6	7	8	9
38.	-.3329	.0000	-.3469*	-.2328	.0557	.1971	-.0210	-.0548	-.1260
39.	.3288	.0800	.3838*	.1201	.2563	-.3072	.1963	.3391	.3447
40.	.2670	.0679	.2757	.0945	-.1380	.0372	-.0661	.3730*	.2381
41.	.1496	-.1372	.3175	.2971	.1547	-.3120	-.1129	.2175	-.0558
42.	.1437	.3249	.1048	-.0990	.0455	.1004	.2753	.2106	.0322
43.	.5898**	.1439	.4339*	.1730	-.1713	.1137	.1183	.2921	-.1611

TABLE 11, continued

	10	11	12	13	14	15	16	17	18
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.	.4284*								
12.	.3059	.5766**							
13.	-.1086	.3409	.5849*						
14.	-.1301	.1758	.1665	.3813*					
15.	.1980	.2371	.0169	.1120	.4832**				
16.	-.0202	.4210*	.3254	.3296	.1782	.2447			
17.	.1937	.4154*	.0244	.0656	.4619**	.3201	.2955		
18.	-.1186	.0659	-.2335	-.0685	.0931	.3785*	.0832	-.0910	
19.	-.4449*	-.1156	-.1017	-.1144	-.0982	-.0024	.0383	-.1122	.0701
20.	-.2595	.0366	.1023	.2036	.2447	.0398	.1751	.1029	.2302
21.	.0710	.2887	.1240	.0587	-.0946	.1514	.2708	-.1039	.2371
22.	.4065*	-.0694	.1346	-.0358	-.2036	-.1971	-.2231	-.0041	-.5831**

TABLE 11, continued

	10	11	12	13	14	15	16	17	18
23.	.2461	.6013**	.4969**	.2061	.2526	.1456	.3319	.4538**	-.1577
24.	-.2229	-.3169	-.2368	-.2255	-.0017	-.0071	-.0542	-.2222	-.0140
25.	-.2981	-.3395	-.2247	.1034	.0349	.0501	.0226	.0173	-.1727
26.	-.3072	-.0810	-.1696	.2367	.1342	-.0385	.1273	.1559	-.2221
27.	-.1803	.1194	.0153	.0654	-.0582	-.1286	.1918	.0006	-.1089
28.	-.1233	.1438	.0571	.1777	-.0576	-.1600	.1801	.1374	-.0976
29.	-.3081	-.0256	-.0388	.3717	.2146	-.2257	-.0672	-.0100	-.0102
30.	-.1590	-.1348	-.1061	.1147	.0117	-.3142	-.3297	-.1831	.1795
31.	-.3333	-.4082*	-.1223	.2642	.0364	-.1389	-.3027	-.1782	-.1628
32.	-.3412	-.3608*	-.3486*	-.1017	-.1979	-.0928	.0371	-.2613	-.0420
33.	-.1779	-.0199	-.0593	.3369	.1342	.1145	.1077	-.0244	.2168
34.	.2928	.0258	.3411	-.0373	.0601	-.0949	-.0263	.1021	-.2423
35.	-.0808	.0723	-.0678	.1889	-.0534	.1428	.1664	-.1559	.2543
36.	.0000	-.2640	-.1563	-.1130	.0737	-.0661	-.3911*	.1905	-.2406
37.	.3333	.2628	.2913	.4093*	.0307	.1926	.1659	.1265	.1471
38.	-.1291	.0131	-.0592	.2791	.0605	.1145	.0586	-.0900	.2698
39.	.2464	.0014	.3532*	.0884	.1766	-.0607	.0365	.1699	-.2502
40.	.2277	-.0346	-.0426	-.1223	-.0195	.0879	.0919	.1399	.0323
41.	.0082	-.3845*	-.1973	-.1978	-.4900**	-.2989	.0832	-.0698	-.0523
42.	.2231	.2926	.3488*	.4049*	.4666**	.4717*	.2147	.2094	.0160
43.	.0972	-.0103	.1271	-.0846	-.6625**	-.2295	-.0699	-.3087	-.1799

TABLE 11, continued

	19	20	21	22	23	24	25	26	27
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									
19.									
20.	.4646**								
21.	.3513*	.4764**							
22.	-.4109*	-.2569	-.1911						

TABLE 11, continued

	19	20	21	22	23	24	25	26	27
23.	-.0376	-.0232	-.0476	.0477					
24.	.0007	-.0401	.0709	-.2314	-.3778*				
25.	.0909	.1560	.1279	.3030	-.0817	-.0741			
26.	.1974	.2115	.0377	-.1263	-.2180	.2723	.4700**		
27.	.2020	.1385	.4392*	-.2059	.0493	.1592	.1853	.3085	
28.	.1371	.1444	.3323	-.1280	.0930	-.0553	.2271	.3360	.9020**
29.	-.0701	.0167	-.1127	.0488	-.0374	-.3409	.0827	-.0090	-.2027
30.	-.1037	.1068	-.1557	-.0387	-.2626	-.3243	-.3556*	-.3401	-.2314
31.	.0785	.0955	-.2532	.2353	-.2022	-.2842	.2981	.0808	-.1803
32.	-.1442	-.1875	-.2890	.1226	-.3955**	.1969	.2543	.2610	.0160
33.	-.0267	-.0646	-.2567	-.0709	.1601	-.2418	.1808	-.0039	.1383
34.	-.1505	.0578	.0658	.2749	-.0297	.3278	-.2182	.0552	-.1593
35.	.2290	.0541	.0894	-.0951	.0857	-.0114	.1085	.1294	.0319
36.	.0189	-.1439	-.2769	.0797	-.1144	.2996	.1667	.2531	-.0327
37.	-.3711*	-.0513	.0428	.1070	.1600	-.4368*	-.0497	-.2318	-.2745
38.	.0049	-.1915	-.1970	-.0829	.1604	-.2106	.1443	-.0626	.1321
39.	-.0290	.2386	.0311	.1494	.0847	.2082	-.1837	.1156	-.1549
40.	-.2326	-.0050	.0128	.0870	.0487	.2067	-.2182	-.1815	.1403
41.	-.0740	-.1632	-.2701	.1377	-.4024*	.0200	-.0217	.0147	-.3433
42.	-.1383	.1247	.1619	.0773	.3037	-.0952	.0878	-.1003	.0268
43.	.0005	-.1543	.1898	.2812	-.2150	.1971	-.0215	-.0920	.1730

TABLE 11, continued

	28	29	30	31	32	33	34	35	36
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									
19.									
20.									
21.									
22.									

TABLE 11, continued

	28	29	30	31	32	33	34	35	36
23.									
24.									
25.									
26.									
27.									
28.									
29.	-.1971								
30.	-.1777	.6761**							
31.	-.1088	.5792**	.4192*						
32.	-.0048	.0792	-.0095	.2187					
33.	.3220	.0867	.1087	.2102	.1252				
34.	-.1310	-.2586	-.1763	-.2277	-.1921	-.5759**			
35.	.0721	.0090	.0035	-.0808	-.0573	.6315*	-.3077		
36.	.0324	-.3031	-.2909	.0000	-.1761	-.0362	.2182	-.1085	
37.	-.1040	.1273	.2554	-.0222	-.1604	.1132	-.0325	.0593	-.1491
38.	.2950	.0477	.0560	.1291	-.0339	.9393**	-.5040**	.6888**	.0000
39.	-.0769	-.2217	-.1247	-.1479	-.2393	-.3945*	.8097**	-.2431	.3306
40.	.1734	-.3187	-.1622	-.0325	.1238	-.0552	.2698	-.3235	.0727
41.	-.2819	-.0018	.1014	.1459	.1528	-.2291	.1551	-.1715	.0753
42.	.0263	.0820	-.0679	.2181	-.1793	.1493	.0624	.0111	-.0673
43.	.0629	-.2071	-.1341	.0844	.2132	-.3117	.1861	-.2106	-.0024

TABLE 11, continued

	37	38	39	40	41	42	43
34.							
35.							
36.							
37.							
38.	.0861						
39.	.1698	-.4454*					
40.	.0325	-.1260	.3447				
41.	.1823	-.2057	.1333	.0201	.0000		
42.	.3261	.1667	.0451	.1301	.0000	-.3340	
43.	-.0174	-.2400	-.0487	.1225	.0000	.3763*	.0413

TABLE 12

Significant Intercorrelations of Variables[a]

Correlated Variable	Variable
	1. Verbal Scale IQ (WISC)
3.	Vocabulary (WISC)
12.	Wide Range Achievement Test-Reading
-33.	Reading-Father (Familial History of Language Disability)
34.	Reading-Mother (Familial History of Language Disability)
-35.	Spelling-Father (Familial History of Language Disability)
43.	Gilmore Oral Reading Test (ratio of total errors to total words read)
	2. Digit Span (WISC)
19.	Rhythm (auditory)
20.	Time (auditory)
21.	Tonal Memory (auditory)

Note.-Minus sign before variable number indicates negative correlation.

[a] Level of significance is .05 or less.

TABLE 12, continued

Correlated Variable	Variable
	3. Vocabulary (WISC)
1.	Verbal Scale IQ (WISC)
34.	Reading-Mother (Familial History of Language Disability)
-35.	Spelling-Father (Familial History of Language Disability)
-38.	Overall Judgment-Father (Familial History of Language Disability)
39.	Overall Judgment-Mother (Familial History of Language Disability)
43.	Gilmore Oral Reading Test (ratio of total errors to total words read)
	4. Picture Completion (WISC)
24.	Auditory Intrasensory Integration Test (total reaction time)
	5. Mazes (WISC)
12.	Wide Range Achievement Test-Reading
	6. Letter Recognition Test (number correct)
27.	Benton's Finger Localization Test (correct responses to double simultaneous stimulation)

TABLE 12, continued

Correlated Variable	Variable
	7. Benton's Visual Retention Test-Delayed Recall (number right)
~~-30.~~	~~Apposition of Thumb (neurological)~~
	8. Alphabet-Verbal
9.	Alphabet-Written
10.	Alphabet-Total (verbal and written scores combined)
-19.	Rhythm (auditory)
22.	Auditory Blending
37.	Motor Coordination-Father (Familial History of Language Disability)
40.	Subjects' Brothers with Specific Dyslexia (Familial History of Language Disability)
	9. Alphabet-Written
8.	Alphabet-Verbal
10.	Alphabet-Total (verbal and written scores combined)
-31.	Supination and Pronation of Hands (neurological)
-32.	Crawling (Medical History Inventory)

TABLE 12, continued

Correlated Variable	Variable
	10. Alphabet-Total (verbal and written scores combined)
8.	Alphabet-Verbal
9.	Alphabet-Written
11.	Wide Range Achievement Test-Spelling
-19.	Rhythm (auditory)
22.	Auditory Blending
	11. Wide Range Achievement Test-Spelling
10.	Alphabet-Total (verbal and written scores combined)
12.	Wide Range Achievement Test-Reading
16.	Iowa Silent Reading Test
17.	Handwriting
23.	Auditory Intrasensory Integration Test (number right)
-31.	Supination and Pronation of Hands (neurological)
-32.	Crawling (Medical History Inventory)
-41.	Gilmore Oral Reading Test (ratio of substitution errors to total words read)

TABLE 12, continued

Correlated Variable	Variable
	12. Wide Range Achievement Test-Reading
1.	Verbal Scale IQ (WISC)
~~5.~~	~~Mazes (WISC)~~
11.	Wide Range Achievement Test-Spelling
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
23.	Auditory Intrasensory Integration Test (number right)
-32.	Crawling (Medical History Inventory)
39.	Overall Judgment-Mother (Familial History of Language Disability)
42.	Gilmore Oral Reading Test (number of words read)
	13. Gilmore Oral Reading Test-Rate (number of words read per minute)
12.	Wide Range Achievement Test-Reading
14.	Gilmore Oral Reading Test-Accuracy (number of errors)
29.	Approximation and Abduction (neurological)
37.	Motor Coordination-Father (Familial History of Language Disability)
42.	Gilmore Oral Reading Test (number of words read)

TABLE 12, continued

Correlated Variable	Variable
	14. Gilmore Oral Reading Test-Accuracy (number of errors)
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
15.	Gilmore Oral Reading Test-Comprehension (number of correct answers)
17.	Handwriting
-41.	Gilmore Oral Reading Test (ratio of substitution errors to total words read)
42.	Gilmore Oral Reading Test (number of words read)
-43.	Gilmore Oral Reading Test (ratio of total errors to total words read)
	15. Gilmore Oral Reading Test-Comprehension
14.	Gilmore Oral Reading Test-Accuracy (number of errors)
18.	Loudness (auditory)
42.	Gilmore Oral Reading Test (number of words read)
	16. Iowa Silent Reading Test
11.	Wide Range Achievement Test-Spelling
-36.	Directional Orientation-Mother (Familial History of Language Disability)

TABLE 12, continued

Correlated Variable	Variable
	17. Handwriting
11.	Wide Range Achievement Test-Spelling
~~14.~~	~~Gilmore Oral Reading Test-Accuracy (number of~~ errors)
23.	Auditory Intrasensory Integration Test (number right)
	18. Loudness (auditory)
15.	Gilmore Oral Reading Test-Comprehension (number of correct answers)
-22.	Auditory Blending
	19. Rhythm (auditory)
2.	Digit Span (WISC)
-8.	Alphabet-Verbal
-10.	Alphabet-Total (verbal and written scores combined)
20.	Time (auditory)
21.	Tonal Memory (auditory)
-22.	Auditory Blending
-37.	Motor Coordination-Father (Familial History of Language Disability)

TABLE 12, continued

Correlated Variable	Variable
	20. Time (auditory)
2.	Digit Span (WISC)
19.	Rhythm (auditory)
21.	Tonal Memory (auditory)
	21. Tonal Memory (auditory)
2.	Digit Span (WISC)
19.	Rhythm (auditory)
20.	Time (auditory)
27.	Benton's Finger Localization Test (correct responses to double simultaneous stimulation)
	22. Auditory Blending
8.	Alphabet-Verbal
10.	Alphabet-Total (verbal and written scores combined)
-18.	Loudness (auditory)
-19.	Rhythm (auditory)

TABLE 12, continued

Correlated Variable	Variable
	23. Auditory Intrasensory Integration Test (number right)
11.	Wide Range Achievement Test-Spelling
12.	Wide Range Achievement Test-Reading
17.	Handwriting
-24.	Auditory Intrasensory Integration Test (total reaction time)
-32.	Crawling (Medical History Inventory)
-41.	Gilmore Oral Reading Test (ratio of substitution errors to total words read)
	24. Auditory Intrasensory Integration Test (total reaction time)
4.	Picture Completion (WISC)
-23.	Auditory Intrasensory Integration Test (number right)
-37.	Motor Coordination-Father (Familial History of Language Disability)
	25. Dominance-Foot (Experimental group is left footed)
26.	Dominance-Incomplete Handedness
-30.	Apposition of Thumb (neurological)

TABLE 12, continued

Correlated Variable	Variable
	<u>26. Dominance-Incomplete Handedness</u>
25.	Dominance-Foot (Experimental group is left footed)
	<u>27. Benton's Finger Localization Test (correct responses to double simultaneous stimulation)</u>
6.	Letter Recognition Test (number correct)
21.	Tonal Memory (auditory)
28.	Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)
	<u>28. Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)</u>
27.	Benton's Finger Localization Test (correct responses to double simultaneous stimulation)
	<u>29. Approximation and Abduction (neurological)</u>
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
30.	Apposition of Thumb (neurological)
31.	Supination and Pronation of Hands (neurological)

TABLE 12, continued

Correlated Variable	Variable
	30. Apposition of Thumb (neurological)
-7.	Benton's Visual Retention Test-Delayed Recall (number right)
-25.	Dominance-Foot (experimental group is left footed)
29.	Approximation and Abduction (neurological)
31.	Supination and Pronation of Hands (neurological)
	31. Supination and Pronation of Hands (neurological)
-9.	Alphabet-Written
-11.	Wide Range Achievement Test-Spelling
29.	Approximation and Abduction (neurological)
30.	Apposition of Thumb (neurological)
	32. Crawling (Medical History Inventory)
-9.	Alphabet-Written
-11.	Wide Range Achievement Test-Spelling
-12.	Wide Range Achievement Test-Reading
-23.	Auditory Intrasensory Integration Test (number right)

TABLE 12, continued

Correlated Variable	Variable
	33. Reading-Father (Familial History of Language Disability)
-1.	Verbal Scale IQ (WISC)
-34.	Reading-Mother (Familial History of Language Disability)
35.	Spelling-Father (Familial History of Language Disability)
38.	Overall Judgment-Father (Familial History of Language Disability)
-39.	Overall Judgment-Mother (Familial History of Language Disability)
	34. Reading-Mother (Familial History of Language Disability)
1.	Verbal Scale IQ (WISC)
3.	Vocabulary (WISC)
-33.	Reading-Father (Familial History of Language Disability)
-38.	Overall Judgment-Father (Familial History of Language Disability)
39.	Overall Judgment-Mother (Familial History of Language Disability)

TABLE 12, continued

Correlated Variable	Variable
	35. Spelling-Father (Familial History of Language Disability)
~~-1.~~	~~Verbal Scale IQ (WISC)~~
-3.	Vocabulary (WISC)
33.	Reading-Father (Familial History of Language Disability)
38.	Overall Judgment-Father (Familial History of Language Disability)
	36. Directional Orientation-Mother (Familial History of Language Disability)
-16.	Iowa Silent Reading Test
	37. Motor Coordination-Father (Familial History of Language Disability)
8.	Alphabet-Verbal
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
-19.	Rhythm (auditory)
-24.	Auditory Intrasensory Integration Test (total reaction time)

TABLE 12, continued

Correlated Variable	Variable
	38. Overall Judgment-Father (Familial History of Language Disability)
~~-3.~~	~~Vocabulary (WISC)~~
33.	Reading-Father (Familial History of Language Disability)
-34.	Reading-Mother (Familial History of Language Disability)
35.	Spelling-Father (Familial History of Language Disability)
-39.	Overall Judgment-Mother (Familial History of Language Disability)
	39. Overall Judgment-Mother (Familial History of Language Disability)
3.	Vocabulary (WISC)
12.	Wide Range Achievement Test-Reading
-33.	Reading-Father (Familial History of Language Disability)
34.	Reading-Mother (Familial History of Language Disability)
-38.	Overall Judgment-Father (Familial History of Language Disability)
	40. Subjects' Brothers with Specific Dyslexia (Familial History of Language Disability)
8.	Alphabet-Verbal

TABLE 12, continued

Correlated Variable	Variable
	41. Gilmore Oral Reading Test (ratio of substitution errors to total words read)
-11.	Wide Range Achievement Test-Spelling
-14.	Gilmore Oral Reading Test-Accuracy (number of errors)
-23.	Auditory Intrasensory Integration Test (number right)
43.	Gilmore Oral Reading Test (ratio of total number of errors to total number of words read)
	42. Gilmore Oral Reading Test (number of words read)
12.	Wide Range Achievement Test-Reading
13.	Gilmore Oral Reading Test-Rate (number of words read per minute)
14.	Gilmore Oral Reading Test-Accuracy (number of errors)
15.	Gilmore Oral Reading Test-Comprehension (number of correct answers)
	43. Gilmore Oral Reading Test (ratio of total errors to total words read)
1.	Verbal Scale IQ (WISC)
3.	Vocabulary (WISC)
-14.	Gilmore Oral Reading Test-Accuracy (number of errors)
41.	Gilmore Oral Reading Test (ratio of substitution errors to total number of words read)

TABLE 13

Important Loadings in Rotated Factor Analysis of Significant Variables Listed in Table 5

Variable Number	Factor Loading	Variables Within Each Factor
		Factor I
33.	-.8815	Reading-Father (Familial History)
35.	-.7979	Spelling-Father (Familial History)
38.	-.8887	Overall Judgment-Father (Familial History)
		Factor II
11.	.7434	Wide Range Achievement Test-Spelling
12.	.6643	Wide Range Achievement Test-Reading
16.	.7301	Iowa Silent Reading Test
23.	.6937	Auditory Intrasensory Integration Test (number right)
36.	-.5419	Directional Orientation-Mother (Familial History)
		Factor III
27.	.9071	Benton's Finger Localization Test (correct responses to double simultaneous stimulation)
28.	.9328	Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)

TABLE 13, continued

Variable Number	Factor Loading	Variables Within Each Factor
		Factor IV
29.	.8473	Approximation and Abduction of Fingers ~~(neurological)~~
30.	.8098	Apposition of Thumb (neurological)
31.	.6041	Supination and Pronation of Outstretched Hands (neurological)
		Factor V
2.	.9196	Digit Span (WISC)
19.	.5916	Rhythm (auditory)
20.	.7278	Time (auditory)
		Factor VI
7.	.7251	Benton's Visual Retention Test-Delayed Recall (number right)
25.	.8022	Dominance-Foot (experimental group is left footed)
26.	.4925	Dominance-Incomplete Handedness[a]

[a] This variable which is barely beyond the .05 level was included in the factor analysis for clinical reasons. (See variable 1, Table 6.)

TABLE 13, continued

Variable Factor	Factor Loading	Variables Within Each Factor
		Factor VII
4.	.8054	Picture Completion (WISC)
24.	.5007	Auditory Intrasensory Integration Test (total reaction time)
32.	.4822	Crawling (Medical History Inventory)
		Factor VIII
8.	.7640	Alphabet-Verbal
9.	.6982	Alphabet-Written
10.	.8487	Alphabet-Total (verbal and written scores combined)
37.	.5406	Motor Coordination-Father (Familial History)
		Factor IX
14.	.8107	Gilmore Oral Reading Test-Accuracy
15.	.7445	Gilmore Oral Reading Test-Comprehension
41.	-.5242	Gilmore Oral Reading Test (ratio of substitution errors to total words read)
42.	.7057	Gilmore Oral Reading Test (number of words read)

TABLE 13, continued

Variable Number	Factor Loading	Variables Within Each Factor
		Factor X
5.	.8102	Mazes (WISC)
		Factor XI
6.	-.5498	Letter Recognition Test (number correct)[b]
40.	.4827	Subjects' Brothers with Specific Dyslexia
		Factor XII
34.	.8070	Reading-Mother (Familial History)
39.	.8065	Overall Judgment-Mother (Familial History)
		Factor XIII
18.	.8553	Loudness (auditory)
21.	.5419	Tonal Memory (auditory)
22.	-.5245	Auditory Blending

[b] This variable which is barely beyond the .05 level was included in the factor analysis for clinical reasons. (See variable 2, Table 6.)

TABLE 13, continued

Variable Number	Factor Loading	Variables Within Each Factor
		Factor XIV
1.	.8465	Verbal Scale IQ (WISC)
3.	.8142	Vocabulary (WISC)
17.	-.4292	Handwriting
43.	.6652	Gilmore Oral Reading Test (ratio of total errors to total words read)

TABLE 14

Variables with Highest Loadings Selected from Rotated Factor Analysis for Use in Hierarchical Grouping Analysis

Variable Number[a]	Factor Loading		Factor Number
38.	-.8887	Overall Judgment-Father (Familial History of Language Disability)	I
11.	.7434	Wide Range Achievement Test-Spelling	II
28.	.9328	Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)	III
29.	.8473	Approximation and Abduction of Fingers (neurological)	IV
2.	.9196	Digit Span (WISC)	V
25.	.8022	Dominance-Foot (experimental group is left footed.)	VI
4.	.8054	Picture Completion (WISC)	VII
10.	.8487	Alphabet-Total (verbal & written scores combined)	VIII

Note.-Only the variable within each factor with the highest loading was selected for inclusion in the hierarchical grouping analysis.

[a] The variable numbers are those listed in Table 13.

TABLE 14, continued

Variable Number	Factor Loading		Factor Number
14.	.8107	Gilmore Oral Reading Test-Accuracy	IX
~~5.~~	~~.8102~~	~~Mazes (WISC)~~	~~X~~
6.	-.5498	Letter Recognition Test (number correct)	XI
39.	.8070	Reading-Mother (Familial History of Language Disability)	XII
18.	.8553	Loudness (auditory)	XIII
1.	.8465	Verbal Scale IQ (WISC)	XIV

TABLE 15

Organization by Areas of Measurement of 14 Factors and Their Highest Loadings Derived from Factor Analysis

Measurement Area		Variable	Factor Number
Familial History of Language Disability			
	38.	Overall Judgment-Father	I
	39.	Reading-Mother	XII
Language			
	10.	Alphabet-Total (verbal and written scores combined)	VIII
	11.	Wide Range Achievement Test-Spelling	II
	14.	Gilmore Oral Reading-Accuracy	IX
Neuropsychological			
	28.	Benton's Finger Localization Test (combined score of correct responses for single & double simultaneous stimulation)	III
Neurological			
	29.	Approximation and Abduction of Fingers	IV
Auditory			
	2.	Digit Span (WISC)	V
	18.	Loudness	XIII

Note.-These variables are the ones with the highest loadings in Table 13 and as listed in Table 14.

TABLE 15, continued

Measurement Area		Variable	Factor Number
Dominance			
	25.	Dominance-Foot (experimental group is left footed)	VI
Intellectual			
	1.	Verbal Scale IQ (WISC)	XIV
	4.	Picture Completion (WISC)	VII
Visual Perceptual Recognition			
	6.	Letter Recognition Test (number correct)	XI
Visual Perceptual Organization and Visual-Motor Coordination			
	5.	Mazes (WISC)	X

TABLE 16

Names of Factors in Rotated Factor Analysis

Factor Number	Factor Name
I	Familial history of language disability-father
II	Spelling deficiency
III	Finger agnosia
IV	Finger-hand dyspraxia
V	Auditory memory deficit
VI	Incomplete peripheral dominance
VII	Visual perception of pictorial details
VIII	Reproduction of alphabet deficiency
IX	Oral reading deficiency
X	Poor visuomotor coordination and planning
XI	Letter recognition deficit
XII	Familial history of reading disability-mother
XIII	Auditory discrimination deficit
XIV	Verbal mediation deficiency

TABLE 17

Assignment of Children in Experimental Group to Mutually Exclusive Groups According to Hierarchical Grouping Analysis

Classification of experimental children by number

Group A	Group B	Group C
01	02	03
04	08	05
06	09	13
07	11	19
10	12	22
20	14	28
21	15	29
24	16	
	17	
	18	
	23	
	25	
	26	
	27	
	30	
	31	
	32	
N = 8	17	7

TABLE 18

Analysis of Variance of 14 Important Loadings from Factor Analysis Used in Hierarchical Grouping Analysis Indicating Three Syndrome Patterns of Specific Dyslexia

Variable	_F_ Ratio	Means and means transformed into standard scores						Probability Level
		Group A		Group B		Group C		
1. Verbal Scale IQ (WISC)	5.95	99.37	(41.0)	110.71	(51.9)	113.71	(54.71)	.0068
2. Digit Span (WISC)	1.49	8.25	(45.9)	9.71	(52.9)	8.71	(48.1)	.2409
3. Picture Completion (WISC)	2.36	11.87	(46.1)	12.59	(48.9)	14.43	(56.7)	.1122
4. Mazes (WISC)	2.15	10.87	(55.6)	9.41	(47.2)	10.00	(50.7)	.1344
5. Letter Recognition	5.76	11.25	(43.0)	12.00	(55.0)	11.43	(45.9)	.0078
6. Alphabet-Total	8.44	.00	(42.0)	.35	(49.4)	.86	(60.0)	.0013

Note.-Numbers in brackets refer to means transformed to standard scores.

TABLE 18, continued

	Variable	F Ratio	Means and means transformed into standard scores						Probability Level
			Group A		Group B		Group C		
7.	Spelling	.52	33.37	(49.6)	32.94	(48.8)	36.29	(53.4)	.5989
8.	Gilmore Oral Reading-Accuracy	2.63	35.50	(56.4)	32.00	(48.9)	30.43	(45.4)	.0892
9.	Loudness (auditory)	.92	42.75	(54.1)	30.53	(48.9)	27.86	(47.6)	.4083
10.	Foot Dominance	18.04	.87	(53.1)	.94	(54.6)	.14	(36.3)	.0000*
11.	Benton's Finger Localization Test (combined score of correct res-								

* P = .00005

TABLE 18, continued

Variable	$\underline{F}$ Ratio	Group A		Group B		Group C		Probability Level
		Means and means transformed into standard scores						
ponses for single & double simultaneous stimulation)	9.41	28.87	(44.9)	33.71	(55.8)	27.43	(41.6)	.0007
12. Approximation and Abduction (neurological)	13.44	1.37	(61.6)	.29	(45.4)	.43	(47.3)	.0003
13. Overall Judgment-Father	2.71	.50	(50.0)	.64	(52.9)	.14	(42.9)	.0832
14. Reading-Mother	3.45	.50	(48.0)	.47	(47.4)	1.00	(58.0)	.0453

TABLE 19

Qualitative Description of the Performance of Three Subgroups of Children with Specific Dyslexia on a Select Number of Significant Variables

Variable	Group A	Group B	Group C
Verbal Scale IQ	low[a]	middle-high	high
Letter Recognition Test	high	low	middle-high
Alphabet-Total	low	middle	high
Foot Dominance	right	right	left
Benton's Finger Localization	middle-low	high	low
Overall Judgment-Father	middle-high[b]	high	low
Reading-Mother	low	low	high

[a] The qualitative terms refer to the level of performance: low means poor performance and high means good performance.

[b] Low means presence of language disability, middle-high means tendency toward absence of language disability, and high means absence of language disability.

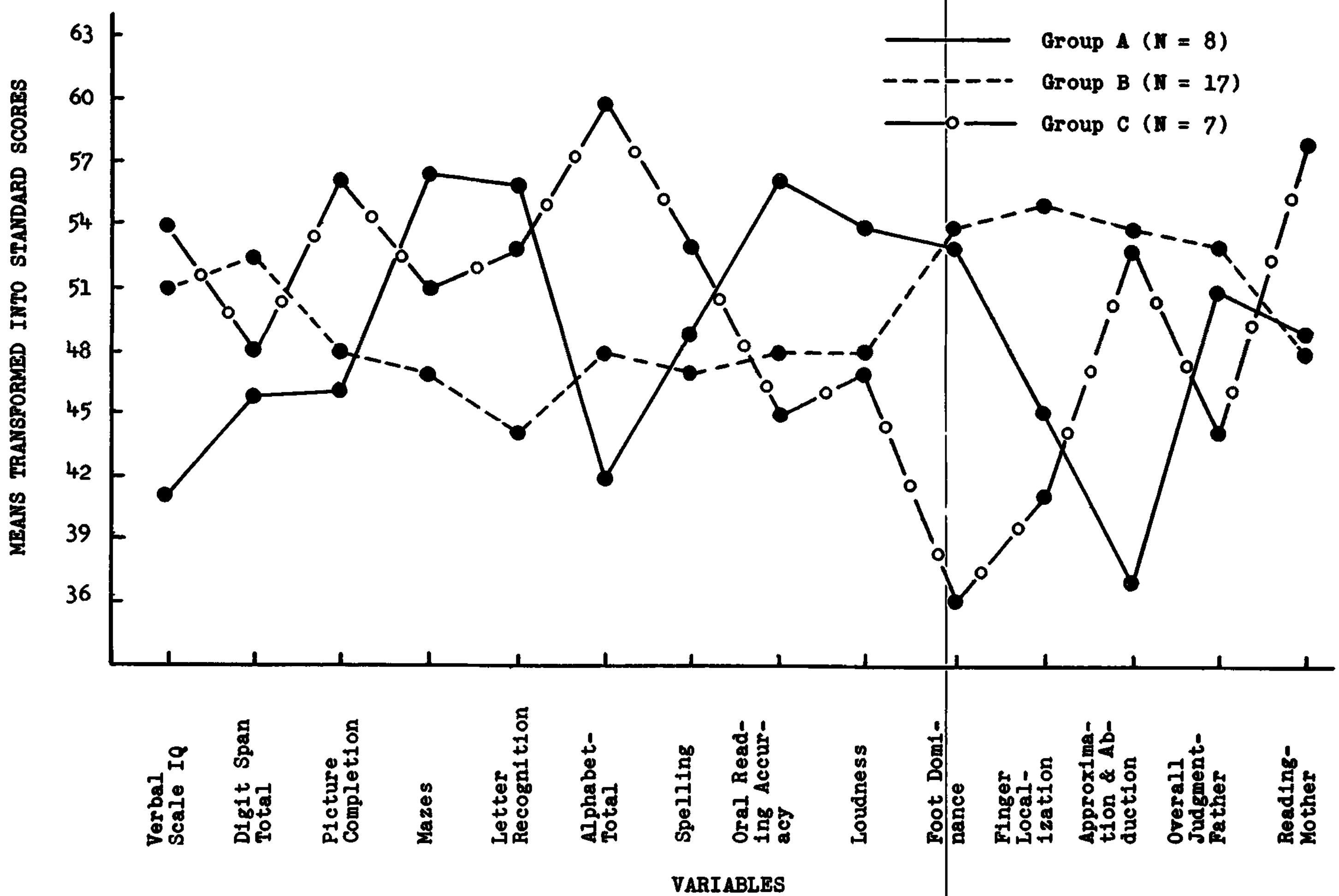

Fig. 1. Profile of standard scores derived from analysis of variance of three syndrome patterns identified by hierarchical grouping analysis.

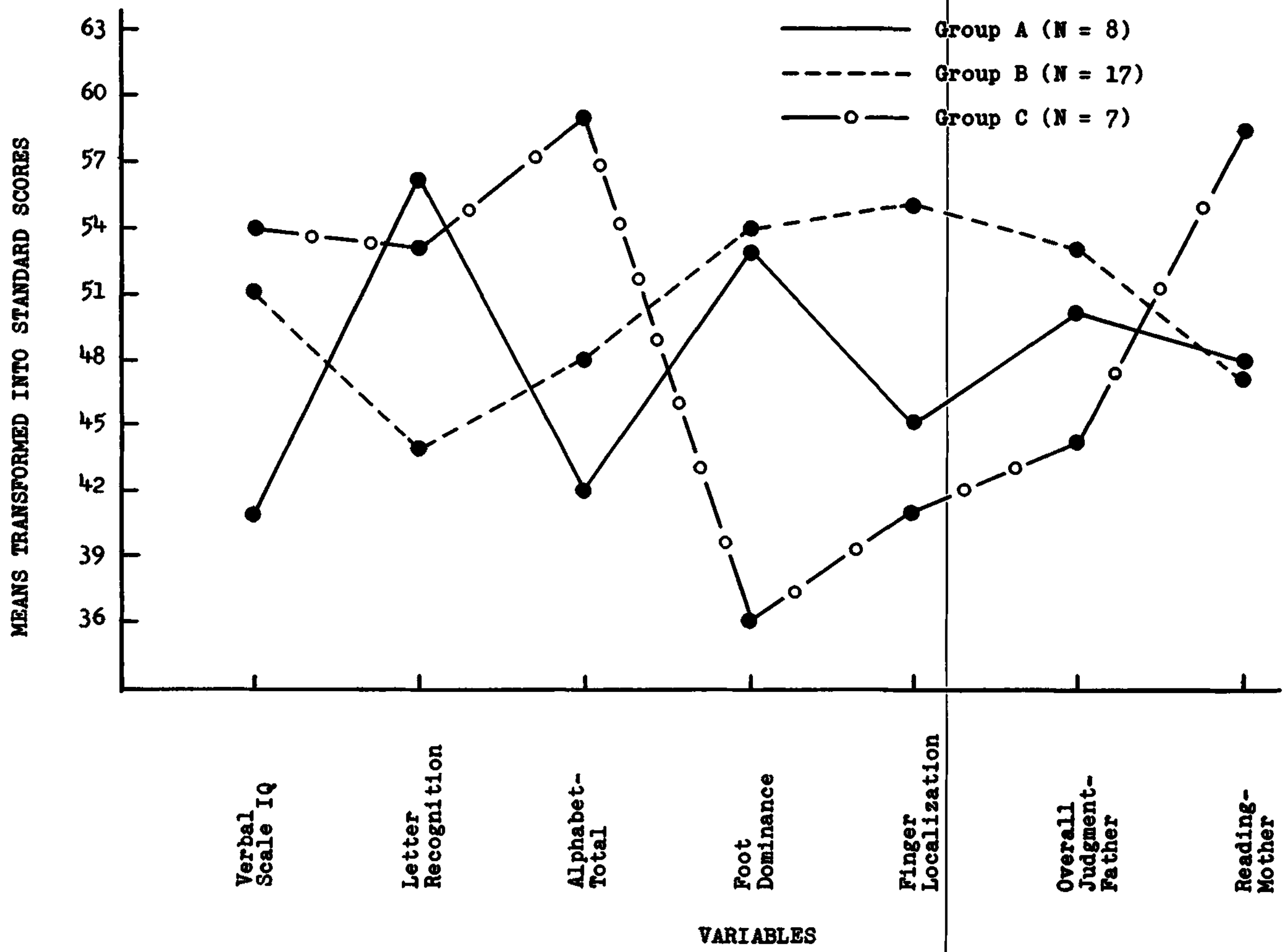

Fig. 2. Profile of variables with significant group *F* ratios derived from the 14 variables presented in Fig. 1.

CHAPTER V

DISCUSSION OF RESULTS

The sequence for this discussion is: (a) quantitative differences between the experimental group and the control group, (b) statistical characteristics of the experimental group; (c) syndrome patterns of specific dyslexia, and (d) implications for research.

Quantitative Differences between the Experimental and Control Groups

The number of measurements that significantly differentiates the experimental group from the control group supports clinical hypotheses that specific dyslexia is a distinct entity. The variety of significant variables intimates that, in reference to this study, specific dyslexia is a complex phenomenon. Furthermore, specific dyslexia defies a simple theoretical explanation. Single-factor theories, such as cerebral dominance, visual imperception, familial history, neurological dysfunction, maturational lag, etc., may be too limited to account for the diversity of the results found in this study. Multi-factor theories, as presently developed, appear too vague in explaining antecedent-subsequent relationships and therefore offer little interpretive help. Discussion of the findings in this study, therefore, focuses on a descriptive explanation of the data rather than relating them to any particular theory.

Table 7 presents in a more meaningful way the interrelations of the 43 significant variables that distinguish the experimental group from the control group. It may be used as a guide to the relative contribution of the several areas of measurement and the processes or functions associated with these measurements. (The reader is referred to Tables 5 and 6 for a listing of the tests of these significant variables and those that tend toward significance.) The measurement areas which contribute considerably to a difference between the two groups in Table 7 are (a) intellectual, (b) familial history of language disability, (c) language, and (d) auditory. The measurement areas containing few significant variables are (a) visual perception, (b) dominance, (c) neuropsychological, (d) neurological, and (e) medical history. Measurement areas not listed in Table 7 because they contain no significant variables are (a) "repeated grade," (b) speech, (c) right-left discrimination, (d) EEG, and (e) age.

Miscellaneous Variable

The variable, "Repeated Grade," was studied because clinical experience had suggested that a number of children with specific dyslexia repeated one or more grades because of poor academic performance related to their reading problem. This measure, however, was not significant (P = .9130). One explanation is that the children were in the last two months of the third or fourth grades at the time of testing. Had they been in a higher grade a significant difference might have been found. (The opportunity or frequency for failing a grade for children with dyslexia increases with advancement in grade level, assuming that a reading disability results in academic failure as a child progresses through school.)

Language

Measurement was made in five educational areas: (a) reading (oral and silent); (b) handwriting; (c) spelling, (d) reproduction of the alphabet (oral and written); and (e) arithmetic computation. The total number of language measures was 29, of which 23 were in reading. Of these 29 measures, 13 (44.83%) were significant at the .05 level or less (see Table 9).

Reading. Several measures of reading differentiated the experimental and control groups: (a) word attack skills; (b) silent reading comprehension; (c) total number of oral words read; (d) ratio of oral substitution errors to total number of words read; (e) oral reading accuracy; (f) comprehension in oral reading; (g) rate in oral reading: and (h) ratio of total number of errors to total number of words read orally. The experimental group's performance was inferior on all of these measures.

Perhaps of equal interest to the researcher is knowledge of reading errors that were not significantly related to children with specific dyslexia, errors that were common to normal readers. The errors (and related behavior) in which no significant difference was found between the experimental and control groups were the following: (a) hesitation errors: (b) mispronunciation errors; (c) repetition errors; (d) omission errors; (e) number of words pronounced by the examiner; (f) insertion errors; (g) disregard of punctuation, (h) reading word-by-word; (i) reading in a monotone voice; (j) poor enunciation; (k) strained pitch; (l) finger pointing; (m) loss of place, and (n) volume too loud or too soft.

It is not surprising that children with dyslexia have poorly developed word attack skills, that they have difficulty in comprehending what is read orally and silently, that oral reading is poor in accuracy, and that rate of reading is slow. What is surprising is that only one type of reading error significantly differentiated the two groups, namely, substitution error. Whether this finding is peculiar to this sample of children is not determinable, since comparable data from other studies are not available for children with dyslexia and normal readers.

The verification of the fact that children with specific dyslexia make significantly more substitution errors confirms what Orton (1937) and his co-workers have known for many years. The traditionally reported reversal or rotational error of "was" for "saw" is a case in point. Orton (1928) referred to this as strephosymbolia, or twisted symbols.

The substitution error represents a visuoperceptive symbolic or associational difficulty that occurs at the integrative level of psycholinguistic functioning. This error is not a "pure" visual perception function as found, for example, in the three subtests of the Primary Mental Abilities test (Thurstone & Thurstone, 1962). Benton (1962b) and Fuller (1964) distinguished nonsymbolic visuoperceptive deficits from conceptual (symbolic) and associational difficulties. The Primary Mental Abilities subtests are measurements of the former and the substitution error is a measurement of the latter.

Parenthetically, researchers may find it more productive to explore visual perception in dyslexia in reference to the Arabic alphabet or some approximation thereof, whether in single units or combinations of units, rather than studying visual perception in relation to geometric figures and the like.

<u>Handwriting</u>. Disturbance in handwriting has often been associated with specific dyslexia (Benton, 1962b; Bryant et al., 1964; Saunders, 1962; Schiffman, 1962). This study found a significant difference between the experimental and control groups in handwriting (P = .0002, variable 17 in Table 5). Many of the hand written specimens in the experimental group were easily discernible in terms of qualitative characteristics as follows: disorganization of letters; slanting or irregular line formation, disregard of margin, evidence of erasing; etc. Some of the writing appeared to be at the first grade level even though presented in cursive form. A specimen, indicating these characteristics, is presented in Figure 3, page 210.

<u>Spelling</u>. Spelling was one of the most significant variables found in this study (P = .00005, variable 2, Table 5), the experimental group performing at a lower level than the control group. It is significantly correlated with several other measures, as listed in Table 12; however, discussion of these correlations is presented in this chapter under <u>Statistical Characteristics of the Experimental Group</u>, subsection <u>Principal Axis Factor Analysis with Varima Rotation</u>.

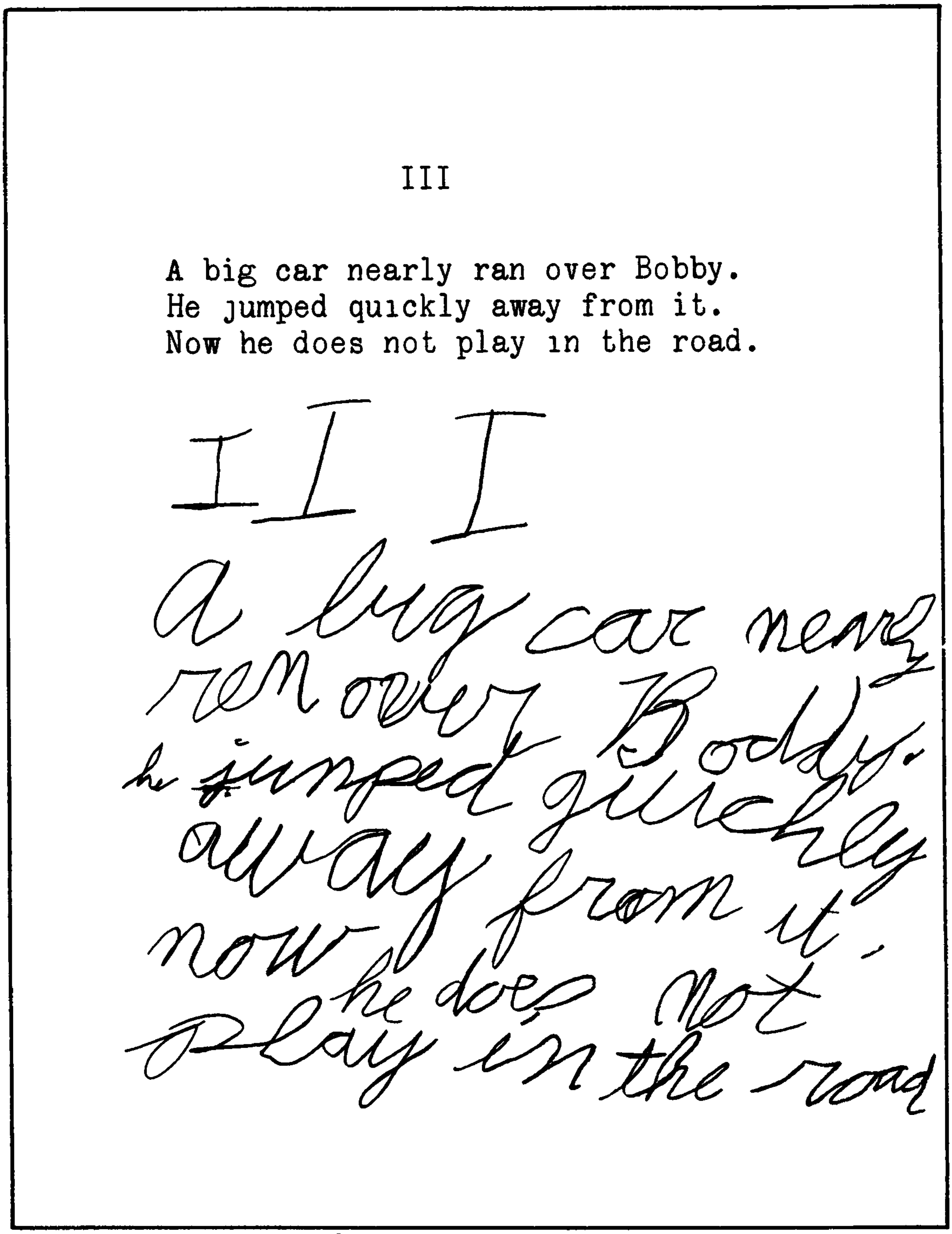

Fig. 3. Handwriting specimen of a student from the experimental group, age 9 years, 6 months, 3rd grade, 9th month, Full Scale IQ 120.

Clinical observation of the types of spelling errors produced by the experimental group is in keeping with the report by Gillingham and Stillman (1956). These authors, and others associated with Dr. Samuel T. Orton, stated that bizarre or unusual spelling was one of several manifestations of specific language disability (specific dyslexia). Bizarre spelling may reflect a conflict between two perceptual modalities, auditory discrimination and/or other auditory variables and visual memory of words. Assuming a dysfunction in auditory discrimination and visual memory, the child may alternately respond to insufficient and inadequate cues from both perceptual areas. Integration and association of this type of incomplete and "scrambled" information results, so to speak, in bizarre spelling. Examples of some of the bizarre spelling produced by the experimental group are shown in Table 20.

It is reasonable to postulate that poor spelling ability distinguishes children with dyslexia from normal readers, in view of the findings in this and other studies. This may not, however, be an exclusive characteristic of children with dyslexia; for example, it is found in children with subnormal intelligence. In a clinical setting, one would certainly consider spelling ability in diagnosing dyslexia.

TABLE 20

Examples of Misspelled Words by Experimental Group

Grade Level	Spelling Word	Written Response
1.3	in	an, on
1.6	man	mad
1.7	will	whil, wale, wiele, went, welt
2.1	cut	keat, cait, ket, cout
2.4	say	snaj, sask, said
2.5	arm	land, ram
2.6	cook	koc, cter, cocke, cog, kuc
2.7	wall	youl, wohe, woke
2.8	light	ligen, lat
3.0	must	muse, mut, not, mose
3.1	train	truin, tura, rane
3.2	order	hored, rordr, rod, owdr, oret, otr, ounr, otere, redr
3.3	person	peren, pust, prese, peusoun, prason, prosin, prsun
3.4	reach	reish, reark, rich, reas, reshe
3.5	enter	earner, nit, tanter, amtur
3.6	watch	whol, wint, warch, waclth

Alphabet. The findings in this study demonstrated that the experimental group was unable to write or recite the alphabet in sequence as well as the control group. The three measures of the alphabet are shown in Table 5 with the following levels of significance: variable 13, Alphabet-Total ($P = .0001$); variable 14, Alphabet-Written ($P = .0002$); and variable 37, Alphabet-Verbal ($P = .0270$), all of which indicate poor performance by the experimental group. Inability to reproduce the alphabet is an important theoretical and educational consideration; it has been ignored to a considerable degree by present systems of teaching. If the child manifests uncertainty and instability in this function, there should be little wonder that he is unable to cope with the molar aspects of these units.

Money (1962) discussed the principle of form constancy in regard to visual perception of the alphabet; however, this does not account for the finding on the verbal recitation of the alphabet. More research is needed on problems associated with learning and reproducing the alphabet. Learning theory, in addition to perceptual and cognitive theories, may offer some answers.

Arithmetic. Most authorities did not present evidence for a deficiency in arithmetic computation in specific dyslexia.

Rabinovitch et al. (1954) did, however, indicate a deficiency in their primary reading retardation group (specific dyslexia). The present study did not find a significant difference between the experimental and the control groups on arithmetic computation (P = .6113). The Arithmetic subtest on the WISC also did not produce a significant difference. The mean scaled scores on this subtest for the experimental and control groups were 11.8125 and 12.6087 with P = .2356. The difference between this and the Rabinovitch study may be related to the criterion variables used in selecting and classifying children into diagnostic groups.

Intellectual

The criterion measure for determining the intellectual level for the two groups was the Peabody Picture Vocabulary Test (Dunn, 1959). In Table 5, the comparability of the groups on the measure of IQ is reflected in the WISC Full Scale IQ (experimental = 110.5625, control = 114.0000, P = .1814). This suggests that differences between the two groups may not be attributed to a generalized or global intellectual factor. There was, however, a significant difference on the WISC Verbal Scale IQ (experimental = 108.5313, control = 115.1304, P = .0190). A cautious attitude must be maintained in generalizing from this finding to the population of children with dyslexia, since evidence is presented in a later section of this chapter that indicates that all of the children in the experimental group did not have a low Verbal Scale IQ.

There was no significant difference between the two groups on the WISC Performance Scale IQ (experimental = 110.7188, control = 109.4783, P = .6687).

Four subtests on the WISC, two verbal and two performance, were significant (see Table 5). The mean scaled scores are as follows: Digit Span (experimental = 9.1250, control = 11.1304, P = .0017); Vocabulary (experimental = 10.6250, control = 12.3913, P = .0072); Picture Completion (experimental = 12.8125, control = 11.1304, P = .0124); and Mazes (experimental = 9.9063, control = 12.5217, P = .0001). The control group performed at a higher level on all of these subtests except Picture Completion. None of the other WISC subtests was significant. (Object Assembly was not administered.) The Digit Span subtest which is interpreted as measuring immediate or short term auditory memory is significantly correlated with several auditory variables as evidenced in Table 12 (see variable 2). Since the experimental group is deficient on a number of auditory measures it is not unwarranted to consider Digit Span as measuring an auditory function. This is discussed more completely in the subsection below titled Auditory.

Depending on one's theoretical frame of reference, several explanations may account for the experimental group's poorer performance on the Vocabulary subtest. The most obvious interpretation is a quantitative one wherein the disability in reading itself discourages the child from reading and that the lowered vocabulary is directly related to the amount of material read. This assumes that the more a child reads the greater is the vocabulary level. A second explanation pertains to a general verbal-cognitive deficiency in responding to, integrating, and expressing verbal synbolic language. Benton (1962b) discussed this type of difficulty in relation to specific dyslexia. In a more general sense the work of Osgood (1957a, 1957b) and McCarthy and Kirk (1961), concerning psycholinguistic functions, is applicable to this discussion.

The results of the Picture Completion subtest were not anticipated since this phenomenon had not been mentioned in the literature in relation to dyslexia. One possible explanation for the superior performance by the experimental group is that children with dyslexia compensate for the disability by noting details in the pictures that accompany reading material. In this sense, they learn to carefully note pictorial details, a requirement which is basic to Picture Completion.

Of the measures involving the WISC, the Mazes subtest was the most significant in indicating poor performance on the part of the experimental group (see variable 10, Table 5). Further consideration of this is deferred to the section on Visual Perception.

Clinical researchers who evaluate children with dyslexia and other reading disabilities frequently report that these children achieve low scores on the WISC Coding subtest. This study did not find a significant difference between the two groups on this subtest. The mean scaled scores are experimental = 9.9688 and control = 10.6087, with P = .3424. This writer has no explanation for this finding except to say that some clinical hypotheses are not validated under experimental conditions involving control groups.

In summary, five of 16 measures (31.25%) on the WISC were significant, as indicated in Table 9. The results obtained are additional proof of its value in diagnosis and research.

Visual Perception

Thirteen measurements were made in this area involving the following tests: Minnesota Percepto-Diagnostic Test (MPD) (Fuller & Laird, 1963b), Raven's Coloured Progressive Matrices (Raven, 1956); Primary Mental Abilities-Perceptual Speed, Spatial Relations, and Figure Grouping (Thurstone & Thurstone, 1962); Benton's (1955) Visual Retention Test-Visual Motor Reproduction, Immediate Recall, and Delayed Recall; and Letter Recognition Test. Only two of these 13 measures were significant; namely, Benton's Visual Retention Test-Delayed Recall and the Letter Recognition Test. The experimental group performed at a lower level than the control group on these two tests at the following respective levels of significance: $P = .0261$ (variable 36, Table 5) and $P = .0594$ (variable 2, Table 6). As previously stated, the Letter Recognition Test was arbitrarily classified as significant so that it could be included in the additional statistical analyses in this study.

Divided opinion on the role of visual perception was mentioned in Chapter II. Considering the age and intellectual level of the children in this study, the results agree with those writers who do not consider dyslexia as a pervasive visuoperceptive disorder (Benton, 1962b; Fuller, 1964; Rabinovitch, 1962). Benton presented a tenable hypothesis that the role of form perception in dyslexia, for older children with adequate intelligence, had been rather exaggerated: and Fuller presented experimental evidence that visual perception in regard to directional orientation was not related to dyslexia. This is not tantamount to saying that no deficiency in visual perception is associated with dyslexia. After a child with dyslexia has reached or passed the sensory-motor developmental asymptote, visual perception, as conventionally measured by geometric figures, probably is of minimal influence.

The conclusion that disordered visual perception is not related to dyslexia past a certain age level may not necessarily be true when visual perception is involved in or associated with verbal-cognitive functions. For example, the results of the Letter Recognition Test do suggest some difficulty in visual perception. In this test the child selects a given letter from among several, a perceptual configuration that constitutes a symbol. The psychological process involved in this test is probably a less "pure" visual perceptual process than that needed in responding to the MPD Test (Fuller & Laird, 1963b) and the three subtests on the Primary Mental Abilities Test (Thurstone & Thurstone, 1962). By way of illustration, a dyslexic child could correctly perceive and copy a letter as a pattern, in the manner of the Bender

Gestalt test. The pattern's identity as a letter, however, involves more than perceptual processes. Identifying alphabetic letters is not simply perception; it is cognition.

The results from Benton's (1955) Visual Retention Test-Delayed Recall are considered in relation to Money's (1962) discussion of visual memory and cognition. Money considered the possibility that the child with specific dyslexia is a nonvisile cognitional person weak in visual imagery and visual memory, as contrasted with one who has eidetic memory. On the Benton test, the significantly poorer performance by the children in the experimental group suggests that they are weak in nonverbal visile memory. Since the Benton test consists of geometric stimuli, the process it purports to measure is nonverbal in nature. Whether this is related to poor verbal visual memory, e.g., recognition and recall of words previously learned, is not known. A more appropriate measure of verbal visual memory could be achieved by an experiment involving sensible words on a memory drum.

The results from the Primary Mental Abilities (Thurston & Thurston, 1962) subtests were nonsignificant. The perceptual speed subtest, however, tended toward significance (P [illegible] .0856, variable 11, Table 6). Kass (1962) found that her group of children, ages 7-0 to 9-11 in grades two, three and four, was significantly below average on this subtest. She compared the results of her 21 children with a theoretical population mean (z test). The difference between these two reports may be related to a mean age difference and an intellectual difference. Since Kass did not use a control group, there may be additional variables peculiar to her sample of children that could account for the differences in these findings. The relation of perceptual speed to specific dyslexia should, however, remain an open question until additional, more conclusive research is reported.

The Coloured Progressive Matrices (Raven, 1956) did not distinguish the two groups (P = .3162). As Raven (1963) described this instrument, it is "a test of observation and clear thinking . . ." in which the stimulus material is arranged "to assess the chief cognitive processes . . . (p.3)." Principles of Gestalt perception are involved as the subject apprehends "discrete figures as spatially related wholes and (analyzes) them into their components . . .(p. 24)." Thus, this is a cognitive nonverbal visual perception test. These statements by Raven suggest a similarity between the Matrices test and the subtests on the Primary Mental Abilities test, in contrast with the Letter Recognition Test. The results of the experimental and control groups on the Matrices test support the hypothesis that cognitive visual perception, in relation to geometric figures (nonverbal stimuli), is not a deficit characteristic of the experimental group. On the other hand, a deficit in cognitive visual perception, in relation to verbal or verbal symbolic stimuli, is postulated. This statement, when considering the findings on Benton's (1955) Visual Retention Test-Delayed Recall, implies that nonverbal visile cognition is not the deficit characteristic involved in this test. Rather, it indicates that a deficit in memory is the reason that the experimental group performed less adequately than the control group on the Benton test. The problem in discussing the role of visual cognition in specific dyslexia is the lack of an agreed-upon operational definition of the term. It is suggested that future consideration of visual cognition be made in regard to the types of stimulus material utilized in assessment, whether it be geometric figures, and the like, or verbal stimuli, as in the Letter Recognition Test.

The Mazes subtest of the WISC is discussed under the rubric of Visual Perception since it seems to bear more relation to it than to verbal cognitive intellectual factors, even though it is classified in Table 7 with the intellectual measures.

Kass' (1963) description of the Mazes subtest indicates that it measures a type of visual-motor predictive process. Observations in the present study on how the children in the experimental group performed on this subtest indicates that at least two processes are involved, a visual-motor coordination factor and a Gestalt cognitive map factor, to use Tolman's (1951) term. Wechsler (1949) described three types of errors made in this subtest, two of which seem to reflect these two factors; namely, crossing any line that forms the boundary of the maze, and entering into a major blind alley. The former is a visual-motor error and the latter pertains to a cognitive map of what-leads-to-what. Some of the children in the experimental group were able to find their way through the mazes, but in so doing made a number of errors in crossing the boundary lines. Others were entirely unable to find their way out of the mazes within the time limits of the subtest. They characteristically would trace and retrace erroneous solutions to the problem. The interpretive meaning of this subtest, in regard to the experimental group, is obscured by the two types of processes involved in its performance. In studying children with dyslexia, it is suggested that three scoring systems be used: the original system in Wechsler's manual (1944), one based on motor incoordination errors; and one based on entering blind alleys. This would allow for a differential analysis of the problems associated with the solving the Mazes subtest and the relation they have with specific dyslexia.

In summary, two out of 13 (15.38%) visual perceptual tests significantly differentiated the experimental from the control group and several tests tended toward significance (see Table 9). All of these measures may be viewed from the context of cognitive mediating processes and/or visual perception. The relation of visual perception to dyslexia, however, is more meaningfully understood in relation to age. Younger children with assumed dyslexia may manifest considerable difficulty in visual perception, whereas older children may be viewed as having more trouble with visual cognitive difficulties rather than visual perception.

Auditory

This category produced a very high proportion of significant variables--58.33% (see Table 9). Two auditory variables tended toward significance, Sound Localization and Pitch (see Table 6). All of the significant variables, with the exception of Auditory Intrasensory Integration--which later statistical analysis revealed to be more of a spelling measure--and Auditory Blending, involve various forms of auditory discrimination i.e., rhythm, time, tonal memory, and loudness. All of these are from the Seashore Measures of Musical Talent (Seashore et al., 1960). The only subtest from the Seashore battery that was not significant or did not tend toward significance was Timbre.

The findings from the Seashore test substantiate reports in the literature that indicate a relation between dyslexia and auditory discrimination. There is little doubt, in view of cumulative research, that auditory dysfunction is a characteristic of children with dyslexia. The relation of auditory dysfunction to retraining is another question, a relation which has not been experimentally studied in dyslexic children. As Waites (1965) stated, children with specific dyslexia who are quite deficient in the auditory channel appear to be more resistive to retraining than those not manifesting extensive deficiencies in auditory discrimination.

The Digit Span subtest on the WISC also differentiated the experimental group from the control group, the latter performing at a higher level. This subtest is viewed as measuring an auditory function, namely, immediate auditory memory and/or an ability to cope with auditory sequencing stimuli. This assumption is made as Digit Span is significantly correlated with several auditory variables.

The absolute difference between digits correctly recited forward and digits correctly recited backwards was an additional computation performed with the Digit Span subtest. Poorer performance on digits recited backwards has been considered as an indication of cerebral dysfunction or brain damage. The absolute mean difference between digits recited forward and backwards for the experimental and control groups is 1.8438 and 1.6087 respectively with P = .3968. (No child in either group recited more digits backwards than forwards.) This nonsignificant difference indicates that this computational operation was of no value in differentiating the experimental group from the control group.

The experimental group was significantly below the performance level of the control group on the Auditory Blending Test (P = .0075, variable 27, Table 5). The auditory variables on the Seashore test pertain to auditory discrimination of likeness (sameness) and difference, whereas the Auditory Blending Test is more a measure of auditory integration than discrimination. The latter test involves the ability to blend or integrate temporally spaced auditory sounds. This finding agrees with a number of other reports that indicates that poor readers are deficient in auditory blending ability.

The results of auditory measurements suggest that the experimental group had more difficulty than the control group in several aspects of auditory functioning; namely, auditory discrimination, immediate auditory memory, and auditory blending. In addition, Sound Localization tended toward significance (see Table 6). The number and variety of auditory measurements found significant in this study imply that auditory dysfunction is a significant characteristic of the experimental group. Generalization from this study to the population of children with dyslexia is warranted in view of other studies that report similar results.

In concluding this discussion, one may state that considerably more attention should be given to auditory variables associated with dyslexia. Perhaps the influence of visual perceptual factors has been overemphasized, particularly in the child with dyslexia who has passed the sensory-motor developmental asymptote, and has overshadowed attention on auditory dysfunction. Language is first learned through the auditory channel. So is reading. If this primary channel is defective in some functional manner then whatever is later added to the learning process, for example visual perceptual training in reading, will be restricted in its effectiveness by defects associated with auditory reception and integration of sensible sounds and sound patterns.

Speech

None of the speech variables significantly differentiated the two groups in this study; specifically, articulation--total number of sounds correctly produced or total number of a group of defective sounds found significant by Jordan (1960)--and diadochokinesis (total number of left-right tongue movements during a 10 second interval and rhythm of left-right tongue movements). Notice is taken of the fact, however, that others have found a relation between speech problems and dyslexia (Cole & Walker, 1964; de Hirsch, 1963b; Hardy, 1962; Ingram, 1959; Orton, 1928; Rabinovitch, et al., 1954). These studies may reflect a nonsignificant correlation because most of them were clinical studies rather than experimental. However, the question should remain open and subjected to additional experimental research.

Lateral Dominance

Two out of 10 measures in this area were significant as follows: Dominance-Foot (the experimental group is left footed) and Dominance-Incomplete Handedness. The first is significant with P = .0089 (variable 29, Table 5) and the second tended toward significance with P = .0575 (variable 1, Table 6). The latter measure was arbitrarily classified as significant since it was very close to the conventional .05 level. (For clinical reasons it was included with the significant variables for additional statistical analysis since it is frequently mentioned in the literature as related to dyslexia.) For additional information on the 10 measures or classifications of lateral dominance, see Chapter III, Harris Tests of Lateral Dominance.

In Chapter II it was reported that some consider the theory of lateral dominance basic to dyslexia and that a number of investigators have presented research supporting this view. Four measures in this study focused upon this issue: right lateralization (complete or incomplete), left lateralization (complete or incomplete); cross dominance; and complete lateralization, regardless of the side lateralized. None of these measures significantly differentiated the experimental group from the control group. It is possible, however, to infer some form of incomplete lateral dominance in the experimental group. Dominance-Foot (variable 29, Table 5) and Dominance-Incomplete handedness (variable 1, Table 6) were significant and Dominance-Incomplete Footedness (variable 12, Table 6) tended toward significance.

This study tends to de-emphasize the importance of concepts related to lateral dominance in children with dyslexia.

Following the suggestion of Zangwill (1964), it may be more appropriate to speak of peripheral lateral dominance or lack of peripheral lateral dominance. Further discussion of this issue is presented in the section on factor analysis.

Right-Left Discrimination

None of the four measures of right-left discrimination was significant: subject's execution of examiner's commands; subject's verbal description of pictorial stimuli. The respective levels of significance for these measures are P = .4562, .2332, .2533, and .9327.

These findings support Benton's (1962b) review of the literature on directional sense. He said that the importance of this variable had been overemphasized in older children with dyslexia who have adequate intelligence. Although it is impossible to make a direct comparison with Harris' (1957) findings, since they are in percentages, nevertheless the results of the present study may be considered comparable to his. He found only 6 percent of a sample of children with reading disabilities to be deficient in right-left discrimination. As is the case with a number of neuropsychological variables reviewed and studied in this research project, the age of the child with dyslexia is crucial to whether or not problems of right-left discrimination are present.

Finger Localization

Finger localization or the problem of finger agnosia has often been discussed in relation to the Gerstmann syndrome (Gerstmann, 1940). The relation of finger agnosia to dyslexia has received limited attention in the experimental literature; however, it was included in this study at the suggestion of Benton (1964). Two of the three measures on the Benton Finger Localization Test were significant, as presented in Table 5; namely, combined score of correct responses for single and double simultaneous stimulation ($P = .0422$, variable 38), and correct responses to double simultaneous stimulation ($P = .0445$, variable 40). There was no significant difference between the two groups on single stimulation. The statistical importance of finger localization to dyslexia is not clear at this time since it appears to be primarily an isolated function unrelated to the other variables in this study. Substantiation of this is seen in Table 12 where finger localization does not correlate significantly with any other variable. (The two measures of finger localization do, however, correlate significantly with each other.)

Neurological Examination

Three out of 41 variables (7.32%) in the neurological examination significantly differentiated the two groups (see Table 9). These variables and their levels of significance are listed in Table 5. The variables are Apposition of Thumb and Fingers (variable 9), Approximation and Abduction of Fingers (variable 18), and Supination and Pronation of Hands (variable 19). These variables are measures of hand and finger fine muscle coordination. They indicate that the experimental group evidenced motor incoordination to a significant degree. Five measures of the lower extremities were not significant and thus did not reveal motor incoordination.

A number of authorities have agreed that no consistent neurological pattern is associated with dyslexia (Benton, 1964; Birch, 1964a; Drew, 1956; Waites, 1965). Some writers have interpreted "soft" neurological signs as indicative of minimal brain damage in children with specific dyslexia or other reading disabilities. This assumption appears to be unwarranted in view of current criticism in the literature, which questions the validity of such an assumption (Birch, 1964b; Cohn, 1964). The present study supports the view that neurological variables associated with a central nervous system lesion are not present in children with specific dyslexia, whether these variables be "soft" or otherwise.

One may conclude from the neurological examination that the experimental group evidenced significant motor incoordination in the upper extremities. No other variables in the neurological examination significantly differentiated the two groups. The results of this study would argue against the assumption of a relation between specific dyslexia and brain damage or minimal brain damage Acceptance of the null hypothesis is, therefore, warranted.

EEG

None of the 18 measures--9 wake and 9 sleep tracings--significantly differentiated the two groups. This is in keeping with the results of the neurological examination in this study and is further substantiation of lack of a relation between specific dyslexia and brain damage. Although Money (1962) stated that positive EEG findings were not routinely produced from EEG tracings, Benton and Byrd (1963) did report that some studies indicated positive EEG findings associated with reading disability. The use of a control group in this present study may explain why no significant findings were produced. Another possible explanation for the lack of agreement between this and other studies which report positive findings is that the neurologist who interpreted the tracings in this study was trained in pediatric neurology. Some of the other investigators who have interpreted EEG tracings may have been adult neurologists and this may account for the difference. The relevance of this factor should at least be considered since the norms for normal and pathological EEG tracings for children and adults are, to some degree, different.

Medical History

One out of 27 medical history variables (3.70%) was significant in this study (see Table 9). It is Crawling (variable 23, Table 5). This finding is more indicative of late motor development rather than generalized motor disability, since it is not significantly correlated with current neurological assessment of motor function. (See Table 12 for a listing of the significant correlations with variable 32, Crawling). It is not significantly correlated with upper and lower motor extremities nor with handwriting, a motor variable which significantly differentiated the two groups. One may conclude that the children in the experimental group were "late bloomers" in generalized motor development and that this is unrelated to present motor functioning.

As discussed in Chapter II, a number of investigators have presented evidence of a significant correlation between medical history factors (prenatal, paranatal, and postnatal) and reading difficulty. The negative results in this study concerning the relation between natal factors and dyslexia are not necessarily in conflict with other studies if one can assume that different samples of children with reading disabilities were studied. There is the possibility that studies demonstrating significant medical history variables were done with children who incurred brain damage during one or another phase of their natal development. The children in the present study were prescreened, i.e., no children were included in the experimental group who had a history of brain damage or who manifested current medical signs of brain damage. Children in these other studies were not prescreened or prediagnosed in terms of ruling out signs of brain damage. They were selected from a more heterogeneous population representing reading disability in general. This present study, therefore, failed to confirm an antecedent-subsequent relation between natal variables and dyslexia.

Familial History of Language Disability

More explanatory attention has been given to a genetic basis for specific dyslexia than any other single hypothesis.

The results of this study confirmed this view. Eight out of 18 measures (44.44%) in this area significantly differentiated the experimental group from the control group, the difference indicating a familial history of language disability for the experimental group (see Table 9). Two variables tended toward significance and are presented in Table 6 (see variable 5 and 7). Five of the significant variables pertain to males (four father and one brother) and three pertain to mother (see Table 7).

Most incidence studies report more males are involved with specific dyslexia than females. This study suggests that the mothers manifest a history of reading disability equally with the fathers. Suspicion is cast on the results of this study in view of the preponderance of evidence to the contrary in other studies. The children in the experimental group were diagnosed six months to a year before their selection for participation in this study. In addition, some of the mothers had received non-technical literature on dyslexia. Interest in their child and attention to his struggles with educational difficulties may have contributed to a hypersensitivity to his learning problems and especially to dyslexia following the diagnosis of the condition. This is to suggest that the mothers may have been overly sensitive to their own nominal or nonsignificant difficulties in reading. This may explain why the results of this study showed a familial history of reading difficulty in the mothers. (The family history information was obtained from them in the interview situation.) Clinically speaking, there was no doubt in the interviewer's opinion concerning information on the familial problems associated with the fathers. This was not necessarily true in the case of the familial history of the mothers in the experimental group, even though their verbal responses indicated reading problems. The mothers' responses to the other items in the familial history (handwriting, laterality, directional orientation, motor coordination, speech, and siblings) were specific and concise and no question is raised concerning their validity.

The findings concerning siblings of the children in the experimental and control groups indicate that brothers of the children in the experimental group have significantly more language problems than do the brothers of the control group children. No significant difference was found for the sisters of both groups of children ($P = .1182$). If, as indicated in this study, the mothers in the experimental group are involved equally with the fathers in reading disability, one would expect this finding to be present in their daughters. Lack of verification of involvement on the part of their daughters may be interpreted as lending support to the reasoning developed above.

Other areas of the familial history revealed a difference between the parents of both groups. Mothers of the experimental group were inferior on Directional Orientation (P = .0002, variable 15, Table 5). The manner in which these mothers described their directional disorientation illustrates this. Many of them reported in the interview that it was necessary for them to recite the four points of the compass in order to locate themselves spatially when driving only a few miles away from home. This behavior was not, however, reported by the mothers in the control group. There was no significant difference between the fathers of both groups on Directional Orientation (P = .1182).

The fathers in the experimental group were significantly deficient on Motor Coordination (P = .0478, variable 41, Table 5). This was reflected in the interview as a generalized awkwardness or clumsiness. There was no significant difference between the mothers on this variable.

The results of the Familial History of Language Disability imply that the fathers and mothers in the experimental group are deficient on similar measures and also deficient on dissimilar measures. Both are deficient in Reading. The mothers, but not the fathers, are deficient on Directional Orientation. The fathers, but not the mothers, are deficient on Spelling and Motor Coordination.

In concluding this discussion, it is suggested that a more definitive approach to the question of a genetic basis for specific dyslexia may be found in evaluating the parents of an experimental and control group by utilizing standardized measurement instruments rather than by means of an interview. The interview permits interviewer and interviewee bias, particularly where subjective interpretation of the data is the basis for judgment. The interview is at best only an approximation to the problem, and in clinical practice it may be the only practical approach. Possibly a more structured interview schedule would produce more reliable and valid information.

Other than improving the interview, it is recommended for research purposes that parents of children with dyslexia be evaluated in terms of a familial history of language disability.

Statistical Characteristics of the Experimental Group

This discussion pertains only to the statistical analysis of the experimental group. This involves intercorrelation and principal axis factor analysis with verimax rotation.

<u>Intercorrelation of Significant Variables</u>

As shown in Table 12, the following measurements have more variables correlated with them than do the other measurements: WISC Verbal Scale IQ (variable 1); WISC Vocabulary (variable 3; Alphabet-Verbal (variable 8); Wide Range Achievement Test-Spelling (variable 11); Wide Range Achievement Test-Reading (variable 12). Gilmore Oral Reading Test-Accuracy (variable 14); and Rhythm (variable 19). The greater number of intercorrelations with these measurements may reflect the preponderant number of variables in the intellectual, language, and auditory areas. It may also indicate that these specific measurements are more closely related to the other variables than the measurements with fewer correlations.

The correlation between intelligence and reading ability has been well established in educational research. This is not always, however, a one-to-one relationship, particularly in certain subcategories of reading disability. The results of the WISC Full Scale IQ demonstrated no significant difference between the experimental group and the control group.

One may assume from this finding that the problem of dyslexia in the experimental group does not result from a generalized condition of low intelligence. (See Table 4 in Chapter III for the means of the two groups and the probability level.) The association between verbal ability, concept formation, verbal mediation, verbal cognition, and dyslexia is another question.

Clarification of the relation between verbal abilities and dyslexia may be gleaned from the intercorrelations presented in Table 12. The two measurements reflecting the highest degree of verbal ability in this study were Verbal Scale IQ (variable 1) and Vocabulary (variable 3). These measurements were significantly correlated (positively) with each other. They jointly correlate with several variables· Reading-Mother (variable 34); Spelling-Father (variable 35); and Gilmore Oral Reading--total errors/total number of words read (variable 43). Variables which correlate either with the Full Scale IQ or the Vocabulary are as follows: Wide Range Achievement Test-Reading (variable 12), Reading-Father (variable 33), and Overall Judgment-Mother (variable 39). The former two variables do not correlate significantly with the majority of reading variables: Gilmore Oral Reading Test-Accuracy (variable 14); Gilmore Oral Reading Test-Comprehension (variable 15); Iowa Silent Reading Test (variable 16); Gilmore Oral Reading Test--substitution errors/total number of words read (variable 41); and Gilmore Oral Reading Test--number of words read (variable 42). This is surprising because a deficiency in verbal ability, concept formation, verbal mediation, or verbal cognition has frequently been postulated as a basic factor in dyslexia. If this is a correct postulation for most older children with dyslexia whose intelligence is adequate, then one would expect this to be demonstrated in positive and significant correlations between verbal ability (Verbal Scale IQ and Vocabulary) and reading ability. Such, however, was not the case in this study.

In view of these findings it is reasonable to question the assumption that a verbal deficiency is a pervasive characteristic of dyslexia. A converse statement is offered for consideration: A verbal deficit is not necessarily characteristic of most children with dyslexia. Or, to state it differently, some but not all children with dyslexia are deficient in verbal mediating ability. The validity, or at least heuristic value, of this consideration is tenable in so far as this study is concerned, since three types of subgroups of dyslexia were discovered by the hierarchical grouping analysis procedure. One group was low in verbal ability and one group was high in verbal ability.

Returning to the intercorrelations in Table 12, the WISC Digit Span subtest (variable 2) is significantly (positively) correlated with three variables, all of which are auditory measures: Rhythm (variable 19); Time (variable 20); and Tonal Memory (variable 21). It is not, however, significantly correlated with other auditory measures, e.g., Loudness and Auditory Blending. There is little doubt that Digit Span is a measure of auditory functioning for the children with dyslexia in this study.

Additional discussion of the 43 significant intercorrelated variables in Table 12 is deferred to the following section on factor analysis. The factor analytic structure presented in Table 13 reduces the complexity associated with a discussion of these variables.

Principal Axis Factor Analysis with Varimax Rotation

As previously stated, the primary purpose of the factor analysis was to derive important loadings from the 43 significant variables for use in the hierarchical grouping analysis procedure. A brief discussion of the 14 factors presented in Table 13 will, however, add to our understanding of the experimental group in particular and of dyslexia in general.

Factor I in Table 13 is definitely a familial one involving the father. The three important loadings pertain to reading (variable 33), spelling (variable 35), and Overall Judgment of language disability (variable 38). This is in keeping with incidence studies which have demonstrated a higher ratio of males to females and with studies which have shown a correlation of reading disability between male children and their fathers. As Money (1962) stated, there is a sex difference in children with dyslexia and although the ratios vary from one study to another, it is generally accepted that the male incidence is at least twice that of the female. Other estimates have been considerably higher.

Factor II in Table 13 is composed of several different test variables, two reading measures (variable 12 and 16) and two spelling measures (variables 11 and 23). The fifth important loading in this factor is a familial history variable involving directional orientation on the part of the mother. One can understand the relation between Wide Range Achievement Test-Spelling (variable 11) and the Auditory Intrasensory Integration Test (variable 23). The latter in effect is a spelling test wherein the examiner spells a word and the child integrates the separate letters into a whole word. (The name of the test was selected prior to this study as it appeared to describe the process involved in its performance.) In Table 12 it is not significantly correlated with any of the auditory measures nor are any auditory measures present in Factor II, except the Auditory Intrasensory variable. Of the two reading variables, one measures word attack skills (variable 12) and the other measures comprehension in silent reading (variable 16). The former is essentially a measure of skill in syllabication, particularly in regard to the more difficult words where sight vocabulary is of little help. There appears to be a relation between this function of reading (syllabication) and spelling, especially with regard to the more difficult words which a child has to "sound out" to himself before being able to spell. This assumption is substantiated by the significant correlation between syllabication (variable 12) and spelling (variable 11), as shown in Table 12. Silent reading and lack of directional orientation for the mother (the negative loading indicating the presence of a familial history disability) do not on the surface seem to be meaningfully related to these other variables. Notwithstanding this, one may say that Factor II is primarily a spelling factor involving various aspects of the spelling process.

The importance of Factor II needs to be emphasized in view of the fact that some, but not all, investigators have indicated that a spelling disability is central to specific dyslexia. As in the case of auditory functioning, neglect of the spelling variable may have hampered our efforts in constructing more adequate theories about dyslexia. For example, in Table 12, Wide Range Achievement Test-Spelling (variable 11) was significantly (positively) correlated with Handwriting, variable 17. For the most part, poor handwriting has been considered a manifestation of poor motor coordination and such may be the case, even though none of the neurological variables involving hand coordination were significantly correlated with handwriting. A consideration of the interrelation between spelling and handwriting may facilitate the development of improved methods of language retraining in these two areas. For example, a child who evidences early difficulties in writing letters and words may need to overlearn visual and auditory recognition of letters and overlearn the spelling of words in verbal recitation before attempting to write words. The poor writing may reflect uncertainty in spelling, a process that precedes the recording of the word on paper. Regardless of the line of reasoning one may pursue, the emphasis should be on a reconsideration of how a disability in either spelling or handwriting may influence one another in learning.

Factor III in Table 13 is finger localization and its important loadings are two measures on Benton's (1955) Finger

Localization Test. The purity of this factor is indicated by the few measures significantly correlated with it (see variable 27 in Table 12). Variable 28 in this table, which is the combined scores for single and double stimulation, is correlated only with the single stimulation subtest. Factor III, in reference to the experimental group, is considered to be a finger agnosis factor.

Factor IV in Table 13 contains important loadings from the neurological examination. All of these involve fine motor coordination of the hands and fingers. This factor indicates that generalized motor disability is not characteristic of the experimental group. (This is the only factor with neurological variables.) Factor IV, therefore, pertains to fine muscle coordination of the upper extremities.

Factor V in Table 13 is an auditory factor composed of two subtests from the Seashore Measures of Musical Talent (Seashore, et al., 1960)--Rhythm (variable 19) and Time variable 20)--and the WISC Digit Span subtest (variable 2), a measure that has been previously described as an auditory function. The loadings in this factor, and the significant correlations with the Digit Span subtest, clearly establish the Digit Span subtest as a measure of auditory function in the children in the experimental group. Tonal Memory, which is significantly correlated with Digit Span in Table 12, is not a component of Factor V. Tonal Memory is an important loading in Factor XIII. Factor V may involve a memory component and/or an auditory sequencing component, both of which appear to be characteristic of Rhythm and Digit Span. These two components are not an aspect of Time, an auditory discrimination judgment that compares the relative length of two auditory signals.

Factor VI in Table 13 contains two lateral dominance measures and one delayed visual retention measure. The dominance measures are Dominance-Foot (variable 25) and Incomplete Handedness (variable 26). These measures indicate that the children in the experimental group are left footed and that either their left or right hand is incompletely dominant. On the 10 measures of the Harris Test of Lateral Dominance the children did not use the same hand for all 10 activities pertaining to the use of their hands. One may imply a lack of peripheral lateral dominance when considering these variables together. Why Factor VI is heavily loaded with a delayed visual retention measure is not clear. (This variable measures visual retention of geometric figures. The child is shown the geometric figures and, after a 15 second delay during which time he does not see the figures, he reproduces the figures on paper.) Nevertheless, Factor VI is described as incomplete peripheral dominance. This is not necessarily the same as central (cortical) illateralization (Zangwill, 1964).

Factor VII in Table 13 contains three unrelated test measures· Picture Completion (variable 4); Auditory Intrasensory Integration Test (variable 24); and Crawling (variable 32). The highest loading is Picture Completion and for this reason Factor VII is viewed as reflecting the inherent characteristics of this subtest as described by Wechsler (1944):

> Ostensibly it measures the individual's basic perceptual and conceptual abilities insofar as these are involved in the visual recognition and identification of familiar objects and forms (p. 90).

The superiority of the experimental group on Picture Completion is contraindication that visual agnosia is characteristic of specific dyslexia. There is no reason to assume that superior visual perception for meaningful objects is inherent in children with dyslexia. Rather, this finding suggests that the experimental group developed a compensatory mechanism for poor reading ability.

Factor VIII in Table 13 contains the measures of the alphabet (variables 8, 9, and 10) and the measure of Motor Coordination-Father (variable 37). The highest loading is variable 10, Alphabet-Total (verbal and written scores combined). The meaning of Factor VIII depends upon the assumptions one postulates about the process or processes involved in reciting and writing the alphabet. A sequential memory process is one aspect of reproducing the alphabet, whether it be verbal-auditory or subvocal-graphic. The types of errors made by the experimental group reflect a sequencing memory disability. All of the written errors, with few exceptions, were errors of incorrect sequential placement of the letters or errors of omission. The few exceptions were rotational errors, such as found in a "z" rotated 180 degrees. The combination of these types of errors indicates a deficiency in memory and sequencing ability. Most of the errors in verbal recitation of the alphabet were omission errors.

Occasionally, reference has been made in the literature to the relation of reading disability and/or specific dyslexia to sequencing ability. For example, Kass (1963) found that her sample of children with a severe reading disability had difficulty on the Visual-Motor Sequential subtest of the Illinois Test of Psycholinguistic Abilities. This subtest measures the ability to reproduce from memory a series of pictures of objects or geometric symbols presented visually. Although this subtest is different from the reproduction of the alphabet, the sequencing factor is similar. It is not certain whether the recitation of the alphabet and the writing of it are dependent upon memory or sequencing or both. Additional research is needed to clarify this question.

Factor IX in Table 13 is clearly an oral reading factor, the loadings of which come from the Gilmore Oral Reading Test, as follows: Accuracy (variable 14); Comprehension (variable 15); substitution errors/total number of words read (variable 41), and number of words read (variable 42). Oral reading tests generally measure three separate processes in reading; namely, accuracy, comprehension, and rate. These measures are employed in diagnosing cases of reading disability. Factor IX indicates that there is little difference between accuracy and comprehension, the implication being that one measure is as useful as the other in determining a disability in oral reading. Reading rate is not included as an important loading in this factor nor is it included in any of the other factors. Since it is not factorially similar to accuracy and comprehension, it may be clinically useful in a differential diagnosis of reading disability. If one loading in Factor IX were selected as a single measure of oral reading deficiency in the experimental group, it would be accuracy since it has the highest loading.

The Mazes subtest on the WISC is the only important loading in Factor X in Table 13. The problem of deciding whether this subtest reflects a motor coordination ability or a cognitive perceptual-motor predictive ability is undecided since there are no other important loadings in Factor X from which to draw additional information. The cognitive predictive hypothesis may be elaborated as reflecting a visual motor directional orientation (or spatial orientation) factor. In order to present jointly the apparently dissimilar hypotheses of coordination and orientation, Factor X is described as a visual motor coordination and planning ability in Table 16, the table listing the designations of the 14 factors.

Factor XI in Table 13 encompasses two dissimilar measures; namely, Letter Recognition Test (variable 6) and Subjects' Brothers with Specific Dyslexia (variable 40). Variable 6 is the higher of the two loadings and it is viewed as a verbal perceptual-cognitive measurement. Since this measure is the higher of the two loadings, Factor XI is assumed to reflect a verbal perceptual-cognitive function.

Factor XII in Table 13 pertains to the familial history of the mother; Reading (variable 34) and Overall Judgment of a language disability (variable 39). As mentioned previously, certain experimental design problems may be associated with the findings that the mothers present a history of language disability. No discussion, therefore, is made for Factor XII.

Factor XIII in Table 13 is the second factor concerning auditory variables (see discussion of Factor V). Factor XIII involves Loudness (variable 18), Tonal Memory (variable 21), and Auditory Blending (variable 22). The last is negatively related to the other two variables, i.e., those who score high on Loudness and Tonal Memory score low on Auditory blending. The two positive loadings suggest that this is an auditory discrimination factor.

Factor XIV in Table 13 is primarily a verbal-cognitive, concept formation, or verbal mediation factor, since the three highest loadings are Verbal Scale IQ (variable 1), Vocabulary (variable 3) and total number of errors/total number of words read (variable 43). The fourth important loading, Handwriting (variable 17), is negatively related to these variables. This negative relation is due to the nature of the scoring system for Handwriting; it demonstrates that good handwriting is correlated with a high performance on the Verbal Scale IQ.

Handwriting ability, therefore, may involve more than ability in eye-hand coordination.

The 14 factors and their important loadings, as indicated in Table 14, are summarized in Table 16. A descriptive title is given to these factors. For the most part, importance was given to the highest loading within each factor in deriving these titles. This procedure admittedly is somewhat arbitrary, but it represents an approximation to the structure of each factor.

Syndrome Patterns of Specific Dyslexia

The results of the hierarchical grouping analysis and the analysis of variance answered the second question posed in this study: What arethe subgroupings or clinical syndrome patterns within the category of dyslexia? The analysis of variance of 14 selected variables on which the three subgroups of children within the experimental group were compared (the three subgroups were identified by the hierarchical grouping analysis procedure) gives credence to a diagnostic consideration of types of dyslexia. In terms of this study, the children with dyslexia are measurably different from normal readers, and they cluster into three syndrome patterns on variables that distinguish them from the control group.

Two major considerations are present in discussing the results of the analysis of variance of the three subgroups. The first consideration pertains to the likeness or homogeneity of the three subgroups and the second consideration pertains to the difference or heterogeneity of these groups.

An understanding of the ways in which children with dyslexia are alike is as important to the construction of theoretical models as is an understanding of the ways in which they are different. Discussion of this first consideration is in reference to the nonsignificant groups $\underline{F}$ ratios in the analysis of variance (see Table 18).

The variables in Table 18 on which the three syndrome patterns are similar (nonsignificant groups $\underline{F}$ ratios) are as follows: Digit Span (variable 2), Picture Completion (variable 3), Mazes (variable 4), Spelling (variable 7), and Loudness (variable 9). The factorial designation of these variables as set forth in Table 16, are as follows: auditory memory, visual perception of pictorial details, visuomotor coordination and planning, spelling, and auditory discrimination. These factorial designations indicate that the children in the experimental group are similar in the following ways: They are deficient in auditory memory, auditory discrimination, and spelling. They perform poorly on tasks requiring visual motor coordination and/or cognitive planning of what-leads-to-what. Lastly, they are superior in visual perception of pictorial details. These factors or processes, therefore, do not significantly differentiate the three syndrome patterns of specific dyslexia.

The second consideration pertains to the ways in which the children in the experimental group differ. Some leniency is taken at this point, as all variables whose *F* ratios tended toward significance (.06 to the .10 level) are included with the significant variables (.05 level and less). The significant *F* ratios in the analysis of variance in Table 18 are as follows: Verbal Scale IQ (variable 1), Letter Recognotion (variable 5), Alphabet-Total (variable 6), Gilmore Oral Reading-Accuracy (variable 8), Foot Dominance (variable 10), Benton's Finger Localization Test (variable 11), Approximation and Abduction (variable 12), Overall Judgment-Father (variable 13, and Reading-Mother (variable 14). The factorial designation of these measures as set forth in Table 16, are as follows: verbal mediation, letter recognition, reproduction of alphabet, oral reading, incomplete peripheral dominance, finger agnosia, finger-hand dyspraxia, familial history of language disability-father, and familial history of reading disability-mother.

The statistical discovery of three types of dyslexia is in keeping with a statement by Money (1962). He stated that the diagnosis of specific dyslexia depended upon the clinical appraisal of the configuration of symptoms and test measurements, and not on a single telltale sign or signs. A statistical consideration of types of dyslexia facilitates the clinical configurational approach. It enables the clinician to be more systematic in ordering his observations of the test data.

A configural evaluation of dyslexia associated with the experimental group is seen in Figure 1, page 202. In Figure 2, page 203, only significant variables are used in the profiles for the three dyslexic groups. One of the more interesting findings pertains to Verbal Scale IQ (variable 1) in Figure 1. Group A is significantly lower than Group C on this variable. There is a 14 point difference between the mean Verbal Scale IQ of these two groups (Group A = 99.37 and Group C = 113.71). Although low ability in verbal mediation is frequently assumed to be related to dyslexia, this finding suggests that this assumption is applicable to only a certain proportion of children with dyslexia as the mean Verbal Scale IQ of Group C indicates adequate verbal mediation ability.

The nonsignificant correlation between verbal ability and oral reading proficiency previously discussed is further illustrated in Figure 1. Group A, which is low in verbal ability, is high in oral reading accuracy (variable 8). Group C, which is high in verbal ability, is low in oral reading accuracy.

It is difficult to organize the various variables in Figure 2 into meaningful patterns for the three dyslexic groups. The diversity of these measures and the lack of a comprehensive theory of specific dyslexia necessitates the postponement at this time of an adequate conceptualization of the three groups. An empirical description of these patterns, as presented in Chapter IV, is preferable to speculation.

Generalizations to the population of children with dyslexia from the data concerning the differences between the experimental group and the control group is tenably warranted. Generalizations as to subtypes of dyslexia, however, should be made with caution. Additional research is needed, particularly studies of replication, to substantiate the hypothesis of categories of dyslexia. One may state, however, that this study does give some credence to the assumption that children with dyslexia constitute a heterogeneous group on some variables and a homogeneous group on other variables.

Problems associated with generalizations from this study to the population of dyslexic readers do not preclude the possibility of utilizing the findings as diagnostic guidelines. The following considerations are offered. Dyslexia is not primarily associated with low intelligence, brain damage, cultural deprivation, disruptive or irregular school attendance, substandard educational instruction, poor motivation, and emotional problems of a primary nature. If problems associated with school attendance and quality of educational instruction are present, then careful consideration and weight must be given to these factors and their influence on abilities that directly reflect educational training--reading, spelling, handwriting, and arithmetic computation. This is also true of cultural deprivation; a child may have dyslexia but the diagnostic picture becomes somewhat obscured by the influence of this variable.

The clinical evaluation of an individual suspected of dyslexia should reflect the following characteristics· low Digit Span on the WISC; Picture Completion on the WISC at or above the mean of the Performance Scale IQ; low score on the Mazes subtest of the WISC; poor quality in handwriting. and reading and spelling level one or more years below peers of comparable intellectual ability and educational experience. Furthermore, substandard performance should be manifested in auditory discrimination, particularly the Loudness subtest on the Seashore Test and auditory blending.

A deficiency in oral reading accuracy in a dyslexic individual should be present but reference only to grade level norms can be misleading when evaluating this function. For example, a child with superior intelligence may perform slightly below grade level, at grade level or slightly above grade level. Reference to Table 21 illustrates this. The mean grade level for the experimental group is 4.31 whereas the mean grade for reading is 3.7. This difference of approximately 5 months is not great enough to indicate a disability in reading. When the experimental group is matched with a peer group of comparable intelligence, the deficit in reading ability is more pronounced. The experimental group is one year and nine months below the control group, a difference that is significant.

The problem of determining the presence or absence of dyslexia in reference to grade level norms for bright individuals applies equally well when consideration is given to the children. In Table 21, it is seen that the experimental group spelled at grade level, the conclusion being that there is no deficiency or disability in spelling. However, when the experimental group is compared with a matched group, a significant difference is noted. The experimental group is two years and eight months below the spelling level of the control group.

TABLE 21

Comparison of Reading and Spelling Levels for the Experimental and Control Groups

Group	Mean Grade Level	Mean Reading Level (accuracy)	Mean Spelling Level
Experimental	4.31	3.7	4.0*
Control	4.28	5.6	6.8**

* P = .00005
** P = .00005

In summary, this study indicates that certain guidelines may be established in diagnosing children with dyslexia in reference to age and intellectual norms. This does not apply necessarily to grade level norms of reading and spelling since the level of performance in these skills is influenced by intelligence.

Implications for Research

Specific dyslexia is a complex phenomenon. Clinical-observational studies have advanced our knowledge sufficnently so that it is now possible to conduct meaningful experimental research. Several areas of research are suggested below.

A replication of this study involving the significant variables is needed to clarify problems of reliability and validity. The replication should utilize similar selection criterion variables. A sample of children with different intellectual abilities and at a different grade level may produce different results. The finding that children with specific dyslexia can be classified into subcategories needs additional consideration, particularly in reference to homogeneous and heterogeneous variables as previously discussed.

Apart from the specific findings in this study, there are other areas of research that should be considered. For example, lognitudinal studies of multiple variables could contribute immeasurably to our knowledge about developmental or maturational factors associated with specific dyslexia and other forms of reading problems. Benton and Bird (1963) particularly stressed the value of this type of research.

Somewhat related to longitudinal research is the need for more predictive knowledge about specific dyslexia. This entails identification of variables in kindergarten and first grade children that would predict reading and related disabilities at a later time in the educational experience of the child. This knowledge could assist the educator in planning a reading program for those suspected of a potential reading problem. Much frustration and anguish could be removed for the child, his parents, and his teachers if early detection could be realized, to say nothing of the expenditure of time, effort, and money.

Most research has focused on children with reading disabilities. Research on the adult poor reader is a neglected area in the several professions interested in reading. An adequate diagnostic battery of tests for the adult with specific dyslexia has not as yet been reported in the literature. Moreover, matched group studies of good and poor adult readers would add considerably to our theoretical knowledge about reading problems. This information could assist the diagnostician and educator in planning appropriate methods of reeducation. Although many speed reading courses are currently available, no research has been reported that demonstrates the efficacy of this type of instruction for the adult with specific dyslexia.

Finally, a consideration of reconstructive language training for children with specific dyslexia is offered. Diagnosing specific dyslexia and identifying relevant variables are only the first steps. Most of the dyslexic research is etiological and diagnostic in nature, a fact that probably reflects the interests of the investigators. Those who study the underlying problems of dyslexia are primarily interested in theory, research, and diagnosis. For example, of the 13 contributors in Money's (1962) book, only one had been trained in language therapy for children with specific dyslexia. It is suggested that some institution or agency with adequate resources in money, equipment, diagnosticians, reading therapists, and a clinic population from which to draw, might initiate a comprehensive, long term study of reading therapy for children with specific dyslexia. For example, the Orton-Gillingham (Gillingham & Stillman, 1956) alphabetic-phonetic system of language retraining is a logical one to study since it has been especially developed for children with specific dyslexia. It has been clinically tested and proven successful for some 30 years in various parts of the country. Recurrent in these studies is the indication that a highly structured, multi-sensory, and sequential training program in sound-symbol association is necessary and vital. In comparing various methods of reading therapy related to the development of sound-symbol association--the lack of which is probably the most basic deficit in the dyslexic reader--Bateman (1965) wrote that the Orton-Gillingham program:

> is the most thoroughly multi-sensory in that every practical combination of mode of stimulus and response is employed to better insure an enduring association being built. The importance of this enduring storage cannot be overemphasized . . . (pp. 6-7).

A consideration of the Orton-Gillingham approach to language retraining in the context of a theoretical model of psycholinguistic functioning could advance our knowledge about the processes involved in dyslexia, as well as producing insights on specific aspects of retraining. For example, Bateman (1965) stated that the Orton-Gillingham system covers almost the entire psycholinguistic model developed by Osgood (1957a, 1957b) and its extension by McCarthy and Kirk (1961).

Comprehensive research in investigating this relation between the Osgood model and the Orton-Gillingham approach to language training may study the conditions under which changes occur in basic organismic psychological (memory, perception, cognition) and psychoneurological (perceptual-motor integration, right-left discrimination, directional orientation, body schema) processes. Knowledge on how to produce corrective changes in psychological and psychoneurological processes should lead to more refined and definitive educational methods of language retraining, as well as contributing general knowledge to psychology and neurology.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Specific dyslexia is considered to be an inborn neuropsychological learning disability revealed primarily by poor performance in reading, spelling, and handwriting. Frequently, poor auditory discrimination is implicated. It is specific in that it is not a manifestation of aphasia or visual agnosia. Etiological or antecedent factors assumed not to be related to specific dyslexia are low intelligence, minimal brain damage, cultural deprivation, poor or insufficient academic instruction, poor motivation, and primary emotional disturbances.

This study investigated three major areas related to specific dyslexia: (a) the quantitative ways in which children with specific dyslexia differ from normal readers: (b) the statistical characteristics of children with specific dyslexia; and (c) the subpatterns or clinical syndromes within the category of specific dyslexia. After reviewing the literature, 197 variables or measurement operations were selected for evaluation.

Thirty-two children previously diagnosed with specific dyslexia were matched with a control group of 23 normal readers. Selection variables, 10 in all, were statistically held constant with the exception of reading and spelling. The experimental group was one or more years below grade level in reading and spelling. The control group was at or above grade level in reading and spelling. Only children with IQ scores of 90 or above were included in the two groups. (The mean IQ for the experimental group is 112.5 and that of the control group is 113.9.)

Five methods of statistical analysis were used to answer the three problems posed in this study. Simple analysis of variance identified the variables that distinguished the experimental group from the control group. Data from the experimental group on significant variables differentiating the two groups were subjected to intercorrelation and factor analysis. Hierarchical grouping analysis categorized the children in the experimental group into three subgroups. These were compared on 14 variables by the analysis of variance method.

Conclusions

The results of this study indicated that the experimental group differed from the control group on 43 significant variables in the following areas: intellectual; educational (reading, spelling, handwriting, reproduction of the alphabet, etc.); visual perception of pictorial details, letter recognition; auditory memory and discrimination; peripheral lateral dominance; fine muscle coordination; finger localization; and familial history of language disability in both parents and brothers of the children in the experimental group. The experimental group was further characterized by three subgroups or syndrome patterns on 14 variables, seven of which were significant.

Recommendations

Several areas for research were suggested as follows: replication of the present study; longitudinal research with multiple variables; investigation of predictive variables of reading disability; diagnostic consideration of adults with reading disability; and research on present methods of reading retraining, particularly the Orton-Gillingham system of language retraining.

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APPENDIX A

Intellectual

WISC Subtests Used Plus Two
Additional Computations

Subtests
- Information
- Comprehension
- Arithmetic
- Similarities
- Vocabulary
- Digit Span[a]

- Picture Completion
- Picture Arrangement
- Block Design
- Coding
- Mazes[b]

- Verbal Scale IQ
- Performance Scale IQ[c]
- Full Scale IQ

Additional Computations
- Verbal Scale minus Performance Scale (magnitude of difference)
- Digits forward minus Digits backward (magnitude of difference)

---

[a] Not used in computing Verbal Scale IQ.
[b] Not used in computing Performance Scale IQ.
[c] Performance Scale IQ based on prorating of four subtests.

APPENDIX B

Language

Letter Recognition Test

h k b r n u j i l p t f a s o e c m w d x q

q x d w m c e o s a f t p l i j u n r b k h

t s c d h r j p a e w q k n i f o m x b u l

n l a e x b j t o w h r i f c d k u p s m q

x w c o a t l j n b h m d q e s f p i u r k

s h e d f p i u r k q x w c o a t l j n b m

p i d r k q u m x s f n j l b w e h c o a t

a f o t e p c l m i w j d u x n s r q k h b

l t i f j a u s n o r e b c q m x k w h d p

j d m w s h p i u r k x e c b a t l q n o f

e m o f l u b h q w x a p j r d c s t i n k

w m d c x e q j l u p n t r f b a k s h o i

TOTAL NUMBER CORRECT_______ TOTAL REACTION TIME_______

Each line of letters was exposed to the child one at a time. He was asked to find and circle a certain letter for each line (p, b, n, l, e, i, t, w, d, m, h, and r). Total reaction time was the cumulative time required to locate all letters, and it was derived from the time interval between the announced letter and the circling of the letter, whether it was correctly or incorrectly circled. Timing was discontinued after 10 seconds if the child failed to circle a letter.

III

A big car nearly ran over Bobby.
He jumped quickly away from it.
Now he does not play in the road.

In group testing, third grade subjects copied in cursive form the above sentences. Quality of handwriting was judged 0 = very poor, 1 = poor, 2 = good, and 3 = very good.

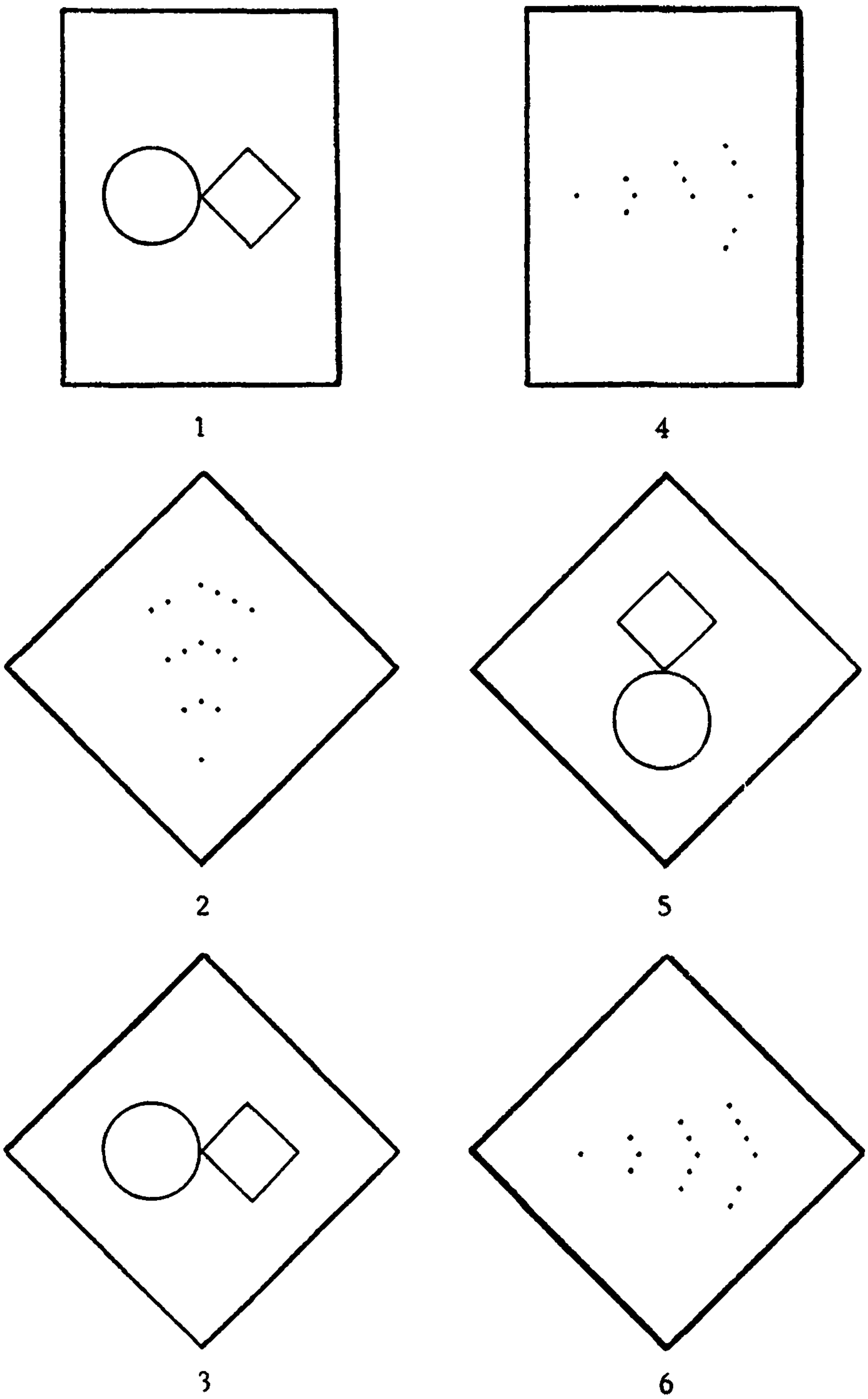
IV

A dozen boys had a jolly picnic.
They rode to the woods in autos.
Some took lunch in large boxes.
All of them had a very fine time.

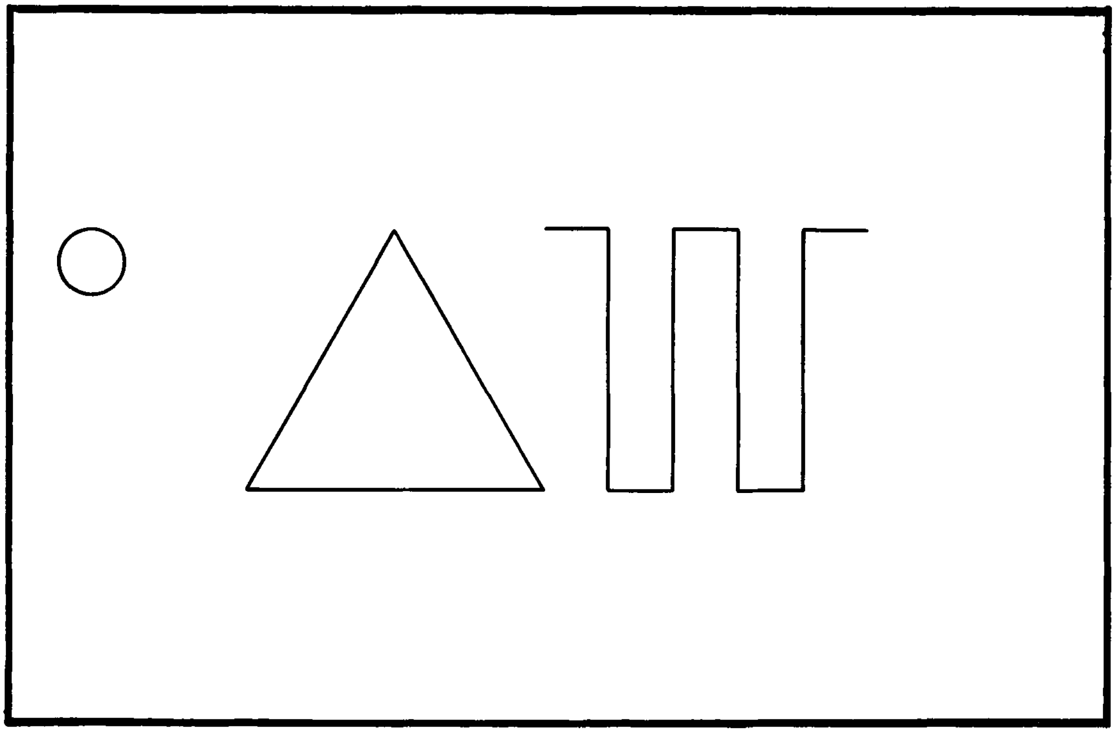
In group testing, fourth grade students copied in cursive form the above sentences. Quality of handwriting was judged 0 = very poor, 1 = poor, 2 = good, and 3 = very good.

APPENDIX C

Visual Perception



Test figures reproduced from the Minnesota Percepto-Diagnostic Test (Fuller & Laird, 1963b, p. 12).

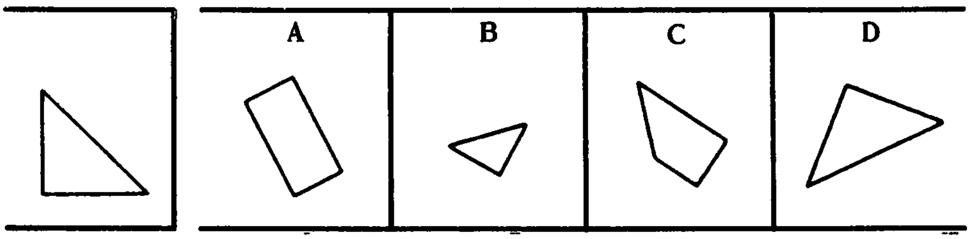


An example of one stimulus card, reduced in size, contained in Revised Visual Retention Test (Benton, 1955). All three forms of the test were administered. In administration C, the subject reproduces 10 designs while viewing them. In administration A, the subject views each design for 10 seconds then reproduces it from memory. In administration D, a 15 second delay is introduced before the subject draws the designs from memory. Ten designs are in each administration and they are presented successively. Scoring consisted of the total number of correct reproductions and the total number of errors for each administration.

Examples of Practice Exercises of Three Subtests
from Primary Mental Abilities
(Thurston & Thurston, 1962)

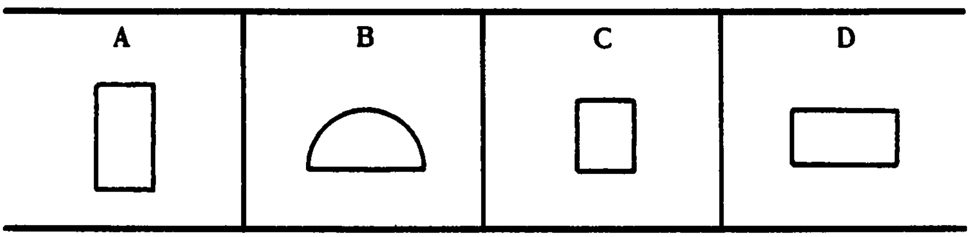
This test is called "Spatial Relations." It is a test to see how well you can recognize shapes and forms. In sample problem S17 the first drawing is one part of a square. Look at the other drawings in the first row and find the shape that is the other part of the square. Put your finger on the other part of the square.

S17.



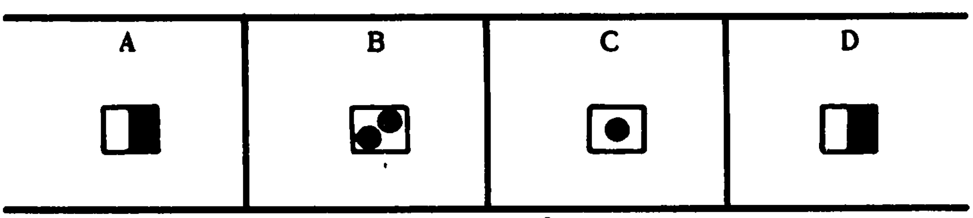
This test is called "Figure Grouping." It is a test to see how well you can see differences in figures. In sample problem S21 three of the drawings are alike, but one is different. Put your finger on the one that is different.

S21



This test is called "Perceptual Speed." It is a test to see how well you can see similarities in drawings. In sample problem S 29 two of the drawings are exactly alike. Put your fingers on the two drawings that are alike.

S29.



APPENDIX D

Auditory and Speech

AUDITORY DISCRIMINATION TEST

FORM I

		X	Y			X	Y
1.	tub - tug			21	cat - cap		
2.	lack - lack			22.	din - bin		
3.	web - wed			23.	lath - lash		
4	leg - led			24.	bum - bomb		
5.	chap - chap			25.	clōthe - clōve		
6	gum - dumb			26.	moon - noon		
7.	bale - gale			27.	shack - sack		
8	sought - fought			28.	sheaf - sheath		
9.	vow - thou			29.	king - king		
10.	shake - shape			30.	badge - badge		
11	zest - zest			31.	pork - cork		
12.	wretch - wretch			32.	fie - thigh		
13.	thread - shred			33	shoal - shawl		
14.	jam - jam			34.	tall - tall		
15.	bass - bath			35.	par - par		
16	tin - pin			36.	pat - pet		
17.	pat - pack			37.	muff - muss		
18.	dim - din			38.	pose - pose		
19.	coast - toast			39.	lease - leash		
20.	thimble - symbol			40.	pen - pin		

	X	Y
Error Score	/30	/10

Auditory Blending Test

Pronounce each word only once as shown in first column. Pause ½ second between syllables.

1. h-o-r-s (horse) ________
2. uh-s (us) ________
3. a-ten-shun (attention) ________
4. s-ap (sap) ________
5. fr-i (fry) ________
6. ch-amp (champ) ________
7. g-o (go) ________
8. d-an-s (dance) ________
9. b-ar-k (bark) ________
10. fl-i-t (flight) ________
11. c-ake (cake) ________
12. n-ice-lee (nicely) ________
13. s-ing-er (singer) ________
14. th-ir-s-tee (thirsty) ________
15. st-a-shun (station) ________

TOTAL NUMBER CORRECT ________

During individual testing, the examiner pronounced each word syllable by syllable. The child was requested to say the word. If he said he did not know the word, he was asked to guess. If he were unable to guess, the response was scored as failed. This administration is slightly modified from the original (Gates & McKillop, 1962).

Auditory Intrasensory Integration Test

1. R-u-n	9. S-i-x	17. M-a-n
2. T-o-p	10. I-c-e	18. G-o-o-d
3. R-e-d	11. I-s	19. T-h-i-s
4. B-o-o-k	12. N-o-w	20. O-v-e-r
5. S-e-a	13. L-i-t-t-l-e	21. T-h-e
6. C-a-n	14. D-i-d	22. Y-o-u
7. T-e-n	15. N-o-t	23. A-l-l
8. O-l-d	16. S-h-e	24. M-u-s-t
		25. A-n-d

TOTAL CORRECT________ TOTAL REACTION TIME________

Pause ½ second between letters when spelling the word. Record the reaction time interval between the last letter of the word and the time the child says the word. Discontinue timing after 10 seconds if the child does not know the word.

This test measures the child's ability to integrate names of letters into a whole word. It is the converse of a spelling test wherein the child writes the letter names after hearing the whole word. It is similar but somewhat different from an auditory blending test wherein the child integrates phonemes into whole words. The test was derived from clinical recognition that children with dyslexia have difficulty integrating spelled words.

The words were selected from the first seven spelling lists in the Morrison-McCall Spelling Scale (Morrison & McCall, 1929). The level of difficulty ranges from grade levels 1.0 to 1.9. All words, therefore, are below the second grade level.

The Total Reaction Time was a cumulative reaction time to each of the spelling words.

Signal to Noise Ratio

Stimulus		Response	Stimulus		Response
1.	that	________	26.	well	________
2.	ill	________	27.	die	________
3.	me	________	28.	one (won)	________
4.	pew	________	29.	then	________
5.	star	________	30.	on	________
6.	and	________	31.	been	________
7.	tree	________	32.	key	________
8.	odd	________	33.	oak	________
9.	ham	________	34.	young	________
10.	smart	________	35.	live	________
11.	dumb	________	36.	hit	________
12.	with	________	37.	bye (buy)	________
13.	off	________	38.	chest	________
14.	thin	________	39.	show	________
15.	gave	________	40.	cap	________
16.	now	________	41.	ale (ail)	________
17.	send	________	42.	tear	________
18.	move	________	43.	hurt	________
19.	ice	________	44.	way	________
20.	eat	________	45.	else	________
21.	rooms	________	46.	does	________
22.	cars	________	47.	your	________
23.	air	________	48.	too	________
24.	new	________	49.	flat	________
25.	jaw	________	50.	ease	________

TOTAL NUMBER CORRECT________

The 50 words above, constituting the signal, were taped from a record prepared by the Central Institute of Deaf, record W-22. They were taped at a 55 db level. White noise constituted the background. It was presented at the 45 db level and originated from a Beltone audiometer. Both signal and noise were taped simultaneously.

The subject was told that he would hear a voice saying, "Say the word _____" while at the same time hearing static interference. When the subject heard the stimulus words, he was to repeat through the microphone on the table in front of him what he heard. The examiner, who was outside the sound room with earphones on, recorded his responses. If at any time she was uncertain as to the response, she stopped the tape and had the subject repeat the word. The total number of correct responses constituted the score.

Sound Localization Test

1.	R	8.	L	15.	CL
2.	L	9.	C	16.	CR
3.	C	10.	CL	17.	R
4.	CL	11.	R	18.	CL
5.	C	12.	L	19.	L
6.	R	13.	CR	20.	CR
7.	CR	14.	C		

TOTAL NUMBER CORRECT______

This test measures the subject's ability to localize the direction from which sound originates. In relation to the position of the subject in the sound room, there were 5 possible choices: right, right oblique, center, left oblique, and left.

A 1000 cps pure tone signal, 40 dps above auditory threshold, was presented to the subject. The signal was fed from a Beltone audiometer to one of three speakers in the room (speaker right, speaker center, and speaker left of subject) or to two speakers simultaneously (speakers right and center, and speakers left and center). Sending the signal through either pairs of speakers created the psychological experience of hearing the tone either right oblique or left oblique. The notational system for the 20 trials is as follows: R (signal comes from the right speaker), L (signal comes from the left speaker), C (signal comes from the center speaker), CR (signal comes from both the center and right speakers), and CL (signal comes from both the center and left speakers). Prior to the 20 test trials, the signal was presented in the following order as demonstration of the task confronting the subject: R, RC, C, CL, and L. Once the subject understood what was expected of him, testing began.

Templin-Darley Screening Test of Articulation

7. bird
13. music
28. rabbit
28. arrow
29. leaf
31. valentine
32. thumb
32. bathtub
32. teeth
33. there
33. feather
33. smooth
35. zipper
36. sheep
36. dishes
36. fish
37. television
41. yellow
41. onion
42. chair
42. matches
42. watch
43. jar
43. engine
44. present
45. bread
46. tree
47. dress
48. crayon
49. grass
50. frog
51. three
52. shredded wheat
76. planting
78. clown
79. glass
80. flower
95. smoke
96. snake
97. spider
98. stair
99. sky
100. sled
101. sweeping
109. twins
110. queen
120. splash
121. sprinkling can
122. string
123. scratch

Each child was shown pictures representing the words the examiner wished to elicit. The letters underlined in the response words above correspond to the sounds within the words the child was to utter.

Diadochokinesis

Total number of left-right lateral tongue movements during a 10 second period of time. ______

Rhythm of left-right lateral tongue movements (coordination).

_____1. Good coordination

_____2. Poor coordination ______

This test measures speed and rhythm in tongue movement. The examiner demonstrated the task and the child practiced the movements several times till he understood what was expected of him. During the 10 second test period, the examiner counted the number of left-to-right tongue movements. Following a brief rest period, the child repeated the task and the examiner observed only his coordination in tongue movement.

APPENDIX E

Neuropsychological

Harris Tests of Lateral Dominance

Hand Preferences

1. How do you throw a ball?......_____	NUMBER OF TIMES RIGHT HAND USED	
2. How do you wind a watch?......_____	_____	
3. How do you hammer a nail?....._____		
4. How do you brush your teeth?.._____		
5. How do you comb your hair?...._____		
6. How do you turn a door knob?.._____		
7. How do you hold an eraser?...._____		
8. How do you use scissors?......_____		
9. How do you cut with a knife?..____		
10. How do you write?............_____		

Foot Dominance

1. How do you kick a football?....._____	NUMBER OF TIMES RIGHT FOOT USED
2. How do you stamp out a fire?..____	_____
3. How do you hop?..... ...._____	

A-B-C Vision Test

1. _____	5. _____	NUMBER OF TIMES RIGHT EYE USED
2. _____	6. _____	_____
3. _____	7. _____	
4. _____	8. _____	

Directions for administration were followed according to the Harris (1958) manual. In the Foot Dominance test, item 3 was added to increase the reliability of this test.

Benton's Right-Left Discrimination Test

Part I. Behavioral Responses (eyes closed).

1.	Touch your right ear with your right hand.	1___
2.	Touch your left knee with your right hand	2___
3.	Touch your right eye with your left hand.	3___
4.	Touch your left ear with your left hand.	4___
5.	Touch your left eye with your right hand.	5___
6.	Touch your left knee with your left hand.	6___
7.	Touch your right shoulder with your left hand.	7___

SUB TOTAL____

Part II. Verbal Responses (pictures).

1.	Pict. A (L hand, L ear) Which hand on which ear?	1___
2.	Pict. B (R hand, L eye) Which hand on which eye?	2___
3.	Pict. C (R hand, R ear) Which hand on which ear?	3___
4.	Pict. D (L hand, R eye) Which hand on which eye?	4___
5.	Pict. E (R hand, L ear) Which hand on which ear?	5___
6.	Pict. F (R hand, R eye) Which hand on which eye?	6___
7.	Pict. G (L hand, L eye) Which hand on which eye?	7___
8.	Pict. H (L hand, R ear) Which hand on which ear?	8___

SUB TOTAL____

GRAND TOTAL____

Part III. Consistent reversal of responses to pictures.

(0 = yes; 1 = no) ___

In Part I, the child was asked to touch parts of his body with his left or right hand. In Part II, he was shown successively eight pictures, each containing a different hand-body part relationship.

Benton's Finger Localization Test (Parts 4 and 5)

The child extends his hand (first right then left) through the curtain attached to the box. The appropriate hand chart, with each finger marked by a number, is placed on the slanted top of the box. Examiner says,

> "I am going to touch one finger at a time under this box. You tell me which finger I touched by <u>naming</u> the number of the finger touched."

<u>Identification of fingers on chart (hand hidden)</u>. Subject points to corresponding finger on model as that touched by the examiner in the following order:

Right Hand 5___ 1___ 3___ 2___ 4___ 3___ 5___ 1___ 4___ 2___

Left Hand 2___ 4___ 1___ 5___ 3___ 4___ 2___ 3___ 1___ 5___

Examiner says,

> "Now I am going to touch two fingers at the same time. You tell me which two fingers I touched by <u>naming</u> the two numbers of the fingers touched."

<u>Identification of two simultaneously stimulated fingers on chart (hand hidden)</u>.

Right Hand 14___ 23___ 24___ 35___ 34___ 32___ 25___ 12___ 34___ 13___

Left Hand 13___ 34___ 35___ 23___ 24___ 14___ 23___ 25___ 12___ 34___

<u>Recording and Scoring</u>. Use check marks for correct responses. If the child changes his response before the next finger is stimulated, the second response is indicated.

The total score is the sum of the correct localizations for each of the separate tests. The grand total is the sum of the total scores for the single and double stimulation. Maximum total score is 20 and grand total is 40.

A mimeograph copy of this test with directions for administration was provided by Benton (1964). Adherence to the directions governed the administration of this test.

APPENDIX F

Neurological

Neurological Evaluation

SPECIAL SENSES

0 1 2 3 Vision (visual acuity correctable to normal)

0 1 2 3 Hearing

0 1 2 3 Taste

0 1 2 3 Smell

CRANIAL NERVES

0 1 2 3 III, IV, & VI--eye movements

Lateral (R· 0 1 2 3, L: 0 1 2 3)
Other (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 V Trigeminal

Motor movement of jaws_____________deviation_______
Sensory: Pain, touch, temp. (R: 0 1 2 3, L· 0 1 2 3)
Corneal reflex (R: 0 1 2 3, L· 0 1 2 3)

0 1 2 3 VII Facial--motor

Palpebral fissures equal_________unequal________
Movement face (R: 0 1 2 3, L: 0 1 2 3)
Movement lip (R: 0 1 2 3, L: 0 1 2 3)
Ability to close one eye independently of the other (R: 0 1 2 3)
(L: 0 1 2 3)
Position of lips at rest Parted some___More____ Much____

0 1 2 3 IX & X Glossopharyngeal and Vagus

Pharyngeal Sensation R___________L_____________
Pharyngeal reflex R____________L_____________

Neurological Evaluation, continued

Palatal sensation R__________L__________
Palatal reflex R__________L__________
Uvula: position____Movement____Sensation___
Phonation (hoarse)___hypernasal___Other_______

0 1 2 3 XII Hypoglossal--tongue movements

Position of tongue at rest Interdental___R___L___
Tongue protruded central____________R___L___
Tongue movement upward_______Lateral: R___L___
Tongue atrophy R__________L__________
Inability to curl tongue at edges__________
Abnormal movements____________________

MOTOR SYSTEMS

Muscle Status:

0 1 2 3 Strength hands (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Strength in arms (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Strength in legs (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Contour:
Muscular 0 1 2 3 (R: 0 1 2 3, L: 0 1 2 3)
Hyposthenic 0 1 2 3 (R: 0 1 2 3, L: 0 1 2 3)
Atrophy 0 1 2 3 (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Tone, Hypotonia (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Tone, Hypertonia (R: 0 1 2 3, L: 0 1 2 3)

Gait, station, & posture:

0 1 2 3 Appearance: dull___hyperactive___slouches____
leans against objects________________
flat feet (weak feet)____with eversion____
rotation_____stiffness_______________
____

0 1 2 3 Stride: normal___wide base___decreased flexion-
ankles____stiffness__________________
____

on toes________ on heels________ on a line________
position of trunk________ head________ on a line____
strength of legs________________________

0 1 2 3 Lower motor neurone system

Decrease in muscle tone	(R: 0 1 2 3, L: 0 1 2 3)
Weakness, muscle	(R: 0 1 2 3, L: 0 1 2 3)
Paralysis, muscle	(R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Upper motor neurone system (pyramidal)

Increase in muscle tone	(R· 0 1 2 3, L: 0 1 2 3)
Spasticity	(R: 0 1 2 3, L: 0 1 2 3)
Clonus	(R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Extrapyramidal system

Rigidity	(R: 0 1 2 3, L: 0 1 2 3)
Tremor (rest)	(R: 0 1 2 3, L: 0 1 2 3)
Choreiform movements	(R: 0 1 2 3, L: 0 1 2 3)
Athetoid positioning	(R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Cerebellar system

Ataxia - Truncal	(R: 0 1 2 3, L: 0 1 2 3)
Dysmetria	(R: 0 1 2 3, L: 0 1 2 3)
Intention tremor	(R: 0 1 2 3, L: 0 1 2 3)
Nystagmus	(R: 0 1 2 3, L: 0 1 2 3)

COORDINATION AND EQUILIBRIUM

Upper Extremities:

0 1 2 3 Alternating flexion and extension of fingers (opening and closing fist) (Bilateral· R & L)

0 1 2 3 Apposition of thumb (Bilateral: R & L)

0 1 2 3 Approximation and abduction of fingers (Bilateral: R & L)

0 1 2 3 Supination and pronation of outstretched hands with wrists extended and fingers abducted (Bilateral: R & L)

Neurological Evaluation, continued

0 1 2 3 Patting chest symmetrically, then alternating supination and pronation touching thighs (Bilateral: R & L)

0 1 2 3 Tandem Walking (straight line)

Lower Extremities:

0 1 2 3 Standing on one foot (R & L)

0 1 2 3 Jumping on both feet

0 1 2 3 Hopping on one foot (R & L)

0 1 2 3 Knee bends

REFLEXES

0 1 2 3 Deep tendon reflexes

(absent, hypoactive, 0 = normal, 1 = hyperactive, 2 = unsustained clonus, 3 = sustained clonus.)

0 1 2 3 Superficial reflexes (R: 0 1 2 3, L: 0 1 2 3)

0 1 2 3 Plantar reflex (Babinski) (R: 0 1 2 3, L: 0 1 2 3)

SENSORY SYSTEMS

0 1 2 3 Pain appreciation equal (right = left) ________

0 1 2 3 Touch appreciation equal (right = left) ________

0 1 2 3 Temperature appreciation equal (right = left) ________

0 1 2 3 Vibratory appreciation equal (right = left) ________

0 1 2 3 Position Toes________ankles________fingers________

Neurological Evaluation, continued

Romberg's sign Present________Absent_________

0 1 2 3 Stereognostic appreciation equal (right = left)

____

0 1 2 3 Extinction Phenomena

Face (right = left) ________________
Hands (right = left) ________________
Legs (right = left) ________________

Instructions for scoring were: Circle 0 (no involvement, 1 (mild), 2 (moderate), or 3 (severe). Use scores following the items in right margin as bases for arriving at rating in left margin.

EEG Scoring System

Wake Tracing		Sleep Tracing	
0 1	Slow	0 1	Slow
0 1	Fast	0 1	Fast
0 1	Mixed (diffuse)	0 1	Mised (diffuse)
0 1	Paroxysmal bursts	0 1	Paroxysmal bursts
0 1	Focal	0 1	Focal
0 1	Immature tracing	0 1	Immature tracing
0 1	14 and 6 cycles per second	0 1	14 and 6 cycles per second
0 1	Abnormal--Other	0 1	Abnormal--Other
0 1	Normal	0 1	Normal

Instructions for scoring were: Circle <u>0</u> (not present) or <u>1</u> (present) to indicate the absence or presence of each factor.

APPENDIX G

Interview Schedules

Medical History Inventory

A. Intrauterine Development

0 1 2 3 Maternal reproduction difficulties

Relative sterility	0 1 2 3
Miscarriage (25% to 50% = 2, over 50% = 3)	0 1 2 3
Stillbirths (25% to 50% = 2, over 50% = 3)	0 1 2 3
Death in 1st week of life (25% = 1, 26% to 50% = 2, over 50% - 3)	0 1 2 3
Prematurity and children with low birth weights	0 1 2 3

0 1 2 3 Maternal health during pregnancy for this child

Uterine bleeding or "spotting"	0 1 2 3
Excessive vomiting	0 1 2 3
Allergies (asthma and/or others)	0 1 2 3
(Pre) eclampsia	0 1 2 3
Heart disease	0 1 2 3
Chronic anemia	0 1 2 3
Surgery under general anesthesia	0 1 2 3
Infections	0 1 2 3
Thyroid disease (hyper or hypo)	0 1 2 3
Diabetes and prediabetes	0 1 2 3
Drugs and medications used during pregnancy	0 1 2 3

B. Natal Factors

0 1 2 3 Length of gestation (37 wks or more = 0; 36-33 wks = 1; 32 to 29 wks = 2; 28 wks or less = 3)

0 1 2 3 Birth weight (5 lbs, 8 ozs or more = 0; 5 lbs, 7 ozs to 4 lbs = 1; 3 lbs, 15 ozs to 3 lbs, 1 oz = 2; 3 lbs or less = 3)

0 1 2 3 Abnormal presentation (breech = 3, other 2 or 1)

0 1 2 3 Caesarean section (anticipated = 2, emergency = 3)

Medical History Inventory, continued

0 1 2 3 Significant injury at birth

C. Neonatal Factors (first week of life)

0 1 2 3 Postdelivery color (cyanotic or jaundiced)

0 1 2 3 Motor apathy

0 1 2 3 "Floppy baby"

0 1 2 3 Respiratory difficulty

0 1 2 3 Sucking (strong = 0, weak = 1, absent = 3)

0 1 2 3 Treatment for noncerebral congenital anomalies

0 1 2 3 Convulsions or cyanotic episodes

0 2 3 Baby stayed in hospital after mother went home

D. Postnatal Factors

0 1 2 3 Diseases

0 1 2 3 Injuries

0 1 2 3 Wake, Hyperactive

0 1 2 3 Wake, Lethargic

0 1 2 3 Sleep behavior: too sleepy or drowsy

0 1 2 3 Sleep behavior: disturbed sleep cycle

E. Age of acquisition of motor skills in infancy and early childhood

0 1 2 3 Crawling (never or later than 1 year in crawling = 3, other = 2, 1, or 0)

Medical History Inventory, continued

0 1 2 3 Sitting without support (by 6 mos = 0; 6-7 mos = 1; 7-8 mos = 2, later than 8 mos = 3)

0 1 2 3 Walking independently (by 14 mos = 0; 15-16 mos = 1; 17-18 mos = 2; later than 18 mos = 3)

0 1 2 3 Dressing self (based on Gesell scale of development)

Pulled on simple garment (24 mos = 0; 25-30 mos = 1; 31-36 mos = 2; 3 years or later = 3)

Put on shoes and unbuttoned clothes (by 36 mos = 0; 37-47 mos = 1; 48-59 mos = 2; 5 years or older = 3)

0 1 2 3 Communicated with single words other than "Mama", "Dada", and/or "bye-bye". (by 12 mos = 0; 13-15 mos = 1; 16-18 mos = 2, older than 18 mos = 3)

0 1 2 3 Communicated with sentences (by 2 yrs = 0; 25-30 mos = 1, 31-36 mos = 2; later than 3 years = 3)

Instructions for Scoring were: Circle 0 (no involvement), 1 (mild 2 (moderate), or 3 (severe). Use scores following the items in right margin as bases for arriving at rating in left margin.

Familial History of Language Disability

__ 1. Reading. (History of poor reading; slow, faltering, and word-by-word reading; poor phonic skills; dislike for reading.)

__ 2. Spelling. (History of poor spelling; present ability reflects many misspelled words; frequent use of dictionary.)

__ 3. Handwriting. (Difficult to read handwriting. Difficulty in learning to write.)

__ 4. Laterality. (Is parent right or left, or mixed, crossed or ambidexterous?)

__ 5. Directional Orientation. (Loses directions easily in driving, especially in a new situation. Does he express discomfort or confusion in spatial orientation?)

__ 6. Motor Coordination. (History of incoordination. Is parent awkward in dancing, walking, sports?)

__ 7. Speech. (Note history of speech problems and present condition--hesitations, stuttering, dysarticulation.)

__ 8. Brother(s). (Is there any history of reading and spell-
__ 9. Sister(s). ing problems in which arithmetic is better?)

__10. Overall Judgment. (Make an overall judgment as to the presence or absence of a familial basis to child's present language problem.)

Scoring: 0 is presence of and 1 is absence of familial history.

Each parent was scored separately. Variables 8 and 9 were scored according to sex of the siblings.