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DIFFERENTIATING BETWEEN LEARNING DISABLED AND NORMALLY ACHIEVING STUDENTS WITH SELECTED COGNITIVE AND NON-COGNITIVE VARIABLES

by

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Date March 16th 1981

This thesis is dedicated to my wife, Myrosia and to my son, Evhen. Their love and support guided me through times of stress and hardship. This thesis is also dedicated to my parents who taught me to value knowledge and hard work.

Labor omnia vincit
(Virgil)

Abstract

The present study was undertaken in order to investigate the effectiveness of a test battery in differentiating between learning disabled and normally achieving children. Included in the test battery were cognitive (Bender Visual-Motor Gestalt Test (Bender), Visual Aural Digit Span Test (VADS), Wide Range Achievement Test (WRAT)) and non-cognitive measures (Student's Perception of Ability Scale (SPAS)). As accurate diagnosis of a learning disability is based in part upon an accepted definition, the definitional dilemma in the field of learning disabilities was discussed together with the resulting problems in diagnosis and assessment. Constructs underlying the above measures were discussed in terms of previous research.

Subjects were 37 learning disabled children who were either enrolled in a remedial programme or were in attendance of an adaptation class. The control group contained 44 normally achieving children in full-time attendance in the regular classroom. The two groups were matched as closely as possible for age (the mean age for the total group was 8.8 years), socio-economic status and IQ.

The discriminant function analysis was used as the main statistical procedure, primarily because already it has proved a valuable technique in psychiatry, not only diagnostically, but also nosologically. Data obtained through the discriminant function analysis were used to classify subsamples (LD=10; NA=10) of the original LD and NA groups. In addition, the Hotelling T^2 was employed in order to determine whether sex was a confounding variable within each group.

In reviewing the results, no sex differences were found within the LD and NA groups. The LD children performed significantly lower on all measures, when these were taken singly, except on the Confidence and Penmanship subscales of the SPAS. The total test battery proved highly effective in differentiating between LD and NA children, yielding a hit rate of 90%. Within the test battery, the Bender and the VADS were most contributory in terms of discriminatory power, while the SPAS was lowest, on the whole, in ability to differentiate between the LD and NA groups. The VADS, in isolation, misclassified 40% of the children (25% of LD; 15% of NA), supporting the position that test batteries have more utility and value than single measures. The usefulness of the discriminant function analysis within an educational framework was discussed, and suggestions were made regarding future research. It was concluded that the optimal approach to diagnosing learning disabilities may, in all actuality, be through the use of sex-specific, age-specific, and IQ range specific variables.

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CHAPTER 1

INTRODUCTION

The search for effective means of assessing learning disabled children is continuous and often frustrating. Because of the uniqueness of the learning disabled, few professionals feel totally confident in interpreting test data to reach the diagnosis "learning disabled." Historically, diagnosis of learning disabilities has focused on a number of isolated variables. Deficits and strengths within the child were identifed and labelled. Task analysis has been used to determine level of skill; learning styles have been analyzed and matched with supposed teaching models; motivation, interests and attitudes have been inventoried and plotted; attention has been given to the significance of parents, siblings, and the home environment. No one would question the importance of each of the variables assessed; however, rarely are they all given to reach a diagnosis. Taken singly they provide little information (Hardin, 1978).

Much of the current debate with regard to the diagnosis of learning disabilities revolves around the basic question of whether or not the field can back up its claims to knowledge and diagnosis with valid empirical evidence. The answer, says Coles (1978), rests in large part on the nature of the learning disabilities test battery - the set of tests used to determine the quantity and quality of learning disabilities in children.

It is the purpose of the present study to validate a battery of tests, comprising of a number of well-established measures and a number of "novel" measures, which, taken singly, have been found to differentiate between learning disabled and normally achieving children.

Generally, the tests in any battery are all designed to fit a model of learning disability based upon an accepted definition. The problem in the field, however, is that no reliable definition of learning disabilities exists. Because a reliable definition of learning disabilities is of crucial importance not only theoretically, but also on a practical level in terms of facilitating the task of those involved in educating the learning disabled child, the issue of definition will be reviewed in some detail first. This will be followed by a look at some of the approaches to the assessment of learning disabilities. The present chapter will conclude with an outline of the test battery selected for the current study.

The Phenomenon of Learning Disabilities

In general, when considering a particular phenomenon, frequently the question "what is it?" serves as a point of departure. With regard to the phenomenon of learning disabilities, despite a wealth of research in recent years, there exists a lack of agreement about what precisely constitutes a learning disability. The involvement of many disciplines in the field with each professional group approaching the problem from a different conceptual viewpoint is cited consistently as being the cause of such disagreement (e.g. Chapman, Boersma & Janzen, 1978; Lerner, 1971; Smith & Polloway, 1979). The result is a "chaos of differing definitions" (Chapman, Boersma & Janzen, 1978, p. 281).

Traditionally, the detection and treatment of learning disorders belonged in the realm of neurology and medicine. As early as 1896, Morgan reported evidence of children suffering from "word blindness." Orton (1937) explored the effect of cerebral dominance of the right or left lobes on certain learning-related behaviours. Both theorists sought physiologically based explanations for inadequate school performance, specifically in reading. This orientation gained its widest acceptance in the hands of Strauss and Werner (Strauss & Kephart, 1955; Strauss & Lehtinen, 1947; Werner, 1948), through whom the concept of minimal brain damage was introduced into the educational arena. Emphasis on perceptual disturbances, distractability, and hyperactivity constituted the nucleus of this approach to the problem and greatly influenced the growth of numerous perceptual-motor models for dealing with brain damage (Frostig & Horne, 1964; Getman, 1965; Kephart, 1971).

By the mid 1950's, psychologists and educators became increasingly dissatisfied with the term brain-injured. The experience of Stevens and Birch (1957) with children who showed milder perceptual-motor disturbances led them to conclude that not all children with learning disorders were suffering from brain damage. As a result, they proposed the term Strauss syndrome to refer to children exhibiting certain learning characteristics such as perceptual disorders, perseveration, and distractability.

However, it soon became apparent that impairments of many of the children with learning difficulties were primarily cognitive and affective in nature, rather than psychomotor. New labels began to surface in the literature. Thus, Johnson (1962) proposed the term "marginal children," and Clements (1966) introduced the term "minimal brain dysfunction."

At the start of the integration phase in the history of learning disabilities (Wiederholt, 1974), in an attempt to shift the emphasis away from definitions which made reference to organic etiology to a definition with increased educational relevance, Kirk and Bateman (1962) coined the term "learning disability." The focus now was on psychological processes involved in speech, language, reading, writing, arithmetic and other educational tasks. Because of its educational relevance, the term learning disability gained wide support and acceptance among professionals and, especially, among the parents of learning disabled children.

Before discussing the definitional dilemma in the field of learning disabilities, it appears appropriate to comment briefly on the term "dyslexia" which has frequently been confused with the term "learning disability." This is understandable, as a large number of children with learning disabilities have specific problems in reading. However, the reading problems of learning disabled children are one aspect of their overall learning problems. Indeed, some children may have a disability in some other area and not in reading, though such cases are in the minority.

While the term "learning disability" has been accepted, its precise definition remains a thorn in the side of all whose concern is with the learning disabled child. Kass (1977) points out that the responsibility for a professional definition of the label "learning disabled" lies on the professions involved and that reaching consensus about the handicap--what it is and how to treat it--represents a great challenge in the field. Recognizing the validity of Kass' statement, one's disillusionment and concern increases in the face of an apparent reluctance to come to grips with this definitional dilemma. A look at the ever-increasing amount of literature on learning disability reveals that, inevitably, the authors do point out that many approaches to and definitions of the problem exist, but these thoughts are abandoned post-haste in favour of one's own 'best' approach. Thought-provoking and humorously critical expressions of such modus operandi are voiced in the literature (Golick, 1978; Lazarus, 1974), and serve to highlight the futility of such an approach.

An explanation of this definitional chaos is that the interrelationships between learning disorders and biological, educational, socioeconomic and psychological variables are confusing and have long presented a problem at the most basic level of science, namely, nosology (Hobbs, 1975). This problem continues to present a major and persistent hurdle to progress in the area of childhood learning disorders, and is nowhere more clearly apparent than in attempts to define learning disability. Historically, the method of classification has been based on the criterion of major handicap, which essentially reduces to the principle of homogeneity by exclusion (Myklebust, 1968; Strauss & Lehtinen, 1947). That is, learning disability was, and continues to be, defined as a major handicap when the behavioural signs (achievement criterion) occurred in the absence of other major handicaps, for example, intellectual retardation, sensory impairment and gross neurological damage (Clements, 1966). Some authors have further restricted this diagnostic classification by excluding other major handicaps, for example, sociocultural deprivation (Eisenberg, 1966) and emotional problems (Myklebust, 1968).

The definition established by the National Advisory Committee on Handicapped Children (NACHC, 1968) represents a synthesis of major aspects of previous definitions. It states:

> Children with special learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written languages. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or to environmental disadvantage. (p. 4)

Although most widely accepted and most frequently employed, the NACHC definition has been criticized on many grounds. Stauffer, Abrams and Pikulski (1978) raise objections because of its sweeping nature and inclusion of many unclear terms. For example, the term "basic psychological processes" is open to interpretation from a neurological approach, a psychological approach, and a school skills approach, each singly valid, yet each excluding the others (Wiederholt, 1975). Secondly, the term appears to be used in at least two ways. For some practitioners it is an educational-behavioural term signifying reading or arithmetic disabilities. Other practitioners, however, employ the term etiologically as an explanation of the problem (Stauffer, Abrams & Pikulski, 1978).

The NACHC definition is among a list of conflicting definitions compiled by the NINDS Task Force (Chalfant & Scheffelin, 1969). Despite differing terminology, there is a substantial degree of agreement among definitions, approaches and classification systems (Hallahan & Kauffman, 1976; Johnson & Morasky, 1977). The following have been identified as major areas of agreement: academic retardation; general involvement of the central nervous system; uneven pattern of development; exclusion of primary physiological problems;

and exclusion of some special problems (i.e., mental retardation, emotional disturbance, socioeconomic disadvantage).

A number of these commonalities have been questioned. Campbell (1979) has criticized the principle of discrepancy. Learning disability is now legally defined in terms of a discrepancy between intelligence and achievement, achievement in academic areas being lower than would be expected on the basis of IQ (Education for All Handicapped Act, 1975, Public Law 94-142). Such a definition is both overinclusive and underinclusive. Campbell (1979) presents cases of a child with specific cognitive disabilities who would not be included in the definition and of a child with family and emotional problems who would be included, in both instances to the child's disadvantage. In addition, there is no consistent agreement in terms of how far behind a pupil should be in order to be classified learning disabled, and the frequently used formulae for quantifying learning disabilities have yet to be validated (Chapman, Boersma & Janzen, 1978).

If we view learning disabilities as lying on a continuum of degree (Sanders, 1979), the role of central nervous system damage at the mild end of the continuum is not clear. The role of brain damage in moderate and severe learning disabilities cannot be denied, but it is not clearly understood. While many learning disabled children show evidence of psychoneurological abnormality, other children with severe neurological impairments demonstrate no apparent difficulty in learning (Black, 1973; Shields, 1973).

Attempts to exclude other major handicaps can be explained in terms of the need to classify on the basis of the criterion that makes for the greatest homogeneity in the subpopulation. Thus, by classifying on the basis of major handicap, one is able to define a smaller and, presumably, less heterogenous, diagnostic group. The categorical separation of learning disability from mental retardation and emotional disturbance has been questioned by Hallahan and Kauffman (1976), who demonstrate commonality of etiological factors and of teaching methods in all three conditions. Furthermore, it has been argued that children with emotional-behavioural problems should probably not be excluded because of the disproportionate increase in these problems in disabled learners over time (Critchley, 1968; Eisenberg, 1966; Kline, 1972). Similarly, children from disadvantaged backgrounds who, nevertheless, have at least average intellectual ability, should likewise not be excluded (Bloom, 1964; Davies, Butler & Goldstein, 1972).

A sharpening and a refinement of the concept of learning disability resulted from the National Project on the Classification of Exceptional Children under the direction of Nicholas Hobbs. A jointly authored article by Wepman, Cruickshank, Deutsch, Morency and Strother (1975) contains a newly formed definition. The definition limits the number and types of children identified as learning disabled by placing emphasis upon perceptual functioning. Etiological and other contributing factors to the disability are of secondary importance, as the disability must be expressed through a perceptual or perceptual-motor handicap in order to be so labelled. Hallahan and Kauffman (1976) argue that it would be more appropriate to regard the definition of Wepman and associates as one of "perceptual disabilities." While perceptual or perceptual-motor handicaps are present in many learning disabled individuals, attempts to determine the perceptual basis of other learning disability symptoms, equally as inhibitory to learning, run into theoretical difficulties.

Consequences resulting from a lack of a reliable definition of learning disability are strongly voiced by Senf (1977) when he writes that "if we cannot define those children who represent the kernel of our concern, then we shall never generate an informational base concerning their problems; nor shall we ever be able to extend that knowledge to those with less severe problems or associated disorders" (p. 539).

The greatest difficulty appears to lie in the failure of establishing specific criteria for inclusion, with an accompanying ease of stating what the category is not (Greenlee & Hare, 1978). The exclusion clause will ultimately have to give way to systems based on specific skills and schemas.

One such schema has been suggested by Sabatino and Miller (1980). They state that learning disabilities as currently ascertained are not a diagnostic entity, neither does the term describe a meaningful population or provide the data useful for meaningful instructional management or placement. As a result, Sabatino and Miller propose two critical features as essential to the understanding and assessment of any broad diagnostic category such as learning disabilities. These criteria are based on individual achievement motivation with its three interrelated components of anxiety, self-perceptions and teacher expectancies, and on unique learning styles expressed in the classroom environment. Similarly, Smith and Polloway (1979) argue for individualized education focusing on the children's needs rather than on their problems.

Recognition of the extreme heterogeneity of the learning disabled population must be acted upon. Both theory and research methodology need to be diverse, and attempts at arriving at a definitive categorization of learning disabilities must be abandoned (Regér, 1979). Changing the conceptual context within which the label "learning disabled" is used is what is needed in the field. Used as a concept and not a category, the term "learning disabilities" would provide a much needed unifying theme to learning problems, generally, especially if emphasis is placed upon specific behaviours, and patterns of abilities and disabilities. Recognition of individual differences should be the principle guiding the educator's task in practice, and not merely in words (Hallahan & Kauffman, 1976).

The Problem of Assessment

Precisely what constitutes a learning disability, therefore, remains a controversial issue. Formulations of cause have been numerous, each one following closely on the heels of its predecessor, yet still we are no closer to solving the mystery of learning disabilities. The only thing that we can say with a high degree of certainty is that "there are some children in regular classrooms who for some unidentifiable reason have difficulty learning" (Chapman, Boersma & Janzen, 1978, p. 284).

Because of such a state of affairs, Grossman (1978), detecting perhaps a feeling of despair, finds it necessary to warn that "we must be careful lest we close the doors to any theory which, whatever its present state, might prove to be a fruitful one" (p. 123). He further reminds us of our duty to ensure that "every student in need get just as much service as is humanly possible, until a final solution might be available" (p. 123).

Problems in definition have logically led to problems in the diagnosis and remediation of learning disabilities. In order to help the child with a learning difficulty, we must first be able to identify him. Despite numerous screening programmes for the early identification of learning disabled children, or "children at risk," the first manifestation of a difficulty in learning is often in the school setting. While development of effective preschool assessment procedures continues to be of utmost importance, the concerns of the present study centre about the identification of learning disabilities in children of elementary school age.

In a very general sense, the objective for educational systems is to advance learning. A means of doing this is through successful diagnosis of children in need. A suitable diagnosis enhances learning through the institution of appropriate remediation, while a faulty diagnosis can lead to treatment that limits the child's progress. Essentially, successful diagnosis results in a teaching-learning environment that better meets the needs of the student.

To help meet these needs, psychological assessment is usually requested to place a child in an appropriate educational setting or to plan an intervention programme. By psychological assessment is meant the "systematic use of a variety of special techniques in order better to understand a given individual, group, or psychological ecology" (McReynolds, 1971, p. 2). In educational terms, however, understanding an individual is not enough. In addition to understanding, the purpose of assessment procedures in education is to help in making decisions (Beggs & Lewis, 1975; Cronbach & Gleser, 1965). It is in this sense that psychological testing like any other technique must be evaluated in terms of the adequacy of its basic assumptions, its helpfulness to persons seeking treatment, and its contributions to actual decision making (Breger, 1968).

Apart from the medical model, one of the traditional approaches to the assessment of learning disabilities has been the psychometric approach. In the latter, reliance on standardized testing yielding normative data has been the focal element. In accordance with the NACHC definition of learning disabilities, the search has been for a disturbance in "one or more of the basic psychological processes" (1968, p. 4). The assumption here is that there are specific abilities that are prerequisite to the acquisition of academic skills and that academic failure is caused by deficits in these abilities. When a child is failing in school, a battery of tests is administered in order to determine the ability deficits. Remedial programmes are then instituted, which aim at developing those skills in which the child is deficient. It is believed that improvement in the basic ability will be parallelled by a comparable improvement in academic achievement.

The validity of this approach has been seriously questioned. Hammill (1971) criticizes the approach on the grounds that it lacks educational relevance. He states that knowledge of IQ, reading level, or neurological status, while interesting and useful, does not provide sufficient information with which either to establish appropriate goals or to construct a reality based training programme for a specific child. Similarly, Mann (1971) calls for improved education of the learning disabled child on the basis of appropriately determined goals. This is most effectively accomplished through a focus on products (achievements) rather than on processes (abilities).

A concern with achievement and its prerequisite skills is the hub of the task analysis approach espoused by, for example, Ysseldyke and Salvia (1974). This approach centres about the assessment of current child characteristics and prescription of specific interventions based on the child's current level of academic skill development. There is no recourse to inferred internal constructs, and the primary assumption of the task analysis model is that elements of the task interact with the skills that are prerequisite to the successful completion of an academic task. Both the task and the skills need to be assessed for intervention to produce desired results.

It might be noted at this point that the two approaches need not be mutually exclusive. A combination of the ability training and task analysis approach is proposed by Eaves and McLaughlin (1977) and Laycock (1978), among others. Eaves and McLaughlin, for example, state that a systematic assessment approach that places various available methods in perspective must be developed. The approach should have broad applicability and take all relevant variables into account. They argue that proponents of task analysis should give careful consideration to their criticism of standardized tests on the grounds that they do not contribute to the formulation of educational objectives. For the value of standardized tests lies not in specifying almost microscopic objectives, but in deciding whether or not these diminutive objectives need to be specified at all. The assessment procedure proposed by Eaves and McLaughlin is tri-phasic: screening (mush); clinical assessment (melon); and follow-up assessment (rock). There is progressive elicitation and elucidation of the individual's strengths and weaknesses.

In a much stronger defence of the process approach to assessment, Torgesen (1979) writes that much of the criticism directed at this approach is valid, primarily because those involved in the ability training model have used inadequate measurement devices and conceptualizations of the processes involved. Psychological processes cannot reliably be measured by a single operation. As Flavell (quoted in Torgesen, 1979) states: "Every task demands from the child knowledge and skills other than, and in addition to, the target concept or ability it was designed to tap." Psychological processes are more reliably measured if critical features of the task are manipulated, and it has been shown that subprocesses involved in specific tasks in specific settings can be measured and trained. By way of integration of the process and task analysis approaches, the identification process responsible for poor learning should start by analyzing the task rather than the child. Torgesen concludes that the notion of deficiencies in the processing activities required for learning is essential to the maintenance of concern with learning disabled children as a special subgroup within the general population.

Writing in a similar vein, Smead (1977) cautions against the premature abandonment of the ability deficit model. She notes that, from a diagnostic-prescriptive point of view, both the ability model and task analysis model are full of shortcomings, although the latter meets diagnostic-prescriptive criteria more successfully. Essentially, both approaches fail to take into account the motivations, values and attitudes of the learner. In a review of some of the studies critical of the ability model, Smead concludes that, while certain assumptions of that model appear invalid, the crucial notion that stable individual differences in certain abilities may be present and capable of being assessed and remediated has not been negated. As in Torgesen (1979), measurement difficulties are again cited as the major pitfall of the ability approach. But, the task analysis model too is not without blemish, as the existence of hierarchies of knowledge is questionable. Smead concludes that both models need to be extended to allow adequate coverage of the teaching-learning environment and need to be used in conjunction. The ability model is retained because of its concern with individual differences and causal explanations; the contribution of the task analysis model lies in its more complete coverage of the diagnostic testing arena.

Recently, Hardin (1978) proposed the application of a fairly new approach to the assessment of learning disabilities. Viewing both ability and task oriented assessment techniques as too restrictive and incomplete, she suggests an "ecological" model, the term ecology implying the "study of the interactions and interrelationships of living organisms with their environments" (p. 15). The environments to be explored are the unique conditions within the child, influences within the school, and dynamics within the home. Understanding the three sets of conditions in combination results in the identification of needs in the cognitive and affective domains, and the establishment of intervention priorities based on the identified needs. In turn, intervention priorities guide the selection of instructional materials.

In the ecological model standardized tests are not excluded, but the emphasis is on appropriate analysis. Thus, the important information is not a normative score or profile but rather an understanding of the behaviours that contributed to the level or score attained. Also, informal assessment complements formal assessment, and in many instances is more fruitful in suggesting teaching interventions (Smead, 1977).

The concept of informal assessment is based on sound logic. Few people, even the most ardent of psychometricians, would disagree that behaviour seen in the testing situation is seldom replicated outside of it, where many other forces impinge upon the individual to produce behaviour. The role of the teacher, therefore, and parent, assumes critical proportions, for these are the significant others who are in daily contact with the child, and understand the child far better than even the most accomplished psychometrician.

The ecological model for the assessment of learning disabilities augurs well for the future. Its greatest value lies in that it places the individual in the context of the many interrelated environments which interact to produce behaviour. The model incorporates a number of proposed alternatives with ease. Ecological assessment would include the assessment of achievement motivation and learning styles (Sabatino & Miller, 1980), attitudes and values (Smead, 1977), physical abnormalities (Pihl, 1979), and social contexts (Coles, 1978), and would utilize both task analysis procedures (Ysseldyke & Salvia, 1974), and techniques for the measurement of processes, or abilities (Torgesen, 1979).

One of the environments that the ecological model explores is the environment within the child. While controversy regarding the relevance of psychological processes to diagnosis and remediation continues to be prominent in the field, there is increasing realization and acceptance of the fact that affective variables play an important role in a child's performance in school. Chapman (1979) states that "the consequences of negative affective characteristics in learning disabled children may lie in the perpetuation of their low levels of academic achievement" (p. 153). It is important, therefore, to consider factors other than cognitive when assessing the learning disabled child.

The focus of the present study centres around the use of selected cognitive and non-cognitive measures as these differentiate between learning disabled and normally achieving children. In selecting a test battery, one thing appeared obvious from the above discussion. There is no final solution or remedy either to the problem of definition of learning disabilities or the ensuing problem of diagnosis and remediation. Risks need to be taken. Such risk-taking may involve the use of less than proper diagnostic instruments and training procedures (Hagin & Silver, 1971). Above all, however, it must be responsible risk-taking.

Realizing that an optimal test battery for the assessment of learning disabilities has yet to be discovered, for purposes of the present study, the risk involves the use of a test battery which is, in effect, a marriage between old and new. The old is represented by the Bender Visual Motor Gestalt Test and the Wide Range Achievement Test; the new by the Visual Aural Digit Span Test and the Student's Perception of Ability Scale. These instruments will be detailed, and rationale for their inclusion presented in chapter 3. The ensuing chapter will deal with a review of the literature, as it pertains to the constructs measured by these instruments.

CHAPTER 2

REVIEW OF LITERATURE AND RESEARCH

Kirk (1972) has urged that we deemphasize our concern with causes, for with learning disabled children the cause is frequently nebulous, often unknown and frequently irremediable. It is for this reason that Kirk proposes the term "correlates" be used instead of "causes," since the emphasis should be primarily on educational correlates or factors relating to the functional behaviour of the learning disabled child.

When Kirk writes of "correlates," he is speaking about those psychological processes that are assumed to underlie learning and achievement in school, and which form the nucleus of the ability deficit model. It was noted in chapter 1 that there is deep-rooted disagreement with regard to the ability deficit model of learning disabilities (Ysseldyke & Salvia, 1974). It was also noted, however, that continuing interest in psychological processes not only is essential for the preservation of concern with learning disabled children as a special subgroup within the general population (Torgesen, 1979), but is also needed to complement other approaches to diagnosis and remediation (e.g. Smead, 1977).

Premature abandonment of the assessment of psychological processes appears unwise, if for no other reason than that we do not yet fully understand the nature of psychological processes as they contribute to various types of disorders. The concerns of the present study revolve around particular variables that frequently have been found to be associated with learning disabled children. Specifically: perceptual-motor ability, auditory-visual integration, and affective variables. These factors, as they relate to the learning disabled child, will be reviewed in the following sections.

Perceptual-Motor Ability

Concern with perceptual difficulties was present at the inception of the field of learning disabilities as a distinct area of knowledge. Gradually, the focus shifted from the study of perceptual dysfunctions in brain-injured children to the study of perceptual disturbances experienced by otherwise normal children in the school setting. Of all the senses, vision has been the most emphasized in the field of learning disabilities. Coupled with this emphasis on visual perception has been the development of numerous educational programmes geared towards the remediation of visual-motor deficits. The underlying assumption of many of these remediation programmes was that appropriate perceptual development is essential to adequate conceptual development (Hallahan & Kauffman, 1976).

The best known in the field is Kephart (1971). He postulates that the child's first encounter with the environment is through motor activity. With maturation, and through building a hierarchy of motor skills, the child learns to experience the world perceptually by matching his perceptual experiences with his motor experiences. That motor development precedes perceptual development has been questioned by Gibson (1969). In her studies of infants, she demonstrated the presence of depth perception in infants by at least 6 months. She argues that if the child has not yet developed depth perception, then he cannot manage the teaching and manipulating behaviour that is necessary for him to learn about his environment.

While the order in which the two skills develop has been objected to, the importance of the interaction between the two is generally agreed, although there might be differences in emphasis. Barsch (1965), for example, stresses the role of motor activity. According to him, learning difficulties are deficits in movement efficiency. Frostig (1976) emphasizes perceptual training in a programme integrating sensorimotor, perceptual, and language training. She states that such a programme has been found optimal for children who suffer from learning deficits.

With the development and ready acceptance of perceptual-motor programmes into many educational curricula, attempts have been made to assess the relevance of perceptual-motor abilities to school learning and achievement.

Lovell, Shapton and Warren (1964) administered a battery of tests to a group of retarded readers, whose mean age was 9.8 years. Results showed that retarded readers exhibited no deficit in performance on an oral test of language, but performed poorly on tests involving spatial relationships, showed directional confusion, made errors in copying words and rotated drawings of abstract designs. Similarly, Shankweiler (1964), upon examination of 12 cases of reading disability, concluded that dyslexia was a disorder of visual perception, often occurring independent of any defect in oral language development.

Lyle and Goyen (1968) investigated the performance on visual recognition tasks under immediate, delayed and sequential conditions. In all three conditions retarded readers performed less well on recognizing letters, lines and shapes. The authors concluded that this was due to a generalized perceptual deficit, which appeared to be greater at younger age levels. Subsequent to this, Lyle (1969) suggested that two factors might be related to reading difficulties. One factor comprised of tasks with a strong perceptual component, while the second factor consisted of items requiring verbal skills. On this basis, Lyle concluded that two types of reading retardation exist. One is non-verbal and related to perceptual skills, the second is verbal. In particular, the perceptual factor plays a big role with children below 8 years.

An article by Gredler (1972) provides a useful summary of investigations into perceptual deficits found in dyslexic children. In agreement with the work of Lyle and Goyen cited above, the author emphasizes that visual perceptual ability operates most strongly in the early stages of learning to read and that this deficiency is not the sole factor producing dyslexia but combines with other deficiencies. Concurring with the latter, Clark (1970), after testing all children in the County of Dunbartonshire, Scotland, (N=1544), who were born between April 1 and August 31, 1959, concluded that the striking finding was the diversity of disabilities and not an underlying pattern common to the group of retarded readers.

The perceptual deficit hypothesis of reading disability has been refuted most strongly by Vellutino and associates (Vellutino, 1978; Vellutino, Steger & Kandel, 1972). In one study (Vellutino et al., 1972) subjects were required to reproduce from memory verbal and non-verbal stimuli first by copying, then by reading. There were no differences between poor and good readers in copying both verbal and non-verbal stimuli. However, the poor readers' performance on the oral reading task was often incorrect. The authors concluded that poor readers are able to process visual representations as well as normals, but find it difficult to integrate and retrieve the verbal equivalents of such input. Moreover, perceptual errors that do occur in the process of reading are manifestations of a reading disorder, and not the cause.

Fletcher and Satz (1979) comment that any unitary deficit explanation, be it a perceptual deficit or deficit in some aspect of verbal mediation, is too simplistic. As Satz and Van Nostrand (quoted in Fletcher and Satz, 1979) state, it seems that perceptual problems are characteristic of poor readers at lower age levels, while linguistic deficits are more apparent in older poor readers, i.e., beyond 9 years.

Sex differences have frequently been observed in connection with perceptual and perceptual-motor abilities and reading. Lovell, Gray and Oliver (1964), after testing a group of 14 and 15-year-olds, reported that differences were seen in visual perception between males in the sample, but not the females. Lawrence and Potter (1970), in a study of children between the ages of 4 and 8 found that children with functional articulation defects also had concomitant defects in the area of visual-motor integration, but that this was true only of males. Similarly, in Coleman's (1968) sample of 90 children from grades one to six, who had been referred for severe language arts and specific reading performance deficits 30% of the children were found to have a visual perceptual disturbance, while almost 50% had some sort of visual problem. These disturbances occurred in a significantly higher number of males than females in the primary grades.

The contribution of component parts of visual-motor functioning has also been investigated. Crary and Ridgway (1971) examined the interrelationships of visual discrimination, visual-motor copying and visual-motor memory abilities to reading achievement. While all three abilities were related, visual discrimination was the best predictor of reading achievement. Chissom (1971) studied the relationship of motor factors to academic criteria between first graders and third graders. Factor analysis yielded three factors: balance, dynamic strength, and gross motor co-ordination. The factor structuring of motor skills was stable over time; however, a significant relationship existed between motor abilities and measures of academic aptitude and academic achievement for children in the first grade only. He concluded that perceptual-motor training would be more successful when administered to younger children.

Symmes and Rapaport (1972), working from a multi-antecedent multi-consequent model, studied a group of children between the ages 7 and 13. The children were screened to exclude those with a poor medical history, sensory impairment, chronic illness, seizures, history of a serious accident, and prenatal and perinatal conditions relating to fetal anoxia. Their results suggested that the association of immaturity in visual-motor functioning that is frequently related to reading difficulty appears only in populations heavily biased in the direction of attendant neurological signs. An interesting finding of the study was that children experiencing reading difficulties were superior in three-dimensional spatial visualization. The authors suggested that the frequent reversals found in these children's reading performance may be due to their encoding two-dimensional forms (e.g., b d) as relating to one three-dimensional form.

Several authors have attempted to show the relationship of visual-motor ability to reading skills and school achievement utilizing a pre-test post-test research design. Ames (1969) identified a number of grade two children in need of perceptual training. After 6 weeks of training in visual-motor activities, the children were retested on a series of tasks. The experimental group had improved significantly, but they were still far behind the average age expectation in terms of visual-motor development. By contrast, the control group had fallen further behind. It was concluded that perceptual training can help a child who is lagging developmentally to perform at his highest potential developmental level. On the other hand, those children who are behind will fall further behind if curative measures are not instituted. Elkind and Deblinger (1969) approached the question of perceptual training from Piaget's theory of decentration. According to this theory, perception moves in the direction of increasing independence from dominant aspects of the visual field to a position in which one explores, reorganizes and anticipates elements in the visual field. This perceptual development is related to reading in that the child must be able to synthesize, explore and scan the printed page, and schematize the letters as words. He must be aware that the same letter can have different sounds in different contexts. In addition, he must be able to transport and anticipate meaning among words and sentences. Elkind and Deblinger matched a group of second-grade Negro children for reading achievement and perceptual ability. The experimental group were trained on a series of non-verbal perceptual exercises for one half hour 3 times a week over a period of 15 weeks, while the control group were given a commercial reading programme. Following training, results revealed that the experimental group had made significantly greater improvement on word recognition and word formation than the control group. These results speak in favour of perceptual training, but the authors stress that this type of training should be coupled with verbal methods for greatest effectiveness.

The studies reviewed up to this point have all dealt with some aspect of reading difficulty. Before reviewing a number of investigations that have utilized the Bender Visual-Motor Gestalt Test (Bender, 1946) as it relates to school achievement, the relationship of visual-motor ability to achievement in mathematics will be noted.

The area of a specific learning disability in arithmetic remains under-researched. The work that has been done suggests that poor visual-motor performance can be detrimental to performance in arithmetic (Wedell, 1973). Smith (1969) includes visual and auditory memory together with visual-motor ability as basic skills requisite to satisfactory performance in arithmetic. Johnson (1979) writes that, whereas the exact nature and importance of perceptual-motor skills in the total learning disability field is currently being debated, there is no argument that much of the performance behaviours necessary in arithmetic demand activity of this type. Problems affecting this segment of learning behaviour present major hurdles to the developing arithmetic pupil.

The possible value of sensorimotor activities in mathematics achievement was highlighted in a project conducted by the International Association for Evaluation of Educational Achievement in Mathematics, reading comprehension and science. The principal factor examined was the age of entry into school and achievement at age 10 and 12. In a review based on this work, Austin and Postlethwaite (1974) concluded that there may be some interaction between age of entry, sensorimotor activities, qualitative planning, and the effect of background on the attainment of intellectual objectives in mathematics. They suggest a closer examination of these variables as they relate to reading comprehension and science.

Many studies examining the relationship of perceptual-motor functioning to school achievement have utilized the Bender. As part of her work at developing a scoring system for the Bender for use with young children, Koppitz (1963) states that visual-motor perception underlies school achievement in the elementary grades in three basic ways: a) the child must be able to perceive a design as a limited whole and be able to control his actions with regard to the stimulus figures; in this respect, he must be able to perceive and understand the beginning and end of a word; b) the child must have the ability to perceive and to copy designs in regard to direction and form, i.e., the ability to write letters correctly and to follow a written word from right to left; and c) he must have the ability to integrate parts into a whole Gestalt, i.e., ability to form whole words out of single letters and to understand that one and one make two.

Initial investigations by Koppitz (1958) showed that the Bender could differentiate between above average and below average students in the first four grades of school. Keogh (1965) found that the correlations between the Bender and reading criteria were significant, but their magnitude was too small to allow confident individual predictions of reading. Rather, the Bender performance reflected the general pattern of school performance. In this respect, poor scores were not good predictors of overall school functioning, whereas good scores were correlated with several areas of maturity pertinent to reading. Keogh concluded by recommending the Bender as a screening technique for the identification of children likely to be successful in the school programme.

A study by Coy (1974) showed that, overall, the Bender failed to predict reading and mathematics achievement in the third grade. He offered the explanation that the Bender may not be sensitive to reading and mathematics difficulties involved in reading and mathematics at this age level, and that there are probably other factors in operation besides visual-motor impairment as measured by the Bender. However, one isolated scoring category was a good predictor in discriminating between high and low readers, the category of integration errors. Becker (1970) placed 64 children of average age 6 with normal intelligence in two groups, distinguishing them by the number of errors of spatial orientation that they had made on the Bender. It was found that inaccurate spatial orientation in Bender test reproductions was related to inferiority in perception of order of letters in words.

Werner, Simonian and Smith (1967) tested 90% of children born in Hawaii in 1955 when they were between 10 and 11 years old. Comparing their results with those of earlier studies, the authors concluded that the correlation between the group administered Bender error scores and both reading grade and reading test scores was significant but less pronounced than had been found previously. In addition, they found that, with intelligence controlled, inadequacy in language functioning rather than level of perceptual-motor skills discriminated most children with reading problems in the upper elementary grades. Similar conclusions were reached by Nielsen and Ringe (1969) as a result of their study of 20 Danish children, aged 9 to 10. They stated that it is probable that the Bender and other perceptual tests (Draw-a Man, Frostig tests) do not differentiate good and poor readers at this age.

Ackerman, Peters and Dykman (1971), using a sample of elementary school boys between the ages of 8 and 12, found that 67% of the learning disabled group as opposed to 44% of the control group made more errors than the mean of equivalent age scores in Koppitz' normative sample. There were, therefore, many false positives and many false negatives. Overall, only 24% of the learning disabled group had a marked visual-motor impairment. On the other hand, Egeland and Dinello (1972), investigating the interrelationship between psycholinguistic abilities, visual-motor skills and achievement in grades three through five, concluded that the visual-motor index, as measured by the Bender, was the one independent variable contributing in a significant way to the multiple correlations for achievement in vocabulary, reading and arithmetic.

Finally, a review of 60 studies using visual-perceptual ability measures was carried out by Larsen and Hammill (1975). The combined result of the correlational research treated in the paper suggested that measured visual-perceptual skills are not sufficiently related to academic achievement to allow reliable predictions. It was suggested that more studies of a longitudinal nature be undertaken to determine the true validity of these constructs and their relationship to school learning.

Evidence on the relationship of perceptual-motor skills to school learning and achievement is certainly contradictory. The only area of some agreement is that visual-perceptual difficulties are not consistently associated with learning difficulties in older children, although they may be more important in younger children (Benton, 1975; Satz & Van Nostrand, quoted in Fletcher & Satz, 1979; Rutter & Yule, 1973).

In terms of the present study, involving third grade pupils, it is predicted that the learning disabled children will demonstrate inferior visual-motor ability. Furthermore, it is predicted that visual-motor performance will contribute substantially to the correct classification of learning disabled and normally achieving children.

Auditory-Visual Integration

The field of learning disabilities has long been characterized by a concern with how children process information (Bryan & Bryan, 1978). Theories, assessment techniques and remediation programmes have focused upon the way in which the learning disabled child receives and utilizes sensory information in performing academic tasks. In this respect, modality systems have provided structure for analysis.

The dichotomy between visual and auditory processes is useful in differentiating between a child's strengths and weaknesses. Identification of strengths and weaknesses carries with it implications for remediation. Some educators (Sabatino & Hayden, 1970) recommend teaching to the child's strengths, whereas others (Hallahan & Cruickshank, 1973) argue that remediation attempts should be directed toward improving the child's ability to process information in the deficit sensory channel.

Kirk and Kirk (1971), however, state that both the deficit oriented and the strength oriented approaches neglect the role of intersensory integration in learning. The assumption that improvement through training in one modality will generalize to other modalities and result in an overall improvement of perceptual functioning is questionable, particularly in the case of children with intersensory integration deficits. They also point out that concentration upon the child's strong, or preferred, modality serves only to widen the gap between abilities and disabilities that existed prior to remediation, and this, in turn, further hinders the development of intersensory integration.

Most classroom activities make many simultaneous demands on children. A child's cognitive processes may be intact for functions within a system, but break down when required to convert from one system to another. Of the processing systems, audition and vision are the two major teloreceptor systems that are critical not only for the development of skills, generally, but academic competence too. Of particular note is the fact that the development of integrative organization between auditory and visual systems appears to be essential for the acquisition of such a primary educational skill as reading, a problem area for a great majority of learning disabled children. Reading, in order to be effective, requires the integration of visual information with other information such as spatial direction and temporal sequence.

The establishment of auditory-visual correspondences is an essential aspect of learning not only reading, but spoken language, writing, and spelling, as well as arithmetical operations. Without these auditory-visual correspondences, children will have difficulty understanding the complex concepts in the world about them, and will fail to develop the increasingly sophisticated skills required to deal effectively with such concepts (Chalfant & Flathouse, 1971).

There are differing viewpoints as to the nature and development of sensory integration. While these lie outside the scope of the present review, it will be sufficient to note that certain authors believe that sensory integration is a result of maturation and experience (Birch & Belmont, 1964; Birch & Lefford, 1967). Others argue that the senses are integrated at first and are differentiated with experience (Bower, 1974). Still others contend that the senses are integrated at all times and that improvement is within a modality (Gibson, 1969). The focus of the following review will be on the studies that have investigated the role of intersensory integration in the performance of academic tasks.

Birch and Belmont (1964) found that children with reading difficulties have problems in transferring from one sensory modality to another. Beery (1967), in an elaboration of the above study, argued that the ability to match auditory stimuli preceded by visual stimuli corresponds more closely to the process of reading, since visual stimuli initiate the matching process. She tested, therefore, the ability to match both auditory-visual, and visual-auditory sequences. Her conclusion was that, regardless of whether the standard was auditory or visual, the ability of the dyslexic children to make comparisons between auditory and visual stimuli was significantly inferior to the average readers. Similarly, Muehl and Kremenack (1966) found that visual-auditory and auditory-visual integration not only predicted reading, but was also significantly related to letter naming ability.

Lovell and Gorton (1968) factor analyzed the performance of a group of backward readers and a group of normal readers on a battery of nine tests. For the reading deficient group, Factor I accounted for 48% of the variance and suggested a dimension of neurological impairment, specific in nature; it correlated highly with tests of auditory-visual integration. In the normal reading group, Factor I was related to language and correlated substantially with auditory-visual integration and sound-symbol association.

The developmental course of auditory-visual integration was studied by Birch and Belmont (1965). The most rapid growth in auditory-visual equivalence was in the earliest school years, between the ages of 5 and 7, reaching an asymptote by the fifth grade. Additionally, it was found that correlations obtained between IQ and auditory-visual integration were associated but not synonymous. In contrast, the correlations between IQ and reading ability rose with age. The authors concluded that, in acquiring reading skills, primary perceptual factors are most important for initial acquisition, but more general intellectual factors are more important for later elaboration of that skill.

The report of an asymptote in auditory-visual integration by the fifth grade was questioned by Reilly (1971). Overall, while results of his study suggested that ability to integrate auditory-visual stimuli was significantly related to reading achievement, the development of that ability is different for boys and girls. Girls develop this ability to a higher level of success earlier than males and it reaches an asymptote by about grade four. For males, on the other hand, the ability develops later, not reaching significance until the second grade, and still developing at grade four level.

It had been stated that the levelling off of ability in auditory-visual integration by grade five may have been due to the low ceiling of the test (Birch & Belmont, 1965). To obviate this flaw, Kahn and Birch (1968) extended the original test to include more difficult items. They studied the relationship of auditory-visual integration and reading achievement in 350 elementary school boys in grades two through six. Auditory-visual matching improved with age and correlated significantly with reading achievement. This association continued even when IQ was partialled out. In addition, visual and auditory discrimination skills, rote memory and application of verbal labels to the physical stimuli were examined as possible mediators of auditory-visual integration. None of the mediators examined satisfactorily accounted for individual differences in auditory-visual integration, with verbal mediation being the least effective.

The latter finding is in sharp contrast to the results of a study by Blank, Weider and Bridger (1968). Blank and his associates found that, generally, the retarded readers were inferior in labelling temporal sequences, whether visual or auditory, tending particularly to omit the pauses which spaced out the temporal sequences. They concluded that, regardless of whether the task is intramodal or cross-modal, retarded readers will have difficulty in coding those aspects of the task which demand a high level of abstraction. Some support for this is provided by Cashdan (1972) who concluded that the main difficulty of poor readers was in attending to and labelling rhythms, rather than in auditory-visual integration as such.

One of the criticisms levelled at Birch and Belmont's study (1965) was that the test used for determining auditory-visual integration may have been confounded by the method of presentation. The auditory stimuli were presented through a series of taps made with a pencil in full view of the subject. The question was: to what degree does that particular test reflect the ability to transpose from temporal to spatial formats within the visual modality, rather than the ability to transpose between audition and vision?

In answer to this question, Sterritt and Rudnick (1966) investigated the ability to transpose between temporal and spatial formats within the same modality (visual), and between modalities (auditory-visual). They found that the former did not differentiate good from poor readers at grade four level, whereas the ability to transpose from auditory-temporal to visual-spatial may be the critical function. The study was replicated on grade three children (Rudnick, Sterritt & Flax, 1967). While both intramodal and cross-modal temporal to spatial transpositions were successful in predicting reading achievement, the translation of visual-temporal to visual-spatial sequences was the best predictor of reading achievement for the third grades. Combined results from the two studies suggest that individual differences in visual perceptual abilities become less important to reading progress with time, and that variations in auditory perceptual abilities and/or ability to transpose between audition and vision may become more important. More specifically, with regard to the latter, the ability to transpose between auditory-temporal and visual-spatial becomes increasingly important, a finding corroborated by Goodnow (1971).

That auditory perception or visual perception per se may be accounting for differences in auditory-visual integration has been investigated. Katz and Deutsch (1964) studied auditory, visual and auditory-visual serial learning in relation to poor reading achievement.

They found that retarded readers performed poorly on auditory tasks, whereas their visual learning skills were almost equivalent to those of the normal group. Vande Voort and Senf (1973) found that accurate perception of complex stimuli in both auditory and visual modalities contributed to variations in performance on auditory-visual integration tasks. Zurif and Carson (1970) point to difficulties in dealing with temporal aspects of non-verbal information, both visual and auditory.

Differences in auditory-visual integration have been explained by variations in sequential memory. Doehring (1968) administered a battery of tests measuring reading and spelling related tasks to equal groups of retarded and normal readers. When the results were factor-analyzed, the chief factor of reading and spelling deficit was found to be related to measures of visual and auditory sequential processing. Bakker (1970) conducted a series of 3 experiments to determine the role of sequential memory in backward readers; he concluded that inferiority in remembering temporal sequences is associated with inability to order letters correctly in reading. Badian (1977) found that a short-term auditory sequential memory deficit appears to be a major factor in the inferior auditory-visual integration performance of retarded readers. Most recently, Amoriell (1979), using more educationally relevant phoneme-grapheme sequences, concluded that visual sequential memory for letters was the only task capable of distinguishing between retarded and normal readers.

Some authors have focused on attention as the crucial variable in auditory-visual integration. Sutton, Hakerem, Zubin and Portnoy (1961) measured reaction time to second stimuli in the same modality (ipsi-modal reaction time), as opposed to reaction time to stimuli in a different modality (cross-modal reaction time) in a group of schizophrenics and normals. The schizophrenics' cross-modal reaction time greatly exceeded their ipsimodal reaction times. The authors interpret the results to mean that attention, or maximal readiness to respond, is not equally available to all sensory inputs at any given moment in time. The occurrence of relevant stimuli in a given sensory modality predisposes the organism to be maximally ready for further stimuli in the same modality. When a further stimulus occurs in another modality, the organism is less prepared and, therefore reaction time is lengthened. Similar findings have been reported with brain-damaged individuals (Benton, Sutton, Kennedy & Brokaw, 1962).

The methodology of the preceding two studies was applied in a study of reading (Raab, Deutsch & Friedman, 1960). It was found that cross-modal shift reaction time was inversely related to reading achievement scores. Authors of that study pointed out, however, that the inability to shift set may be related to the efficiency of the organism's processes in scanning temporally connected events. Elsewhere, Katz and Deutsch (1964) found that retarded readers gave more extraneous associations to stimulus materials, a finding suggestive of an attentional impairment. However, it has also been argued that differences in shifting set in this type of a task may be due to poor response generalization (Katz & Deutsch, 1963), or the fact that there are two storage systems, one for each modality (Senf, 1969).

The findings cited above in connection with the ability of schizophrenics and brain-damaged individuals to shift set point towards a possible neuropsychological basis for differences in auditory-visual integration. Hernandez-Peon (quoted in Katz & Deutsch, 1963) found that the evoked potential of auditory pathways disappeared when a prominent visual stimulus was attended to. Shipley and Jones (1969) write that one important aspect of intersensory integration is its opposite, namely - clear and adequate separation of conflicting or irrelevant (i.e., inherently mismatching stimuli) intersensory perceptions. They found that not only do dyslexic children inadequately match intermodal forms, they inadequately disentangle intersensory distractions, irrelevancies and contradictions. Extending their study, Shipley and Jones applied the evoked brain potential technique to their group of dyslexics. Analysis of electrophysiological data showed a mixed pattern of bimodal interaction in dyslexics, with some evidence of inhibition, or, at very least, a lack of intersensory arousal. Generally, the bimodally evoked audiovisual brain responses in dyslexics were slightly reduced in amplitude (compared with their uninhibited unimodal ones) in contrast to the bimodal enhancement which has sometimes been found in normals.

The studies cited above assume that ability to integrate auditory and visual stimuli is modality specific. Jarman (1978) applied the simultaneous-successive synthesis model to an investigation of auditory-visual integration. According to the simultaneous-successive model of information processing, information received through the senses may be represented either simultaneously or successively regardless of the mode of information presentation. Thus, in the case of auditory information, which is successive, and visual information, which is simultaneous, both can be represented either successively or simultaneously in central processing. Task demands dictate the method of synthesis. Jarman's results indicated that simultaneous and successive central processes are involved in modality matching performance. Further, for the children in the study (fourth graders) it may be more appropriate to deliver instruction in terms of cognitive strategies and central processes used in different types of tasks. For younger children, sensory modalities may prove to be an important instructional variable.

In summary, most writers tend to agree that children with learning difficulties, particularly in the area of reading, are deficient in auditory-visual integration. A number of possible explanations for this deficit focus on the role of temporal to spatial transpositions, sequential memory, attention, and neurophysiological abnormality.

For the purposes of the present study, it is predicted that the learning disabled children will differ significantly from normally achieving children in their ability to process auditory and visual information integratively, and in their ability to process information sequentially. Furthermore, it is predicted that, on the basis of these differences, the learning disabled and normally achieving children will be correctly classified.

Affective Variables

Traditionally, products of learning are of overriding importance in educational systems. Much time and effort is spent in attempts to predict scholastic achievement as an embodiment of the systems' effectiveness. For the most part, cognitive, or intellectual, variables have been utilized to effect such predictions. It appears, however, that the current trend in education is moving in the direction of emphasis on humanistic aspects of education, which includes a consideration of non-intellectual factors (Shavelson, Hubner & Stanton, 1976).

One of the reasons for the shift in focus towards non-intellectual variables is that the validity coefficients of scholastic aptitude tests as predictors of achievement appear to have reached an asymptote in the area of about .50 (Borislow, 1962). The question being asked is - what factors, other than cognitive, contribute to the 75% of the variance left unaccounted for by aptitudinal measures? A factor of some import under increasing investigation is that of self-concept as it relates to academic achievement.

Educators have come to realize the importance of the self-concept, whether as an outcome (i.e., a goal in itself), or as a moderator variable which helps explain differences in achievement outcomes (Shavelson, Hubner & Stanton, 1976). Academic success or failure appears to be as deeply rooted in concepts of the self as it is in measured ability (Purkey, 1970), and there appears to be a direct relationship between the child's self-concept and his academic achievement (LaBenne & Greene, 1969).

By way of a formal definition, LaBenne and Greene (1969) define self-concept as "the person's total appraisal of his appearance, background and origins, abilities and resources, attitudes and feelings, which culminate as a directing force in behavior" (p. 10). Purkey (1970) elucidates the power of this force when he notes that once established, the self-concept provides a screen through which everything else is seen, heard, evaluated, and understood.

The relevance of education to the development of this screen is readily apparent. Purkey (1978) writes that the countless ingredients of self-concept are primarily social, and that next to the home, schools probably exert the single greatest influence on how students see themselves and their abilities. The point is strongly made by Bloom (1977) when he speaks of the latent curriculum which is uniquely taught to and differently learned by each student. The latent curriculum is that aspect of education which teaches the individual who he is in relation to others, and which is most strongly influenced by the judgements of those in the child's immediate environment. The person's immediate, effective, interpersonal environment greatly influences individual subjective appraisals of success (Coopersmith, 1967). It is from a person's actions and relative position within this frame of reference that he comes to believe that he is a success or failure. And among the most notable bases for judgements of success is academic performance, generally manifested by competence relative to the members of one's group.

Enhancement of subjective appraisals of success is best accomplished through a productive school experience, defined by Williams and Cole (1968) as an experience "in which the learner receives consistent, positive communication from the instructor and his immediate academic peer group concerning his ability and achievement" (p. 480). Anecdotal reports give evidence of just how unproductive a learning disabled child's school experience is likely to be. To be sure, the learning disabled child does receive consistent communication, but more often than not it is negative, and its source, unfortunately, is not always the peergroup. Parents, siblings, relatives, teachers, perhaps unwittingly at times, all attach labels (e.g., slow, clumsy) to the child experiencing learning difficulties, as if these were not enough. For the child suffering the oppressive and constant environmental reaction to his learning disability, the consequences are an invisible ocean of private inward suffering: depression, shame, anxiety, guilt, and constantly eroding self-esteem (Holmes, 1975). As the self-concept is a major learning outcome of the classroom experience and an influence in all future learning (Staines, 1963), the importance of self-concept relative to academic achievement cannot be overstated.

Shaw and Alves (1963) found that, when ability levels were held equal, strong associations existed between negative attitudes towards the self and academic achievement. Fink (1962) tested his clinical impression that an adequate concept of self - the positive attitudes and feelings a person has about himself - goes hand in hand with high achievement. Using ninth grade children, he found corroboration of his clinical impression. This conclusion, however, was unquestionable for boys, but less considerable for girls. Shaw, Edson and Bell (1960) investigated the self-concept of bright underachieving high school students. They reported that differences in self-concept did exist between achievers and underachievers. Further analysis of their findings revealed that male underachievers had more negative feelings about themselves than both male achievers and female underachievers. The authors concluded that these sex differences may help explain why underachievement is predominantly a male problem rather than a female one. Stronger associations of self-concept and academic achievement for males have also been reported by Kubiniec (1970).

Primavera, Simon and Primavera (1974) established a relationship between academic achievement and self-esteem, but in direct contrast to the findings reported above, this association held true for girls without exception, but in only one of seven cases for males. The possible influence of sex-role stereotyping was discussed, according to which the feedback in response to academic failure is more drastic and negative for a boy than it is for a girl. Other writers, however, while obtaining significant relationships between self-concept and academic achievement, found no discernible pattern of differences between boys and girls (Caplin, 1969; Kifer, 1975).

Williams and Cole (1968) attempted to relate self-concept to several dimensions of a child's experiences that are deemed fundamental to effective academic adjustment. The global measure of self-concept was found to be significantly and positively correlated with the child's conception of school, social status at school, emotional adjustment, mental ability, reading achievement and mathematical achievement. Kubiniec (1970) found that academic success in college could be predicted by measures of global perception of one's self and one's environment. Similar conclusions were arrived at by Simpson (1977), who investigated the relationship between attitudes toward reading and toward self as related to reading achievement. Results suggested that attitudes toward reading are a separate entity, unrelated to academic success; apparently, what is important is not one's attitudes toward reading, but one's attitudes toward the self.

Rubin, Dorle and Sandidge (1977) reported that self-esteem had a moderate relationship with, but not a strong independent effect, on school achievement and school behaviour. It was concluded that much of the relationship between self-esteem and school performance can best be explained as reflecting common underlying factors, such as ability, background and earlier scholastic success. Earlier scholastic success, together with past self-evaluation, found to be the most powerful single variable in separating high and low achievers in a study by Kubiniec (1970), point to the role of time in the relationship between self-concept and academic achievement.

The importance of time in the relationship between self-concept and academic achievement has to do both with the duration and frequency of repeated experiences either of adequacy and positive feedback, or inadequacy and negative feedback. That the frequency and consistency of adequacy and inadequacy over a period of years has a major effect on self-concept has been stated by Bloom (1977). Kifer (1975) found that with success in academic tasks came positive personality characteristics, and that failure was accompanied by negative personality characteristics. Further, this relationship became stronger with time. Similarly, Black (1974) reported that retarded readers had a lower self-concept than normal readers. Additionally, there was a negative correlation between self-concept, and chronological age and school grade: as the latter increased, measures of the former decreased. Lawrence (1971) found that after a 6 month period in which children received differential amounts of individual personal counselling and remedial teaching, there was a significant rise in self-image, motivation and reading attainment. The length of time spent in counselling, where the emphasis was on repeatedly positive feedback and provision of adequacy experiences, was the most significant contributor to the positive results.

Feelings of inadequacy appear to be present to a great degree whenever children are singled out for special treatment, extending over a period of time. Carroll (1967) investigated the effects of segregated and partially integrated school programmes on self-concept and academic achievement in a group of educably mentally retarded (EMR). Over a period of one year, the segregated EMR pupils showed less improvement in self-concept and reading achievement than their integrated EMR peers. Parmenter (1970) found no significant differences in self-concept development between normals and partially seeing pupils in a unit attached to the normal school, He suggested that the opportunities afforded for academic success together with feelings of achievement which accrue from an integration programme help to develop an adequate self-concept in the partially seeing.

A number of recent studies have examined the self-concept of learning disabled children relative to academic achievement. Doyle (1977) concludes that self-concept relates significantly to sensory-integration abilities in children. The child develops a concept of self from his abilities to manipulate the environment through motor-related tasks. Sensory-integration abilities are considered crucial to adequate school performance (Ayres, 1972). Chamblee (1976) investigated the role of diagnostic prescriptive teaching on the reading achievement and self-concept of first grade learning disabled pupils. He found that diagnostic prescriptive teaching was more effective in improving reading achievement scores than traditional classroom instruction. However, learning disabled children with high reading achievement scores did not have significantly higher self-concept scores than learning disabled children with low reading achievement scores. Both groups tended to score low on measures of self-concept. Shea (1978) reported significantly lower self-esteem scores for learning disabled children than for both reading impaired and emotionally disturbed children.

Thus far, the studies that have been reviewed have dealt with global measures of self-concept. There is evidence to suggest that self-concept is a multidimensional construct embracing a variety of factors. The factor analytic studies of Piers and Harris (1964) and Harrison and Budoff (1972) have isolated school-related self-concept as a factor, as well as other factors, such as physical attributes and popularity.

Bloom (1977) explains the development of an academic self-concept in the following manner. The student's subjective feelings (likes-dislikes) about a school, school subject or a set of learning tasks are much influenced by his perceptions of his adequacy or inadequacy with such tasks. These subjective feelings develop into a subject-related affect which, in turn, generalizes to a school-related affect. For both the subject-related affect and the school-related affect, the object of the affect is outside of the individual. Gradually, this externalized affect is internalized, turned toward the self, and develops into an academic self-concept.

Shavelson, Hubner and Stanton (1976), in a review of studies dealing with the self-concept, conclude that the multifaceted nature of the self-concept is a critical feature in the definition of that construct. They postulate two main facets of self-concept: academic and non-academic. Furthermore, subsumed under the two broad areas is a hierarchy of situation-specific self-concepts (e.g., concept of oneself as a reader, a sportsman, etc.). Support for a more specific "role" or "capacity" model of self-concept is provided by Borislow (1962) who found that general self-evaluations were ineffective at differentiating between a group of high and low achievers, but that evaluations of themselves as students were good discriminators of achievement.

As evidenced by the development and increased usage of multi-faceted self-concept measures, it appears that researchers have followed Wylie's (1961) advice to abandon the unitary model and deal with more molecular constructs having more analytic and predictive value. Marx and Winne (1978), however, have questioned the validity of subscales (physical, social, academic) in self-report measures. Their evidence suggested that these subscales are not empirically differentiable. Although they had some degree of convergent validity, the discriminant validity of the three factors was not established.

Chapman and Boersma (1979a) have criticized Marx and Winne's findings primarily because the measures investigated by these researchers were all designed to assess general self-concept, and because the items within each subscale aimed at specific facets of self-concept are too few in number. Their own work appears to have isolated a unique and discrete aspect of the self-concept, specifically, academic self-concept.

Much of the previous research on academic self-concept had been carried out by Brookover and his associates with junior and senior high school students. In one study of seventh graders, Brookover, Paterson and Thomas (1962) found that self-concept of ability was significantly related to school achievement, even when intelligence was controlled. Further, it was evident that a student's self-concept of ability in a specific school subject may differ from his self-concept in another subject, as well as from his general self-concept of ability.

In addition sex differences were found in favour of females, i.e. females had significantly higher self-concept of ability scores than males.

The research of Boersma and Chapman and associates (Boersma & Chapman, 1978; Boersma, Chapman & Battle, 1979; Boersma, Chapman & Maguire, 1979; Chapman & Boersma, 1979a, 1979b, 1979c) has concentrated on academic self-concept in elementary school children. Combined results of these studies point to the predictive validity of both the academic self-concept and subject-specific self-concept with regard to academic achievement and classificatory groups (e.g., learning disabled versus normally achieving).

Overall, the research evidence clearly shows a persistent and significant relationship between the self-concept and academic achievement, although the exact causal relationship between the two is unclear. The best available evidence suggests that the interaction between self-concept and school performance is reciprocal, that there is continuous interaction between the self and academic achievement, and that each directly influences the other (Purkey, 1970; Williams & Cole, 1968). There is also evidence to suggest the multifaceted nature of self-concept (Shavelson, Hubner & Stanton, 1976; Wylie, 1961) and that more molecular constructs have greater predictive validity (Boersma & Chapman, 1979a; Brookover, Paterson & Thomas, 1962; Shavelson, Hubner & Stanton, 1976; Wylie, 1961).

For purposes of the present study, it is predicted that academic self-concept will be significantly lower in learning disabled children than in normally achieving children. Further, that academic self-concept will contribute to the correct classification of the two groups of children.

Summary

A review of pertinent literature was undertaken in an attempt to explore the relationship of selected cognitive and non-cognitive variables to school performance. Specifically, differential patterns in perceptual motor skills, auditory-visual integration ability and self-concept (academic self-concept) between learning disabled (primarily reading impaired) children and normally achieving children were examined. Research on all three variables proved to be far from unequivocal, although it appears that a moderate degree of confidence can be placed upon their ability to differentiate between learning disabled and normally achieving children. It is surmised that, perhaps in combination, these variables will increase the confidence with which one could correctly classify a child as learning disabled. In addition, because of the higher incidence of learning disabilities among boys, and in light of the findings of a number of the studies reviewed above suggesting a differential pattern of ability and performance among the sexes, it is reasonable to expect that sex may present as a confounding variable.

Therefore, the following are the specific research questions addressed:

1. On the measures employed in the present study, do differential patterns of performance exist between the sexes?
2. Will the learning disabled children obtain significantly lower scores on measures of perceptual-motor skill, auditory-visual integration/sequential processing, and academic self-concept?

3. Is the test battery effective in correctly classifying learning disabled and normally achieving children?

4. Do individual measures of the test battery differ in their contribution to the correct classification of learning disabled and normally achieving children?

CHAPTER 3

METHOD

Subjects

The subjects were third graders from nine different schools in the Edmonton and surrounding districts area (St. Albert and Fort Saskatchewan). Prospective participants in the study were chosen after careful consideration of their school record for data pertaining to their chronological age and any history of academic difficulties. Letters of permission were sent to the parents of these children in the case of seven of the nine schools. In all, 97 letters were sent out and 74 (76%) replies were received. In the case of two of the schools, arrangements were made through the school psychologist. These schools provided eight additional subjects. A total of 82 students, therefore, were selected for the study, including 53 boys and 37 girls.

The learning disabled (LD) sample consisted of 37 children (26 boys, 11 girls). To qualify as LD, a given child had to meet the following criteria:

1) demonstrate a significant discrepancy in achievement in any one of the major academic areas (reading, spelling, arithmetic)
2) have an IQ of 80 or above
3) be free from any demonstrable deficits in sensory and emotional functioning
4) at time of testing, be enrolled in a remedial programme, or be in attendance of an adaptation class.

The criteria for LD were selected to approximate closely with the definition of learning disabilities accepted by the University of Alberta Senate Task Force on "Children and Others With Learning Disabilities" (1979, p. 3).

The significant discrepancy between the child's estimated learning potential and actual school performance was determined by teacher ratings, known to be highly reliable (Fisk, 1979), on the basis of tests administered by the school's reading specialist, and after careful scrutiny of the child's school record.

Whenever possible, ability estimates obtained via standardized intelligence tests and entered on the school record were utilized. Estimates obtained in this manner were provided by the Wechsler Intelligence Scale for Children-Revised (WISC-R) (N=18), the Stanford-Binet Intelligence Scale (N=3), and the Peabody Picture Vocabulary Test (N=3). The remainder of the LD sample were administered the short form of the WISC-R, comprising of the Vocabulary and Block Design subtests (N=13). Scaled scores on these were summed and estimated Full Scale IQ's computed according to Table F-6 in Sattler (1974, p. 562). The validity coefficient of the Vocabulary, Block Design short form is given as .906 (Sattler, 1974, Table F-5, p. 562). The IQ range for the LD sample was 82-126.

Freedom from emotional and sensorial deficits was ascertained through discussion with the child's teacher, remedial teacher, and through study of the school record, which sources also provided information regarding remedial assistance and special class placement.

Overall, the LD sample consisted of 25 children attending a resource room, and 12 children in full-time placement in a junior adaptation class. Difficulties of the former lay in the area of reading, while difficulties of the latter tended to generalize to areas outside of reading (e.g., spelling, writing, arithmetic).

The normally achieving (NA) sample consisted of 45 children (27 boys, 18 girls). To qualify as NA, a given child had to meet the following criteria:

1) be achieving academically at a level commensurate with his estimated learning potential
2) have an IQ of 80 or above
3) be free from any demonstrable deficits in sensorial or emotional functioning
4) be in full-time attendance of the regular classroom; in addition, not have a history of past remedial assistance nor be a repeater.

The procedure for determining these criteria followed the same lines as for the LD sample. In this instance, however, results of standardized intelligence tests were absent from the school record, and, therefore the short form of the WISC-R was administered to all 45 children. In order to closer approximate the IQ range of the LD sample, one boy (IQ=135) was excluded from the study. The IQ range for the NA sample was 83-123.

The final sample consisted of 37 LD (26 boys, 11 girls) and 44 NA (26 boys, 18 girls).

Table 1 presents sample sizes of the LD and NA groups, together with their respective age characteristics, data on socio-economic status (SES), based on father's occupation and classified according to the Blishen scale (Blishen, 1967), and IQ's.

Results of an analysis of variance yielded no statistically significant differences in terms of age, SES, and IQ.

TABLE 1

Age Characteristics (in years), SES and IQ for LD and NA Samples

	LD(N=37) Mean	SD	NA(N=44) Mean	SD	ADJ. DF*	T-RATIO*	PROB.*
age	8.76	.56	8.77	.34	59.47	-0.1746	0.862 (NS)
SES	39.66	13.46	44.07	17.78	80.08	-1.2678	0.209 (NS)
IQ	101.70	10.86	105.79	9.67	74.77	-1.7757	0.080 (NS)

* The Welch T-test was employed to adjust for unequal variance.

Procedure

Testing was carried out during March and April of 1980. Four instruments were used: the Bender Visual-Motor Gestalt Test (Bender), the Visual Aural Digit Span Test (VADS), the Wide Range Achievement Test (WRAT), and the Student's Perception of Ability Scale (SPAS). Additionally, where demand[illegible]he short form of the Wechsler Intelligence Scale for Chi[illegible]ed (WISC-R), consisting of the Vocabulary and Block Des[illegible], was administered. The Bender, the WISC-R, the VADS and the WRAT were administered individually to each child in that order. At the outset, administration time was about 1 hour and was reduced to around 40 minutes per child as the researcher's administration skills increased. At the end of each testing day, those children that had been assessed individually were recalled, and the SPAS was group-administered, in accordance with the test manual's recommendation. Again, following the test developers' advice, the 70 items of the SPAS were read aloud by the examiner in order to obviate any reading difficulties that the children may have been experiencing. This procedure was particularly relevant in the case of the LD children, the majority of whom had been referred for remedial help or special class placement because of reading problems. Administration time for the SPAS was between 20 and 25 minutes.

Measuring Instruments

Bender Visual-Motor Gestalt Test

The Bender Visual-Motor Gestalt Test (Bender) (Bender, 1946) is a maturational test in visual-motor gestalt functions. The test requires the copying of various geometric forms and has been used extensively to measure the developmental process of visual-motor perception in young children. Bender suggested a developmental and clinical approach to the interpretation of test results, and did not concern herself with the construction of an objective scoring system. Hutt (1960) used the Bender as a projective test and analyzed the reproductions in accordance with psychoanalytic theory. Pascal and Suttell's (1951) scoring system is probably the most widely accepted. It was developed for adults from adult test data, and, therefore, its use with children is questionable. The scoring system that is most frequently used with children is the Developmental Scoring System devised by Koppitz (1963) and is the one adopted for the present study.

According to the Koppitz system the Bender is scored for errors. The categories of error that span across the nine cards are: distortion of shape, rotation, integration and perseveration. These error types are not found for each figure, but combine to form 30 mutually exclusive scoring items which are scored either as being present or absent. The child's score on the Bender is the composite score of all his errors.

Only those scoring items were included which were able to differentiate among above average and below average students in either the 1st or 2nd grade at the .05 level or better, or which demonstrated a strong tendency, i.e., significant at the .10 level, in both the 1st and 2nd grades. Pearson product moment correlations between the test scores of five raters were statistically highly significant, ranging from .88 to .96. Test-retest reliabilities computed according to Kendall's Rank Correlation Coefficient ranged from .55 to .66 and were statistically significant at the .001 level (Koppitz, 1963).

The Bender is easy to administer. The child is seated at a table, and provided with a pencil with an eraser and a sheet of paper, size 8-1/2" by 11". Additional sheets of paper are available and are presented on request. There is no time limit to the test, which takes on average 6-1/2 minutes to complete.

A recent review of research with school-age children utilizing the Bender is provided by Buckley (1978). Its use in a variety of settings and for a variety of reasons is well documented, however, Bush and Waugh (1976) advise that its use with learning disorders should be confined to visual-motor aspects. It is to such use that the Bender is put in the present study.

Visual Aural Digit Span Test

The Visual Aural Digit Span Test (VADS) (Koppitz, 1977) involves the reproduction of two- to seven-digit series and consists of four subtests:

1) Aural-Oral (A-O), measuring integration of auditory perception, sequencing and recall;
2) Visual-Oral (V-O), measuring visual-oral integration and recall;
3) Aural-Written (A-W), measuring auditory-visual integration and memory; and
4) Visual-Written (V-W), measuring intrasensory integration of visual input and written expression.

The VADS measures the entire process of perceptual motor integration, sequencing and recall.

In terms of external validity, the VADS appears to be related to achievement, especially to reading achievement (Koppitz, 1977). In this respect, the A-0 and A-W seem significant for younger children, whereas the V-0 and V-W subtests appear significant for second to fifth grade pupils. Moderate correlations exist between the Bender and the VADS Test measures that involve visual-motor integration (A-W, V-W). With respect to IQ, correlations between the VADS subtests and Full Scale WISC IQ range from .26 (A-0) to .42 (V-W), while the correlation between the VADS Test performance, as a whole, and Full Scale WISC IQ is .39. Finally, and most importantly, the VADS has discriminant validity in that it is capable of differentiating between learning disabled and normally achieving children (Koppitz, 1977).

In terms of administration, digits are read off at the rate of one per second in subtests requiring the aural presentation of digits. Where digits are presented visually, exposure time of each series of digits is 10 seconds.

The scoring of the VADS is straightforward. The score for a given VADS subtest equals the longest digit sequence that a child is able to recall without errors. The VADS yields three different types of test scores: the scores for the four subtests, the six scores for the various combinations of the subtest scores, and the total VADS score. In all, eleven different VADS Test measures can be obtained following a single administration. They are as follows: A-0, V-0, A-W, V-W, Aural Input (A-0 + A-W), Visual Input (V-0 + V-W), Oral Expression (A-0 + V-0), Written Expression (A-W + V-W), Intramodal (A-0 + V-W), Intermodal (V-0 + A-W), and the Total VADS score (A-0 + V-0 + A-W + V-W). For purposes of the present study, only scores obtained on each subtest will be used in the statistical analysis of the data.

Wide Range Achievement Test

The Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1978) is a standardized achievement test consisting of three subtests: reading, spelling and arithmetic. Since its appearance on the testing scene in 1936, the WRAT has undergone four revisions: 1946, 1965, 1976, and 1978.

The WRAT consists of two levels. Level 1 is designed for use with children between the ages of 5 and 12. Level 2 is intended for individuals over the age of 12 and can be used with adults.

The WRAT has good statistical and clinical reliability. Correlation coefficients (test-retest) range from .92 to .98 for the reading and spelling subtests, and from .85 to .92 for the arithmetic subtest. The clinical reliability of the WRAT is given as .93 (Jastak & Jastak, 1978).

In addition, the WRAT correlates highly with other achievement measures, tests of intelligence and teacher ratings. In terms of internal consistency, the intercorrelations between the three subtests are high: for reading/spelling they range from .799 to .938; for reading/arithmetic they range from .646 to .806; and for arithmetic/spelling they range from .657 to .803. The high internal consistency of the WRAT tends to confirm that progress in learning (achievement) is controlled by some common variances (Jastak & Jastak, 1978).

On average, the three subtests take 20 to 25 minutes to administer. The spelling subtest requires the child to write 45 words that are dictated to him at the rate of 15 seconds per word. The test is discontinued after 10 consecutive failures. In the reading subtest, the individual is asked to read a list of words the pronounciation of which is given in the test manual. The test is discontinued after 12 consecutive errors. A series of oral and written computations form the arithmetic subtest. The individual is allowed 10 minutes on the written section of this subtest.

In the most recent edition (1978) the raw scores have been scaled in order to provide a better representation of differences in the separate development of reading, spelling and arithmetic skills. These scaled scores are converted into grade ratings, which serve as a base for computing standard deviation scores, percentile ranks and stanines. For purposes of the present study, raw scores will be used in the interest of keeping the form of the data consistent across all instruments used.

<u>Student's Perception of Ability Scale</u>

The Student's Perception of Ability Scale (SPAS) (Boersma & Chapman, 1979) was developed for use in the assessment of academic self-concept in elementary school children. It consists of 70 forced-choice "YES-NO" items that were selected from an original list of 143. Factor-analysis has yielded six subscales: Perception of General Ability (G, 12 items); Perception of Arithmetical Ability (Ar, 12 items); School Satisfaction (SS, 12 items); Perception of Reading and Spelling Ability (R/S, 12 items); Perception of Penmanship and Neatness (P, 12 items); and Confidence in Academic Abilities (C, 10 items).

The subscales are relatively independent of one another, as shown by the relatively low median subscale correlations, ranging from .268

(SS) to .387 (R/S). On the other hand, all the subscales correlate relatively highly with the Full Scale (FS) .541 (SS) to .770 (R/S), suggesting that each subscale appears to be tapping a common domain of academic self-concept.

Test-retest reliability is .834 for FS, and ranges from .714 to .824 for the subscales. Internal consistency, calculated according to Cronbach's alpha, is .915 for FS, and ranges from .686 to .855 for the subscales.

Studies cited in the test manual (1979) suggest that the SPAS holds promise in terms of external validity. Thus, the SPAS appears to be tapping a discrete entity distinguishable from general self-concept. It has moderate correlations with school success, as measured by Average Report Card Scores and standardized achievement tests, while its correlation with intelligence is low. It is moderately to highly correlated with other school related affective variables. Finally, and most importantly for purposes of the present study, it consistently discriminates between normally achieving students and those who have a history of learning difficulties.

Authors of the test recommend that the SPAS be administered in a group, where children may feel more secure. Particular attention is paid to stressing that the SPAS is not a test in which there are right or wrong answers. Emphasis is placed on exhorting students to give honest answers, and students are reassured that their responses will be kept confidential. The SPAS takes about 20 minutes to administer.

The Test Battery: Rationale

The measures selected for use in the study have all proved useful in differentiating between learning disabled (LD) and normally achieving (NA) children. Their usefulness in distinguishing between the two groups of children was, therefore, the prime consideration in their inclusion.

While the VADS appears valuable in its own right, Koppitz (1977) advocates its use as part of a screening battery for elementary school children, a battery which includes the Bender and the Human Figure Drawing (HFD) in addition to the VADS. These measures are seen as complimentary. The VADS measures intersensory integration, sequencing and recall, and correlates well with reading, spelling and arithmetic, whereas the Bender measures visual-motor perception and is most closely related to overall school functioning and mental ability (Koppitz, 1973). The HFD is valuable in assessing social and emotional adjustment, factors that have been shown to influence children's functioning in school (Connolly, 1969; Myklebust & Boshes, 1969; Harris, 1970; Koppitz, 1977).

Elsewhere, Cullen, Boersma and Chapman (1978) researched the power of perceptual-motor, verbal-cognitive and affective variables as measured by the Developmental Test of Visual-Motor Integration (VMI), the WRAT and the SPAS, respectively, to discriminate between LD and NA children. They found that both the WRAT and SPAS differentiated between the two groups, but that the VMI failed to do so.

In terms of the present study, a marriage between the two test batteries outlined above is proposed, based upon the belief that such a union may prove a valuable and effective tool for diagnosing factors related to school success and learning difficulties. The proposed battery consists of: the VADS, the Bender, the WRAT and the SPAS.

Rationale for the inclusion of the VADS is twofold. Firstly, a measure of intrasensory and intersensory functioning is extremely important diagnostically, as it assesses specific areas of strength and weakness in the child. In addition, and of more practical merit is the fact that, on the basis of such a diagnosis, effective preventive and/or remedial strategies can be instituted to suit the individual child. Secondly, what research has been done on the VADS has been carried out in the United States, and thus far, no data exist for a population of Canadian school-children. In view of the diagnostic utility and practical value of the VADS, such information in a Canadian setting is long overdue. It is hoped that the present study will serve as a starting point for further research on this test.

The Bender is included in preference to the VMI in view of the negative findings associated with the latter (Cullen, Boersma & Chapman, 1978; Fisk, 1979), and because a measure of perceptual-motor factors appears to play a role in predicting academic achievement (Carter, Spero & Walsh, 1978). In addition, the Bender has been found to be related to overall school functioning and has proved useful in screening children with learning disabilities (Bender, 1970; DeHirsch, Jansky & Langford, 1966; Koppitz, 1971, 1977).

The value of the WRAT has been ascertained repeatedly. Merwin (1972), in a review of the WRAT in the Seventh Mental Measurements Yearbook, suggests that it has potential as a useful clinical tool for the psychologist dealing with specialized cases. The Physician's Handbook: Screening for MBD (CIBA Medical Horizons, 1973) recommends the use of the WRAT as a valuable and quick screening instrument for learning problems in the areas measured by the test. Additionally, information obtained on the WRAT serves as a base for many resource room programmes. The WRAT is included for these reasons.

Finally, in response to Wylie's (1961) suggestion that more molecular constructs have greater predictive validity, rather than choosing a measure of general emotional maladjustment (HFD), the SPAS is included because it assesses the molecular construct of academic self-concept. While still in its infancy, it has already proven its utility in distinguishing between LD and NA children. It is hoped that the present study will further validate its use with LD children.

While each of the measures has proven useful in isolation, the purpose of the present study is to examine their effectiveness in combination.

Statistical Analysis

The data were analyzed using a Hotelling T^2 analysis and a Discriminant Function Analysis. The Hotelling T^2 statistic was used in order to determine whether any sex differences existed within both the LD and NA samples. The Hotelling T^2 was applied as a rigorous test to determine whether differences existed between males and females on each of the independent measures used in the study, taken either singly or in combination. The Discriminant Function Analysis was adopted in order to test the effectiveness of the test battery to differentiate between LD and NA children. More specifically, whether LD and NA children could be classified correctly as a result of information obtained on the tests. In addition to yielding information regarding the classification of individuals to groups, the Discriminant Function Analysis provides data on the relative contribution that each independent measure makes to the overall discriminant power of the test battery, as a whole. Finally, based on data obtained from the Discriminant Function Analysis, a classificatory procedure was performed on sub-samples (LD=10; NA=10) of the original LD and NA samples. In this respect, each individual was classified according to both the X^2 square probability model and the Bayesian probability model.

CHAPTER 4

RESULTS

This chapter will deal with the outcomes of statistical analyses performed on the data. Initial consideration will be given to results of the Hotelling T^2 analysis, utilized to test for sex differences within both the LD and NA groups. Results of the Discriminant Function Analysis will follow, where the effectiveness of the test battery together with the differential contribution that each individual measure makes in predicting group membership will be examined. Finally, analyses performed on sub-samples from both the LD and NA groups in an attempt to test the classificatory success of the test battery will be presented.

Hotelling T^2: Sex Differences

In order to investigate the possible confounding effects of sex on each of the measures, the Hotelling T^2 statistic was used. In view of the reported differences in visual-motor skills, auditory-visual integration, academic self-concept, and achievement in reading, spelling and arithmetic, and in light of the differential incidence of learning disabilities between the sexes in favour of males, it was a reasonable supposition that discernible patterns of performance in respect of the measures employed in the present investigation might exist.

The Hotelling T^2 test is the more rigorous multivariate analogue of the familiar 2 independent sample t-test. It differs from the latter, however, in one important respect. The Hotelling T^2 considers the covariance among the variables while comparing the differences between all the means simultaneously, rather than singly. In addition to its rigour, one of the values of the Hotelling T^2 analysis is that it allows for linear combinations of subscales without invalidating the statistical process. Thus, it was possible to test for sex differences on the Bender, the R, S and A subtests of the WRAT, the four subtests of the VADS (A-O, V-O, A-W, V-W), the six subscales of the SPAS (G, Ar, SS, R/S, P, C), and the total VADS score (TV) together with the Full Scale SPAS score (FS). Results of these analyses are presented in Table 2 for the LD sample, and in Table 3 for the NA sample.

On the basis of considering the differences between the means of all variables and their particular combinations, the overall Hotelling T^2 value for the LD group was 31.689 (d.f.1=14; d.f.2=22; F=1.423; P=0.223) and did not reach significance. All individual comparisons between the variables proved not significant, although slight differences in means did exist between the males and the females. The males obtained higher means on the Bender, the SPAS FS, and all the SPAS subscales with the exception of SS and P. The girls scored higher, on average, on all WRAT subtests (R, S, A), all VADS subtests (A-O, A-W, V-W) including TV, and on the SS and P subscales of the SPAS.

With respect to the NA sample, the overall Hotelling T^2 value for this group was 27.042 (d.f.1=14; d.f.2=29; F=1.334; P=0.248) and was not significant. There were no significant differences when individual comparisons were made between the males' and females' means on each variable. In the NA sample, males obtained slightly higher scores, on average, on all variables except A-W and SS.

Overall, the females tended to score higher, on average, on A-W

TABLE 2

Hotelling T^2 Comparisons
between Males and Females (LD)

Variable	Males $\bar{X}$	Females $\bar{X}$	T^2	F	P
Bender	4.04	3.82	0.186	0.008	1.000
R	49.31	52.64	0.998	0.045	1.000
S	32.23	34.00	0.857	0.038	1.000
A	26.85	27.73	0.915	0.041	1.000
A-O	4.42	4.45	0.013	0.001	1.000
V-O	4.92	5.36	2.153	0.097	1.000
A-W	4.15	4.36	0.284	0.013	1.000
V-W	5.04	4.91	0.091	0.004	1.000
G	5.96	3.54	4.542	0.204	0.998
Ar	8.31	7.82	0.392	0.018	1.000
SS	7.73	8.72	1.142	0.051	1.000
R/S	7.27	6.54	0.387	0.017	1.000
P	8.15	8.64	0.206	0.009	1.000
C	4.35	2.82	5.285	0.237	0.996
OVERALL T^2			31.689	1.423	0.223
TV	18.54	19.09	0.226	0.010	1.000
FS	41.77	38.09	1.187	0.053	1.000

TABLE 3

Hotelling T^2 Comparisons between Males and Females (NA)

Variable	Males $\bar{X}$	Females $\bar{X}$	T^2	F	P
Bender	1.92	1.83	0.046	0.002	1.000
R	66.04	63.94	1.547	0.076	1.000
S	40.73	39.72	0.788	0.039	1.000
A	29.92	29.67	0.177	0.009	1.000
A-O	5.19	5.17	0.010	0.000	1.000
V-O	6.39	6.17	0.861	0.042	1.000
A-W	5.00	5.22	0.564	0.028	1.000
V-W	6.27	6.27	0.002	0.000	1.000
G	8.85	7.72	1.414	0.070	1.000
Ar	9.73	9.50	0.077	0.004	1.000
SS	9.08	10.11	4.894	0.241	0.996
R/S	10.42	9.61	1.028	0.051	1.000
P	9.85	8.28	4.147	0.205	0.998
C	5.54	3.94	4.245	0.209	0.998
OVERALL T^2			27.047	1.334	0.248
TV	22.85	22.83	0.000	0.000	1.000
FS	53.46	49.17	1.602	0.079	1.000

and SS. The males, on the other hand, tended to obtain higher scores on general academic self-concept (GO) and specific subject related academic self-concept (Ar, R/S).

Thus, results of the Hotelling T^2 analysis failed to reveal any significant differential pattern of performance for males and females on the 14 variables and 2 of their linear combinations (TV and FS).

Discriminant Function Analysis: Differentiation between LD and NA

The Discriminant Function Analysis was employed in the present investigation in order to determine the taxonomic usefulness of the test battery, more specifically, its ability to differentiate between LD and NA children. The particular computer programme used was the Mulv 02. In addition to determining the overall effectiveness of a number of measures in distinguishing between "n" number of groups, this programme also yields information regarding the intercorrelations among the measures together with a simple analysis of variance between variables for each group. In order of presentation, the following section will deal with: the salient relationships among the different measures; results of simple t-tests between the means of the LD and NA groups on each of the separate measures; and the discriminatory power of all the measures taken in combination.

As the Discriminant Function Analysis takes into consideration the intercorrelations among the different variables for each group separately, and then in combination, it would appear useful to ascertain whether intercorrelations among the 14 variables employed in this study differed as a function of group membership. Table 4 presents the intercorrelations for the different measures for the LD and NA

TABLE 4

Intercorrelations* among Measures for the LD and NA groups

*Decimal point omitted

LD (N=37) below the diagonal; NA (N=44) above the diagonal

	Bender	R	S	A	A-O	V-O	A-W	V-W	G	Ar	SS	R/S	P	C
Bender	-	087	115	237	141	101	008	034	011	206	-103	023	-013	108
R	-053	-	771	174	502	433	444	454	414	183	-042	548	141	264
S	-131	929	-	264	511	459	404	464	379	155	028	507	315	343
A	-270	476	477	-	090	098	-151	156	325	256	-104	446	148	253
A-O	-325	365	300	259	-	456	525	390	186	040	000	372	142	136
V-O	-302	429	355	317	562	-	406	414	235	155	162	219	331	261
A-W	-124	525	386	282	554	733	-	381	-012	103	015	062	-082	-014
V-W	-067	628	560	396	554	389	587	-	328	217	126	281	303	465
G	-112	334	275	243	155	213	202	200	-	481	149	731	492	634
Ar	-127	270	196	455	192	208	246	438	525	-	158	409	550	484
SS	-160	-049	035	046	-076	062	027	-073	-114	168	-	034	098	176
R/S	037	370	336	053	307	009	172	132	537	240	003	-	411	556
P	-127	-025	-076	267	-121	-018	041	032	179	-061	211	010	-	557
C	191	-083	-118	-009	-079	-197	-172	-072	482	295	050	409	093	-

groups. Coefficients of .38 were statistically significant at the .01 level.

Generally, the greatest relationship existed between the R and S subtests of the WRAT, the correlation being greater for the LD children. In addition, significant correlations were noted for the R and A, and S and A WRAT subtests, for the LD sample but not the NA sample, suggesting a generalized achievement deficit for the former, and a relative independence among different achievement areas for the latter. Correlations among the VADS subtests were all significant for both groups, but greater, on the whole for the LD sample, indicating that the likelihood of a general short-term memory and intersensory integration deficit is higher for the LD than the NA children. These deficits appear to play a bigger role in the achievement of LD children compared with NA children as demonstrated by higher correlations between the VADS subtests (except V-O) and achievement for the LD sample. Finally, correlations among the SPAS subtests were generally higher for the NA children.

In order to more closely examine the significance of differences in correlations as a function of the group, Fisher's Zr's were calculated where one of the two coefficients met the .38 criterion and both were either positive or negative. In addition, differences were also examined in instances where comparisons between coefficients [illegible] change in sign. Significant results of this analysis are contained in Table 5.

In terms of differences between LD and NA group intercorrelations, two comparisons were significant at the .05 level. Specifically, the correlation between visual-oral and auditory-written integration was

TABLE 5

Comparisons of Intercorrelational Differences between Measures for the LD and NA children

Comparison	LD r	LD Zr	NA r	NA Zr	Diff	Diff / .232	P
V-O - A-W	.773	1.026	.406	.431	.595	2.56	.05
P - C	.093	.093	.557	.628	-.535	-2.31	.05
Bender - A	-.270	-.277	.237	.241	-.518	-2.23	.05
Bender-A-O	-.325	-.337	.141	.141	-.478	-2.06	[illegible]
S - C	-.118	-.119	.343	.357	-.476	-2.05	.05
V-O - C	-.197	-.200	.261	.267	-.467	-2.01	.05
V-W - C	-.072	-.072	.465	.504	-.576	-2.48	.05
Ar - P	-.061	-.061	.550	.618	-.679	-2.93	.01

greater for the LD children than for the NA children (LD r=.773; NA r=.406; Fisher Zr difference=2.56; P=.05). Also, LD children's perception of penmanship does not seem as strongly associated with confidence in their academic abilities as it is for the NA children (LD r=.093; NA r=.557; Fisher Zr difference=2.31; P=.05).

Where comparisons involved a change in sign, three of the significant differences involved the C subscale of the SPAS. In all three instances, the correlation between C and WRAT S, V-O and V-W was negative for the LD children and positive for the NA children. This suggested that the LD children's confidence in their academic ability is greater than is warranted by their achievement in spelling, their visual-oral integration and visual short-term memory, indicating that they are perhaps unrealistic in the way they see themselves as students. The Bender was correlated negatively with the WRAT arithmetic subtest (-.270) and A-O subtest of the VADS (-.325) for the LD group, but positively for the NA group (.237 and .141 respectively). While these correlations failed to reach significance, they nevertheless raise the question that spatial ability may be more important in arithmetic and associated more closely with auditory short-term memory for LD children than for NA children. The greatest difference involved the correlation between two SPAS subscales, Ar and P (LD r=-.061; NA r=.550; Fisher Zr difference=2.93; P=.01). It appears that NA children's perception of their arithmetical ability is strongly associated with their perceptions of penmanship, whereas such a relationship is practically non-existent for the LD children.

To test whether the LD and NA children obtained significantly different scores on the various variables, taken singly, simple analyses of variance were performed in respect of each measure. Means, standard deviations, and results of the analyses are given in Table 6.

As predicted, significant differences at better than the .001 level were found on eleven out of the fourteen measures between the LD and NA groups. Differences among the two groups on Ar were significant at the .01 level. Only P and C subscales of the SPAS failed to differentiate between the LD and NA children at the .05 level. Differences on these subscales, however, were in the expected direction, i.e., in favour of the NA children.

Thus, the LD children demonstrated inferior visual-motor skills, intersensory integration and visual and auditory sequential processing ability, and achievement in reading, arithmetic and spelling. In addition, they generally had a lower academic self-concept when compared with the NA children.

While knowledge of how variables interrelate and which variables, taken singly, yield significantly-different results for two separate groups of individuals is interesting, it is seldom useful, in a practical sense, for the psychologist involved in assessment and diagnosis. Typically, a psychological evaluation proceeds through a number of successive stages, in which information gathered from a test at one stage is either corroborated or attenuated at the next stage, and the next, and so on. With the end of the psychological examination, a competent clinician will have arrived at a hypothesis or series of hypotheses about the individual and a probable diagnosis. The clinician's task would be greatly facilitated if, at the outset, he had an index of the effectiveness of each of the tests in his assessment battery and a "composite score" derived from the total battery which would determine

TABLE 6

One-Way Analysis of Variance for each Variable

	LD		NA			
	$\overline{X}$	SD	$\overline{X}$	SD	F (d.f.1,79)	P
Bender	3.97	1.40	1.89	1.35	46.27	0.00
R	50.30	9.26	65.18	5.53	79.91	0.00
S	32.76	5.30	40.32	3.70	56.73	0.00
A	27.11	2.56	29.82	1.97	29.0[illegible]	0.00
A-0	4.43	0.77	5.18	0.84	17.27	0.00
V-0	5.05	0.85	6.30	0.77	47.93	0.00
A-W	4.22	1.08	5.09	0.96	14.83	0.00
V-W	5.00	1.18	6.27	0.69	36.37	0.00
G	5.24	3.30	8.39	3.10	19.48	0.00
Ar	8.16	2.15	9.64	2.69	7.23	0.01
SS	8.03	2.60	9.50	1.59	9.79	0.00
R/S	7.05	3.21	10.09	2.61	22.07	0.00
P	8.30	2.92	9.21	2.60	2.18	0.14
C	3.89	1.96	4.89	2.62	3.63	0.06
TV	18.70	3.20	22.84	2.48	43.05	0.00
FS	40.68	9.41	51.70	11.15	22.64	0.00

the classification of an individual as belonging to either group A or B. The Discriminant Function Analysis is employed frequently to ascertain the discriminatory power of a battery of predictors and arrive at a "discriminant mean" for that particular battery which would facilitate correct classification.

The Discriminant Function Analysis was utilized in the present study in order to establish the effectiveness of a selected battery of tests in discriminating between LD and NA children. Results of this analysis revealed that the battery of fourteen variables was successful in distinguishing LD children from NA children (Wilks Lambda = 0.334; F = 9.409; P = 0.000). Additionally, a Heck test used to establish the significance of predicting group membership yielded a highly significant canonical correlation (Heck = 0.66; R-Can = 0.816; P = 0.000).

While the discriminatory power of the total test battery is significant, the relative effectiveness of individual measures within the battery is not known. The Discriminant Function Analysis addresses this question by assigning a weighting system to each separate measure. The role of the weighting systems is such that, when they are applied to the scores obtained on their respective measures, they provide maximum discrimination between the groups. The weighting systems are given in Table 7.

For fourteen variables, when it is assumed that each makes an equal contribution and no interrelationships exist, the criterion of high discriminatory power is given by $1/\sqrt{n} = .26$. That assumption is not upheld for the measures under consideration, as significant relationships are present among them. A judgement, therefore, has to

TABLE 17

Normalized Weighting Systems applied to the Bender; WRAT, VADS AND SPAS subtests: (N: LD=37; NA=44)

Variable	Weight
Bender	-0.540
R	0.166
S	-0.110
A	0.096
A-O	-0.138
V-O	0.666
A-W	0.367
V-W	0.171
G	-0.055
Ar	-0.023
SS	0.131
R/S	0.073
P	-0.028
C	0.076

be made regarding the discriminatory power of each measure. It was decided that .30 or better would indicate high, .10 or better would signify moderate, and below .10 would denote low discrimination. In order of discriminatory power, therefore, the V-0, Bender and A-W presented as high discriminators between the LD and NA children. Thus, the measures involving intersensory integration, visual and auditory sequential memory and visual-motor skills appear to possess highest discriminatory power. Moderate discrimination was supplied by intra-m[illegible]es (VADS V-W, A-0), achievement measures (WRAT R, S, A), [illegible]ngs of school satisfaction (SRAS SS). Low discrimination was provided, generally, by measures of self-concept academic. It should be noted that the normalized weighting systems assigned to each variable in this instance relate specifically to this particular constellation of variables. Removal and inclusion of variables from and into the test battery would change the variance-covariance relationship among the variables, hence the weighting systems, and hence the discriminatory power of each variable.

As the VADS subtests ranged from high to moderate discriminatory power, it was decided to perform a separate discriminant analysis solely on the VADS, in order to determine the differential predictive power of its subtests, when these are employed in isolation. Results of this analysis indicated that the VADS on its own successfully discriminated between LD and NA children (Wilks Lambda = 0.552; F = 15.396; 0.000). In addition, the canonical correlation regarding the effectiveness of the VADS subtests in predicting group membership was highly significant (Heck = .448; R-Can = 0.669; P = 0.000). Note, however, that the predictive power of the total battery is greater (R-Can = 0.816).

Normalized weighting systems for the VADS are presented in Table 8. When the VADS is employed in isolation, high discriminatory power is associated with measures involving the visual presentation of materials, i.e., visual sequential memory (V-O, V-W). Measures of intersensory integration (V-O, A-W) and visual intramodal integration provide moderate to high discrimination, while intramodal auditory integration and auditory short-term memory (A-O) fails to contribute to the discriminatory potential of the VADS.

The next step in the analysis involved the assignment of the weights obtained for the total battery to their respective measures for each individual in the LD and NA groups. This resulted in a composite test score for the test battery for each individual. The average of these composite test scores was now calculated for both the LD and NA children. This average is called the "discriminant mean" and was given as 8.456 and 12.370 for the LD and NA children, respectively. The implication of the discriminant mean is that, if a new sample of children were given the test battery and each test score multiplied by its normalized weight, on the basis of which discriminant mean the individual's composite score would approximate, that individual would be classified as either LD or NA.

Classification of Individuals as either LD or NA

A further sample of LD and NA children, although desirable, was not feasible in order to investigate the classificatory potential of the test battery under consideration. It was decided, therefore, to draw sub-samples from the LD and NA groups already available. To this end, ten subjects were drawn randomly from each group in such a way

TABLE 8

Normalized Weighting Systems applied to the VADS: (N: LD=37; NA=44)

Variable	Weight
A-O	-0.000
V-O	0.830
A-W	-0.234
V-W	0.506

that the ratio of males to females remained identical to that of the original sample. Thus, the LD sub-sample consisted of seven males and three females, and the NA sub-sample contained six males and four females. The original sample was, therefore, reduced to sixty one children (LD=27; NA=34).

Because the removal of twenty members from the original sample of eighty one would inevitably alter the magnitude of the inter-correlations among the variables and, therefore, the relative discriminatory power of each variable, a new discriminant analysis was performed, using as input scores of the remaining sixty one members on the fourteen variables. Results of the analysis with N=61 compared most favourably with those obtained from N=81 (N=61: Wilks Lambda = 0.338; F = 6.441; P = 0.000; Heck = 0.662; R-Can = 0.814; P = 0.000; - N=81: Wilks Lambda = 0.334; F = 9.409; P = 0.000; Heck = 0.666; R-Can = 0.816; P = 0.000). The normalized weights for the fourteen variables for N=61 are given in Table 9.

The measures associated with visual-oral integration, visual sequential memory and visual-motor skills had high discriminatory value (V-O, Bender). Moderate discrimination was provided by visual and auditory sequential memory, where mode of expression was written (A-W, V-W), intramodal auditory integration (A-O), reading and spelling achievement (WRAT R, S), school satisfaction and perception of reading and spelling ability (SS, R/S). Achievement in arithmetic (WRAT A) and separate dimensions of academic self-concept (G, Ar, P, C) were low in discriminatory power.

The normalized weights between N=81 and N=61 are compared in Table 10. Considering the rank order in terms of discriminatory power

TABLE 9

Normalized Weighting Systems applied to the Bender; WRAT, VADS and SPAS subtests: (N: LD=27; NA=34)

Variable	Weight
Bender	-0.510
R	0.151
S	-0.109
A	0.079
A-O	-0.257
V-O	0.721
A-W	-0.218
V-W	0.140
G	-0.081
Ar	0.023
SS	0.150
R/S	0.115
P	0.020
C	0.049

TABLE 10

Rank-Order Comparisons of Weighting Systems between N=81 and N=61

Rank	N=81	N=61
1	V-O	V-O
2	Bender	Bender
3	A-W	A-O
4	V-W	A-W
5	R	R
6	A-O	SS
7	SS	V-W
8	S	R/S
9	A	S
10	C	G
11	R/S	A
12	G	C
13	P	Ar
14	Ar	P

between the two analyses, the same variables present as the seven uppermost. Thus, measures involving visual-motor skills (Bender), intersensory and intrasensory integration together with visual and auditory short-term memory (A-O, V-O, A-W, V-W), reading achievement (R) and feelings of school satisfaction (SS) contribute most highly in discriminating between LD and NA children within this particular battery of tests.

The weighting system obtained from N=61 was next applied to the remaining twenty observations, taken out of the original sample, in an attempt to determine the usefulness of the test battery in classifying these observations as belonging to either the LD or NA group. In addition, the a priori probabilities were set at .10 for the LD and .90 for the NA children, in order to represent as realistically as possible the estimated incidence of learning disability in the general population. These a priori probabilities are taken into account when deciding the classification of an individual as either LD or NA.

The particular computer programme employed was the Mulv 03. This programme utilizes two alternative methods of classification: the χ^2 method and the Bayesian method. The essential difference between the two is that the former makes no assumptions regarding normality of distribution, whereas the latter assumes normality of distribution. Discrepancies in classification can, therefore, be expected, though neither method can be presumed to be the more stringent of the two. In both methods, the individual is assigned to that group having the highest probability of group membership.

Table 11 presents data pertinent to the classification of the twenty individuals that had been removed from the total sample.

TABLE 11

Classification of LD (N=10) and NA (N=10): Total Test Battery

O	G	X^2 LD	X^2 NA	$X^2(P)$ LD	$X^2(P)$ NA	B(P) LD	B(P) NA	$X^2(C)$	B(C)
1m	LD	7.653	38.569	0.006	0.000	1.000	0.000	LD	LD
2f	LD	0.387	13.752	0.534	0.000	0.985	0.015	LD	LD
3m	LD	1.154	2.991	0.283	0.084	0.170	0.830	LD	NA*
4m	LD	3.029	25.133	0.082	0.000	1.000	0.000	LD	LD
5f	LD	0.973	17.085	0.324	0.000	0.996	0.004	LD	LD
6m	LD	0.002	6.753	0.999	0.009	0.705	0.295	LD	LD
7m	LD	1.910	21.117	0.167	0.000	0.999	0.001	LD	LD
8f	LD	0.005	6.901	0.999	0.009	0.720	0.280	LD	LD
9m	LD	0.530	14.687	0.467	0.000	0.990	0.010	LD	LD
10m	LD	7.584	38.389	0.006	0.000	1.000	0.000	LD	LD
11m	NA	6.402	0.001	0.011	0.999	0.003	0.997	NA	NA
12f	NA	5.418	0.071	0.020	0.999	0.006	0.994	NA	NA
13m	NA	5.850	0.026	0.016	0.999	0.004	0.996	NA	NA
14m	NA	8.781	0.225	0.003	0.635	0.001	0.999	NA	NA
15m	NA	2.248	1.521	0.134	0.217	0.054	0.946	NA	NA
16f	NA	0.400	5.040	0.527	0.025	0.454	0.546	LD*	NA
17f	NA	8.837	0.236	0.003	0.627	0.001	0.999	NA	NA
18m	NA	3.888	0.465	0.049	0.495	0.015	0.985	NA	NA
19f	NA	2.542	1.260	0.111	0.262	0.041	0.959	NA	NA
20m	NA	4.190	0.354	0.041	0.552	0.012	0.988	NA	NA

O=observation with m=male and f=female; G=original group membership; X^2=chi-square associated with each group; $X^2(P)$=probability associated with chi-square for each group; B(P)=Bayes probability ratio associated with each group; $X^2(C)$=classification according to chi-square; B(C)=classification according to Bayesian method.

* Denotes errors of classification

Success was defined as the correct classification by both the X^2 and the Bayesian method. Out of twenty individuals, the total test battery was successful in correctly classifying eighteen, which constitutes a 90% hit rate. Among the misses, there was one false negative (individual classed as NA when in fact he was LD) and one false positive (individual classed as LD when in fact he was NA).

In order to assess the relative contribution of separate measures to the classificatory power of the test battery, individual tests were removed selectively from the test battery and new analyses conducted with the remaining measures. Thus the test battery was evaluated with either the Bender, the WRAT, the VADS, or the SPAS removed from the battery. In addition, the seven measures that had been estimated as having highest discriminatory power were also removed. Finally, as the VADS subtests had demonstrated moderate to high discrimination, the classificatory potential of the VADS in isolation was examined.

Appendix A contains data pertinent to each separate analysis. Table 12 presents the success-failure rates of various combinations of the tests.

Results demonstrated that, as expected, the total test battery was the most successful in discriminating between LD and NA children. In this particular constellation of measures, it appears that the Bender makes the highest contribution in separating the two groups. The WRAT and the VADS are ranked as equals, while removal of the SPAS was effected without reducing the effectiveness of the remaining measures. Predictive utility of the test battery suffered most when the seven optimum predictors were removed. The VADS, used in isolation, misclassified 40% of the children.

TABLE 12

Comparison of Hit-Rate for Different Combinations of the Tests

Test Combination	Valid Positives	False Negatives	False Positives	Valid Negatives	Hit Rate
Total	9	1	1	9	90%
Total-SPAS	9	1	1	9	90%
Total-VADS	9	1	2	8	85%
Total-WRAT	9	1	2	8	85%
Total-Bender	6	4	1	9	75%
Total-Optimum	6	4	2	8	70%
VADS only	5	5	3	7	60%

Valid positives = the number of children correctly identified as LD.
False negatives = the number of children identified as NA when in fact they were LD.
False positives = the number of children identified as LD when in fact they were NA.
Valid negatives = the number of children correctly identified as NA.

In summary, no sex differences were found within both the LD and NA groups. A number of differences among variable intercorrelations became prominent when LD and NA children were compared. Mainly, these involved visual-oral integration and visual short-term memory. As predicted, the LD children scored significantly lower on each of the measures than the NA children, except on measures assessing their perception of penmanship and confidence in their academic abilities, although these were in the expected direction. Finally, the effectiveness of the test battery employed in the present study in differentiating among LD and NA children was demonstrated.

CHAPTER 5

DISCUSSION

This chapter will attempt to integrate the findings of the study. While the primary focus of the investigation was on establishing the effectiveness of a battery of tests in differentiating between LD and NA children, a number of additional results were also discussed, and these will be dealt with first. Implications of the study and suggestions for future research will conclude the chapter.

It appears that conditions underlying achievement in school may be different for LD children as compared with NA children. Specifically, integrity in perceptual functioning, which includes visual-motor, spatial ability, intersensory and intrasensory integration, visual and auditory short-term memory, may be more related to achievement for LD than NA children. Thus, for example, in the present study a moderate relationship was found between deficit in spatial ability and achievement in arithmetic for the LD children but not the NA children. In addition, there was a slightly greater association between intersensory integration and ability for sequential processing of auditory and visual stimuli, and achievement in reading and arithmetic. In this respect, the intrasensory integration of visual input with written output was particularly notable, a finding supportive of Amoriell (1979), who studied the relationship of phoneme-grapheme correspondences to reading achievement. He found that intra-modal integration of visual stimuli and visual sequential memory were the best predictors of reading achievement.

With respect to the whole process of intersensory integration, sequencing and recall, the interrelationships within this process were high for both the LD and NA children. Much has been written about teaching to either the deficit or intact modality. It appears, however, that in terms of short-term memory processes, such a distinction cannot be made. More importantly, the relationship between modalities was, on the whole, slightly greater for the LD children than the NA children, and it is the former that require some form of remediation. It may be that emphasis should be placed on improving the interaction between modalities (Kirk & Kirk, 1971).

The findings further suggested that, compared with NA children, the LD[1] children's confidence in their abilities as students did not correspond with reality. It was particularly interesting to note during the time of assessment how a number of LD children completed the SPAS in total oblivion to their "miserable" performance on other tests of the battery. It seems that for LD children denial is an important defence mechanism against their experienced difficulties in school.

In the present study, the differences between LD and NA children on the measures employed were in the predicted direction and supportive of previous research. However, the probability of sex differences on these measures suggested by previous investigations was not confirmed. Thus, the LD children were inferior to the NA children in terms of their visual-motor ability, intersensory and intrasensory integration and sequential processing ability, achievement and academic self-concept. It should be noted that the mean age of the children in the present study was 8.8 years, and that the differences found particularly in respect of perceptual functioning may be specifically related to younger children experiencing learning difficulties, as has been suggested by Rutter and Yule (1973). It is likely that deficits in perceptual functioning cease to play a major role in the children's disabilities with increasing age (Satz & Van Nostrand, quoted in Fletcher & Satz, 1979). The only measures that failed to distinguish between the LD and NA children involved the perception of one's penmanship and confidence in one's academic abilities, although both were greater for the NA children and, therefore, in the direction predicted. The failure of perception of penmanship to differentiate between LD and NA children has been reported previously by Chapman and Boersma (1979c) and Chapman (1979). With regard to confidence in one's academic abilities, the findings are not surprising in light of the negative correlations observed between LD children's feelings of confidence and some of the school related abilities underlying academic success.

Whie individual tests can discriminate between groups on the basis of mean differences in performance, there may still be too much overlap between members within each group to allow for accurate prediction of group membership. The discriminant function analysis attempts to reduce the overlap between members of discrete groups by considering a number of variables in combination, and was utilized in the present study for this reason. It had been predicted that the test battery, as a whole, would be successful in discriminating between LD and NA children. This prediction was upheld, with the test battery yielding a hit rate of 90%. The test battery, therefore, was shown to be highly effective in correctly classifying LD and NA children, as the hit rate, the percentage of individuals accurately diagnosed by a test, or battery of tests, is the major measure of diagnostic effectiveness (Yates, 1954).

It had also been predicted that each measure would contribute substantially to the predictive utility of the test battery. Results of two analyses with different sample sizes disclosed that the perceptual measures (Bender, VADS) contributed most to the utility of the battery in differentiating between LD and NA children, together with the reading subtest of the WRAT. With respect to the latter, it is not surprising that an index of reading (word recognition) was an effective discriminator, as the majority of the children classified as LD in the present study had difficulty in the area of reading. The fact that perceptual measures were highest in discriminating power could be due to the existence of "perceptual disabilities" as the largest sub-category of learning disabilities (Hallahan & Kauffman, 1976). Alternatively, it is possible that these measures were the most successful because they constituted 50% of the test battery. Alternatively still, they were prominent due to the age of the children, and it was noted previously that perceptual deficits are more strongly associated with achievement, particularly achievement in reading, in younger grades (Rutter & Yule, 1973). With the exception of feelings of school satisfaction, children's academic self-concept contributed little to the battery's effectiveness.

The differential utility of individual tests in the battery was also examined by analyzing the effects that removal of each test from the battery had on the effectiveness of the remaining measures. Here again, the importance of perceptual functioning, specifically intersensory and intrasensory integration, auditory and visual short-term memory and visual-motor skills, was emphasized as highly effective in discriminating between LD and NA children. Removal of the achievement measure also proved detrimental to the hit rate. Elimination of the academic self-concept measure did not detract from the effectiveness of the total test battery.

In a recent review, Benton (1975) had written that research into intersensory integration is one of the avenues that holds most promise in attempts to understand the nature of dyslexia. Because of this, and because the importance of intersensory integration proved high and consistent over a number of analyses, the effectiveness of the VADS was considered in isolation from all other measures. Measures of visual-oral integration and recall (V-O) and intrasensory integration of visual input and written expression (V-W) made the greatest contribution in terms of discriminating between LD and NA children. This finding supplies confirmation to results reported by Koppitz (1977), who found measures involving visual input (V-O, V-W) more closely related to achievement, particularly achievement in reading, for second- to fifth-grade children. Auditory-visual integration and recall (A-W) was moderately discriminating. Taken together, therefore, measures of intersensory integration (V-O, A-W) were important in differentiating between LD and NA children. The measure of auditory perception, sequencing and recall (A-O) made no contribution at all in the context of the other VADS measures. This result was partially supportive of Koppitz (1977), who found the A-O subtest to be least associated with achievement as measured by the WRAT.

When the VADS was used in isolation, the hit rate suffered greatly. Twenty five percent of the LD and 15% of the NA were misclassified. When the cost of such errors is examined, it is evident that non-detection of a child with learning difficulties is of far greater significance than the misdiagnosis of a child achieving at expected levels as having learning difficulties. NA children placed in a special class will soon be detected. The child with learning difficulties, however, who continues in the mainstream could do so indefinitely and to ill-effect, not only in terms of school learning, but also social adjustment. Many LD children, in fact, first become noticed as juvenile delinquents (Bachara & Zaba, 1978).

Koppitz (1977) recommends the use of the VADS within a battery of tests, and results of the present study support the much laboured and emphatic advice of numerous writers in the field that information about an individual is much more reliable when it is arrived at from a number of different sources.

The fact that the test battery employed in the present study was highly effective in differentiating between LD and NA children does not argue against the use of other measures in our attempts to help children with learning difficulties. Nor does the fact that the measure of academic self-concept failed to make a substantial contribution to the effectiveness of the test battery preclude its utility with LD children. It should be borne uppermost in the mind of those involved in educating children that the focus should be on assessing the child, and not merely testing him. The utilization of standardized tests dealing with cognitive processes is but one step in the total assessment process. The effectiveness and usefulness of these tests can best be gauged by their ability to pinpoint a child who may be at high risk of not benefiting from normal schooling and to suggest further assessment. Further assessment involves obtaining other important information about the child, information about his motivations, values, attitudes, emotional characteristics (self-concept, both general and academic, for example), learning styles and preferences, whether through formal, or informal techniques. A balance between formal and informal techniques is required in order that educators fulfill their duty: to provide children with more effective and appropriate educational and psychological services.

In all probability, the tests used in the present study have their shortcomings. Particularly the Bender, ~~by virtue of its~~ long history, has been criticized. The WRAT has also been scrutinized and is being updated continuously. The VADS and the SPAS are in their infancy, and it is certain that their faults will be highlighted with time. A magical test that will be 100% valid and reliable in measuring significant behaviours will never be produced. While there may be a need for new assessment techniques, what is more pressing is the need for the proper utilization of currently available resources. The present study has indicated one possible avenue in this regard.

The use of discriminant function analysis seems to be a reliable and practical approach to diagnosis. It could assist in computer models for diagnosis. Many computer models, such as the Bayes method, are based on probability theory and, therefore, require estimates of the relative frequency of occurrence of syndromes in the population. Using estimates of the relative frequency of occurrence of significant descriptive symptoms has resulted in computer based models for advocating a treatment of choice with psychiatric patients (Mirabile, Houck & Glueck, 1971).

With regard to the detection of learning disabilities problems arise, as what exactly constitutes the "syndrome" is not known, nor is the relative importance of numerous symptoms known. The arrival at a clear definition is, therefore, a top priority. The use of a formal diagnostic criterion by a number of groups, regardless whether their interests are educational, medical, psychological, psychoneurological, or psychophysiological, will result in a solution of the problem of whether individuals described by different groups are comparable. It is possible that a reliable diagnostic category can be obtained, using already existing definitions, provided that the basic phenomena of a learning disability (e.g., psychological processes, their relative importance and interrelatedness) are clearly and operationally defined and combined in a systematic manner. The use of discriminant function analyses appears to be a step in this direction.

How can the results of the present study be utilized? The weighting systems obtained for the present battery of tests can be utilized with children referred to educational clinics on an experimental basis in order to test their validity. Additionally, in view of the fact that many school systems are now computerizing the information contained in the school record, it is feasible and highly practical to programme the computer to assign the set of weights to available test results in order to gauge the likelihood of a given child experiencing difficulties in school.

This application of results of discriminant function analyses suggests areas for further research. The battery of tests most commonly used to place children in adaptation classes should be examined through discriminant function analysis in order to test its effectiveness in separating children experiencing learning difficulties from those who are achieving at levels commensurate with their estimated learning potential. Those tests that prove low in discriminatory power should be replaced by others shown to yield high discrimination.

The battery examined in the present study could serve as a starting point for such improvements in existing test batteries, particularly the Bender, the VADS and the reading subtest of the WRAT. In view of the contribution of the VADS to the overall effectiveness of the test battery, its standard use in the assessment of LD children is recommended. Thus far, the author is aware of only one practising psychologist who utilizes the VADS in her work with young children.

The development of more refined and reliable neuropsychological tests argues for their inclusion in any battery of tests for LD children. In addition, indices of physical abnormality which appear to be related to learning disability (Pihl, 1979), need to be investigated for their effectiveness in discriminating between LD and NA children. The inclusion of measures tapping into a variety of functions, and their subsequent validation or rejection, would result in the establishment of a comprehensive test battery that would maximize the hit rate, i.e., the percentage of children correctly identified as either LD or NA.

It was recommended above that certain measures utilized in the present study serve as a starting point in the development of a comprehensive test battery. While the results of the present study are impressive in yielding a 90% hit rate, more needs to be done before the battery can be used in educational settings on a regular basis. Its validity and reliability need to be established. In the present study, the success rate of prediction was ascertained by using sub-samples of the original LD and NA groups, where the identity of each child was known prior to the classificatory analysis. Firstly, therefore, a replication of the study is advised in order to establish the stability of the weighting systems obtained in the present case. Secondly, the hit rate of the battery, or parts of the battery, should be determined by applying the weighting systems to the test scores of a new, randomly selected sample of children, whose identity and background would not be available to the researcher. Blind diagnoses of this kind would argue for a higher predictive utility of the test battery.

An additional area of research would involve the examination of age, sex, and intelligence, as these relate to the prediction rate of the battery. It is feasible that with the inclusion and removal of measures into and from the test battery, the effects of sex, age and intelligence may become prominent. As these effects are determined, they can be input into the discriminant and classificatory analysis. It is possible, therefore, that this could result in sex-specific, age-specific and IQ range-specific weighting systems for a number of different test batteries that would be maximally discriminating between LD and NA children. This may, in all actuality, be the best approach for diagnosing learning disabilities, in view of the extreme heterogeneity of learning disabled children.

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APPENDIX A

<u>NOTE</u>:

For all tables contained in Appendix A the following holds:

O=observation with m=male and f-female;

G=original group membership;

X^2=chi-square associated with each group;

X^2(P)=probability associated with chi-square for each group;

B(P)=Bayes probability ratio associated with each group;

X^2(C)=classification according to chi-square;

B(C)=classification according to Bayesian method.

*Denotes errors of classification

Classification of LD (N=10) and NA (N=10):
Total Test Battery minus the SPAS

O	G	X^2 LD	X^2 NA	X^2(P) LD	X^2(P) NA	B(P) LD	B(P) NA	X^2(C)	B(C)
1m	LD	5.537	39.315	0.019	1.000	1.000	0.000	LD	LD
2f	LD	1.468	22.167	0.226	0.000	0.999	0.001	LD	LD
3m	LD	1.378	2.087	0.241	0.149	0.078	0.922	LD	NA*
4m	LD	1.170	20.527	0.279	0.000	0.999	0.001	LD	LD
5f	LD	0.379	15.156	0.538	0.000	0.990	0.010	LD	LD
6m	LD	0.087	6.370	0.999	0.012	0.579	0.421	LD	LD
7m	LD	0.990	19.464	0.320	0.000	0.998	0.002	LD	LD
8f	LD	0.024	5.693	0.999	0.017	0.502	0.498	LD	LD
9m	LD	0.662	17.340	0.416	0.000	0.996	0.004	LD	LD
10m	LD	5.063	37.568	0.024	0.000	1.000	0.000	LD	LD
11m	NA	4.323	0.042	0.038	0.999	0.007	0.993	NA	NA
12f	NA	4.139	0.071	0.042	0.999	0.008	0.992	NA	NA
13m	NA	4.452	0.027	0.035	0.999	0.006	0.994	NA	NA
14m	NA	7.680	0.549	0.006	0.459	0.002	0.998	NA	NA
15m	NA	2.680	0.657	0.102	0.418	0.021	0.979	NA	NA
16f	NA	0.721	3.569	0.396	0.059	0.198	0.802	LD*	NA
17f	NA	4.254	0.052	0.039	0.999	0.007	0.993	NA	NA
18m	NA	3.022	0.452	0.082	0.502	0.016	0.984	NA	NA
19f	NA	1.698	1.607	0.193	0.205	0.054	0.946	NA	NA
20m	NA	3.862	0.131	0.049	0.717	0.009	0.991	NA	NA

Classification of LD (N=10) and NA (N=10):
Total Test Battery minus the VADS

		X^2		X^2(P)		B(P)			
O	G	LD	NA	LD	NA	LD	NA	X^2(C)	B(C)
1m	LD	5.351	38.679	0.021	0.000	1.000	0.000	LD	LD
2f	LD	0.629	17.291	0.428	0.000	0.996	0.004	LD	LD
3m	LD	0.510	4.471	0.475	0.034	0.305	0.695	LD	NA*
4m	LD	1.707	23.561	0.191	0.000	1.000	0.000	LD	LD
5f	LD	2.579	27.671	0.108	0.000	1.000	0.000	LD	LD
6m	LD	0.013	5.703	0.999	0.017	0.510	0.490	LD	LD
7m	LD	2.632	27.906	0.105	0.000	1.000	0.000	LD	LD
8f	LD	0.010	5.627	0.999	0.018	0.501	0.499	LD	LD
9m	LD	0.733	18.010	0.392	0.000	0.999	0.001	LD	LD
10m	LD	6.442	42.567	0.011	0.000	1.000	0.000	LD	LD
11m	NA	3.641	0.245	0.056	0.620	0.011	0.989	NA	NA
12f	NA	5.308	0.002	0.021	0.999	0.004	0.996	NA	NA
13m	NA	5.206	0.000	0.023	0.999	0.004	0.996	NA	NA
14m	NA	9.083	1.008	0.003	0.315	0.001	0.999	NA	NA
15m	NA	1.739	1.675	0.187	0.196	0.055	0.945	NA	NA
16f	NA	0.899	3.228	0.343	0.072	0.162	0.838	LD*	NA
17f	NA	5.044	0.001	0.025	0.999	0.005	0.995	NA	NA
18m	NA	1.195	2.561	0.274	0.110	0.107	0.893	LD*	NA
19f	NA	1.860	1.521	0.173	0.217	0.049	0.951	NA	NA
20m	NA	1.775	1.629	0.183	0.202	0.053	0.947	NA	NA

Classification of LD (N=10) and NA (N=10):
Total Test Battery minus the WRAT

O	G	X^2 LD	X^2 NA	X^2(P) LD	X^2(P) NA	B(P) LD	B(P) NA	X^2(C)	B(C)
1m	LD	4.341	23.884	0.037	0.000	0.999	0.001	LD	LD
2f	LD	0.613	11.938	0.434	0.001	0.963	0.037	LD	LD
3m	LD	1.196	1.929	0.274	0.165	0.117	0.883	LD	NA*
4m	LD	3.719	22.244	0.054	0.000	0.999	0.001	LD	LD
5f	LD	0.857	13.048	0.355	0.000	0.976	0.024	LD	LD
6m	LD	0.292	10.161	0.589	0.001	0.927	0.073	LD	LD
7m	LD	0.970	13.522	0.325	0.000	0.980	0.020	LD	LD
8f	LD	0.110	8.750	0.740	0.003	0.873	0.127	LD	LD
9m	LD	0.235	9.775	0.628	0.002	0.915	0.085	LD	LD
10m	LD	8.077	32.742	0.004	0.000	1.000	0.000	LD	LD
11m	NA	2.148	0.959	0.143	0.328	0.048	0.952	NA	NA
12f	NA	4.196	0.114	0.041	0.736	0.012	0.988	NA	NA
13m	NA	3.651	0.239	0.056	0.625	0.016	0.984	NA	NA
14m	NA	3.066	0.442	0.080	0.506	0.024	0.976	NA	NA
15m	NA	0.498	3.298	0.480	0.069	0.271	0.729	LD*	NA
16f	NA	0.296	3.976	0.587	0.046	0.366	0.634	LD*	NA
17f	NA	8.644	0.415	0.003	0.519	0.001	0.999	NA	NA
18m	NA	2.617	0.659	0.106	0.417	0.033	0.967	NA	NA
19f	NA	2.322	0.837	0.128	0.360	0.042	0.958	NA	NA
20m	NA	2.632	0.651	0.105	0.420	0.033	0.967	NA	NA

Classification of LD (N=10) and NA (N=10):
VADS in isolation

		X^2		$X^2(P)$		B(P)			
O	G	LD	NA	LD	NA	LD	NA	$X^2(C)$	B(C)
1m	LD	2.405	13.267	0.121	0.000	0.949	0.051	LD	LD
2f	LD	0.012	2.839	0.999	0.092	0.254	0.748	LD	NA*
3m	LD	3.490	0.115	0.062	0.735	0.015	0.985	NA*	NA*
4m	LD	1.386	10.288	0.239	0.001	0.875	0.125	LD	LD
5f	LD	0.039	1.905	0.999	0.168	0.172	0.828	LD	NA*
6m	LD	0.007	2.230	0.999	0.135	0.199	0.801	LD	NA*
7m	LD	0.232	5.745	0.630	0.017	0.563	0.437	LD	LD
8f	LD	0.014	2.869	0.999	0.090	0.255	0.745	LD	NA*
9m	LD	0.746	8.079	0.388	0.004	0.762	0.238	LD	LD
10m	LD	1.898	11.841	0.168	0.001	0.922	0.078	LD	LD
11m	NA	4.902	0.550	0.027	0.458	0.009	0.991	NA	NA
12f	NA	0.209	1.700	0.647	0.193	0.147	0.853	LD*	NA
13m	NA	4.239	0.315	0.039	0.575	0.011	0.989	NA	NA
14m	NA	1.331	0.243	0.249	0.622	0.045	0.955	NA	NA
15m	NA	0.014	2.869	0.999	0.090	0.255	0.745	LD*	NA
16f	NA	0.007	2.230	0.999	0.135	0.199	0.801	LD*	NA
17f	NA	6.696	1.385	0.010	0.239	0.006	0.994	NA	NA
18m	NA	4.902	0.550	0.027	0.458	0.009	0.991	NA	NA
19f	NA	1.783	0.079	0.182	0.999	0.034	0.966	NA	NA
20m	NA	6.742	1.409	0.009	0.235	0.006	0.994	NA	NA

Classification of LD (N=10) and NA (N=10):
Total Test Battery minus the Bender

O	G	X^2 LD	X^2 NA	X^2(P) LD	X^2(P) NA	B(P) LD	B(P) NA	X^2(C)	B(C)
1m	LD	9.719	36.737	0.002	0.000	1.000	0.000	LD	LD
2m	LD	0.180	4.323	0.671	0.038	0.411	0.589	LD	NA*
3f	LD	2.909	0.407	0.088	0.523	0.025	0.975	NA*	NA*
4m	LD	3.028	20.362	0.082	0.000	0.998	0.002	LD	LD
5m	LD	0.158	9.018	0.691	0.003	0.881	0.119	LD	LD
6f	LD	0.540	2.991	0.462	0.084	0.230	0.770	LD	NA*
7m	LD	1.937	16.981	0.164	0.000	0.994	0.006	LD	LD
8m	LD	0.611	2.812	0.434	0.094	0.209	0.791	LD	NA*
9f	LD	0.895	13.103	0.344	0.000	0.975	0.025	LD	LD
10m	LD	2.998	20.273	0.083	0.000	0.998	0.002	LD	LD
11m	NA	13.096	2.289	0.000	0.130	0.000	1.000	NA	NA
12f	NA	3.183	0.303	0.074	0.582	0.020	0.980	NA	NA
13m	NA	8.579	0.543	0.003	0.461	0.002	0.998	NA	NA
14m	NA	9.083	0.693	0.003	0.405	0.001	0.999	NA	NA
15m	NA	3.106	0.330	0.078	0.566	0.021	0.979	NA	NA
16f	NA	0.012	5.672	0.999	0.017	0.598	0.402	LD*	LD*
17f	NA	10.755	1.280	0.001	0.258	0.001	0.999	NA	NA
18m	NA	4.232	0.059	0.040	0.999	0.011	0.989	NA	NA
19f	NA	3.598	0.179	0.058	0.672	0.016	0.984	NA	NA
20m	NA	7.728	0.324	0.005	0.569	0.002	0.998	NA	NA

Classification of LD (N=10) and NA (N=10): Total Test Battery minus seven highest discriminators (Bender, A-O, V-O, A-W, V-W, R, SS)

O	G	X^2 LD	X^2 NA	$X^2(P)$ LD	$X^2(P)$ NA	B(P) LD	B(P) NA	$X^2(C)$	B(C)
1m	LD	6.102	28.731	0.014	0.000	1.000	0.000	LD	LD
2f	LD	1.246	12.342	0.246	0.000	0.939	0.061	LD	LD
3m	LD	1.581	0.075	0.209	0.999	0.027	0.973	NA*	NA*
4m	LD	0.074	2.993	0.999	0.084	0.204	0.796	LD	NA*
5f	LD	0.497	8.717	0.481	0.003	0.784	0.216	LD	LD
6m	LD	0.002	1.988	0.999	0.158	0.139	0.861	LD	NA*
7m	LD	2.578	17.480	0.108	0.000	0.990	0.010	LD	LD
8f	LD	0.375	1.332	0.540	0.248	0.088	0.912	LD	NA*
9m	LD	2.092	15.714	0.148	0.000	0.982	0.018	LD	LD
10m	LD	0.819	10.400	0.366	0.001	0.878	0.122	LD	LD
11m	NA	5.164	1.233	0.023	0.267	0.008	0.992	NA	NA
12f	NA	3.045	0.153	0.081	0.696	0.014	0.986	NA	NA
13m	NA	6.757	0.243	0.009	0.120	0.007	0.993	NA	NA
14m	NA	4.848	1.029	0.028	0.311	0.009	0.991	NA	NA
15m	NA	1.884	0.013	0.169	0.999	0.023	0.977	NA	NA
16f	NA	0.002	2.014	0.999	0.156	0.140	0.860	LD*	NA
17f	NA	2.242	0.003	0.134	0.999	0.019	0.981	NA	NA
18m	NA	0.045	2.791	0.999	0.095	0.191	0.809	LD*	NA
19f	NA	3.674	0.391	0.055	0.532	0.011	0.989	NA	NA
20m	NA	2.611	0.046	0.106	0.999	0.016	0.984	NA	NA

APPENDIX B

Raw Data in order of presentation for:

Age, SES, IQ, Bender, WRAT (R, S, A), VADS (A-O, V-O, A-W, V-W, TV), and SPAS (G, Ar, SS, R/S, P, C, FS)

LD Sample

9.08	32.79	106	1	53	36	29	4	6	5	5	20	4	9	12	5	12	2	44
8.25	39.54	112	3	46	29	27	6	6	5	5	22	8	9	9	11	7	4	48
8.67	71.90	94	4	59	37	30	5	5	4	5	19	3	10	7	10	6	4	40
9.08	60.93	126	4	55	34	33	4	5	4	6	19	11	12	6	6	10	5	50
9.08	39.55	88	4	30	22	23	4	4	4	4	16	3	7	7	2	11	4	34
9.08	25.36	95	6	57	34	23	4	5	5	6	20	6	5	8	10	8	6	43
9.17	25.36	110	6	48	28	24	5	5	4	5	19	4	9	10	9	11	5	48
9.17	27.86	113	4	37	27	25	4	4	3	4	15	9	11	12	11	10	5	58
9.17	45.48	123	4	43	27	23	4	6	5	6	21	7	11	5	3	3	2	31
9.08	32.79	101	4	52	32	28	4	4	4	6	18	2	10	9	9	7	6	43
9.17	29.71	105	4	57	36	29	6	7	7	6	26	3	6	11	3	11	2	36
9.00	28.12	103	4	58	35	32	5	7	7	6	25	11	12	7	9	11	5	55
9.08	34.38	96	4	50	31	27	5	5	4	6	20	7	10	10	8	3	4	42
9.33	30.94	90	5	37	26	29	4	4	3	4	15	9	10	7	10	10	9	55
9.00	40.68	107	5	50	34	27	4	4	4	5	17	3	9	5	4	6	2	29
9.17	45.05	82	4	41	28	23	4	4	3	5	16	0	4	6	3	9	3	25
9.25	34.77	90	5	45	31	27	4	6	4	3	17	2	4	6	6	5	2	25
8.75	75.41	103	2	58	35	27	6	6	6	6	24	10	10	7	12	4	8	51
8.42	45.05	109	7	72	46	26	4	5	5	6	20	7	8	8	9	6	5	43
8.75	54.54	99	6	58	35	28	4	5	5	6	20	2	10	10	6	5	2	35
9.42	40.14	91	5	55	36	28	4	5	5	5	19	3	7	7	11	11	2	41
8.83	34.77	88	2	54	38	30	5	4	4	6	19	5	6	8	9	12	1	41
8.42	70.14	109	4	58	37	27	4	5	4	5	18	10	8	2	8	12	5	45
8.25	41.43	95	4	43	26	23	5	5	4	4	18	4	6	4	8	4	3	29
8.25	29.31	93	3	56	38	26	5	5	4	5	19	3	9	9	8	3	1	33
8.42	40.68	117	2	65	46	28	6	6	4	7	23	10	9	6	12	10	5	52
8.50	25.36	100	3	50	30	27	4	4	3	3	14	4	5	5	7	5	3	29
7.58	25.36	106	5	56	36	27	4	5	4	5	18	7	7	9	9	12	2	46
9.00	58.29	112	3	63	39	30	4	5	4	5	18	11	11	12	9	11	7	61
7.58	25.36	89	3	39	26	25	4	5	4	3	16	3	6	8	7	10	4	38
8.58	25.36	112	2	46	31	26	3	5	3	3	14	7	7	11	2	10	3	40
7.33	47.61	102	4	46	32	26	4	5	3	3	15	3	8	12	5	6	4	38
9.58	40.14	100	2	52	35	28	5	6	6	6	23	4	8	11	8	11	2	44
9.33	29.18	91	3	52	33	31	5	6	4	6	21	1	8	5	0	7	2	23
7.83	39.65	121	7	42	28	26	4	4	3	4	15	7	6	5	7	9	5	39
8.42	40.14	89	5	39	26	25	3	4	2	3	12	0	6	12	4	9	7	38
8.92	34.38	96	4	49	32	30	5	5	4	7	21	1	9	9	1	10	3	33

NA Sample

8.75	25.36	100	2	68	43	27	6	7	6	7	26	9	10	11	10	10	3	53
9.08	39.03	106	2	61	36	30	4	5	5	5	19	4	8	7	8	6	1	34
9.08	70.14	112	0	61	37	29	5	5	4	6	20	7	6	8	9	10	4	44
8.83	55.19	112	0	57	38	31	5	6	5	6	22	12	12	9	12	11	4	60
8.83	64.52	112	1	66	37	28	5	5	4	7	21	10	10	11	11	11	7	60
9.00	74.52	115	2	68	43	30	6	6	6	7	25	10	9	10	12	6	4	51
8.42	64.00	123	5	73	44	32	5	7	5	6	23	11	12	9	12	10	9	63
8.58	75.41	112	3	73	45	31	6	6	6	6	24	6	10	7	10	9	2	44
8.92	70.43	115	2	64	40	31	5	6	4	5	20	12	12	11	12	11	4	62
9.17	73.22	109	2	68	41	31	4	5	5	7	21	10	9	9	12	4	6	50
8.42	76.01	109	3	64	45	31	6	6	4	6	22	7	5	10	11	10	8	51
8.58	39.54	106	3	71	46	32	7	7	6	6	26	8	9	10	12	10	4	53
8.92	52.11	115	2	68	39	31	6	7	5	7	25	12	12	11	12	12	8	67
9.17	70.94	115	2	76	43	31	5	7	5	7	24	12	12	9	11	10	5	59
8.58	53.29	115	1	61	39	26	4	7	4	6	21	12	9	12	8	11	5	57
8.75	43.05	109	1	70	42	29	6	6	5	6	23	11	4	10	12	4	5	46
8.67	68.80	112	2	74	43	31	5	6	5	6	22	11	12	9	10	12	5	59
9.50	25.36	88	1	61	40	28	5	7	5	7	24	4	3	6	4	11	2	30
8.83	31.28	100	1	58	34	28	5	6	6	5	22	1	6	9	6	4	1	27
8.25	31.86	106	3	60	38	29	5	6	4	6	21	11	12	9	12	12	8	64
9.17	31.28	88	1	55	35	28	4	5	4	5	18	4	10	11	7	10	1	43
8.83	29.93	112	2	64	37	31	6	7	6	7	26	8	9	11	10	10	4	52
9.00	54.25	117	3	66	37	30	4	5	4	5	18	9	7	6	12	5	1	40
8.42	39.54	83	2	56	37	28	4	5	5	6	20	3	5	11	2	4	1	26
8.75	40.14	117	0	67	45	32	5	6	6	7	24	8	12	9	12	11	7	59
9.00	70.14	94	1	68	43	30	6	7	7	7	27	8	7	8	11	9	3	46
8.08	40.14	97	1	64	40	29	4	7	6	6	23	12	9	10	12	12	8	63
9.00	29.18	109	1	73	43	29	6	7	5	7	25	6	5	11	11	8	4	45
9.00	40.14	106	0	64	39	30	5	7	4	5	21	8	6	10	10	6	2	42
8.67	30.00	100	0	58	35	29	4	5	4	6	19	9	12	10	10	11	9	61
8.58	25.36	100	3	64	40	30	5	7	5	7	24	11	12	12	12	12	10	69
8.92	29.76	97	3	60	35	28	5	7	5	6	23	1	8	9	5	4	3	30
8.17	25.36	117	0	65	41	30	4	7	4	6	21	4	11	10	11	11	5	52
9.25	29.31	106	1	69	39	22	6	6	7	6	25	5	12	9	7	8	3	44
8.33	25.36	97	3	72	44	31	5	7	6	7	25	8	12	12	12	10	3	57
8.75	30.48	106	1	70	43	31	7	7	7	7	28	11	12	11	12	8	6	60
8.17	55.19	112	4	71	49	28	6	7	7	7	27	10	12	10	12	12	10	66
9.17	39.49	115	0	71	48	32	5	7	5	7	24	12	12	9	10	11	8	62
8.58	31.30	106	3	60	40	32	6	6	4	6	22	9	11	9	12	11	5	57
9.33	29.18	91	4	67	39	31	6	7	5	7	25	11	12	5	12	11	8	59
8.83	29.26	109	1	66	40	30	6	7	6	6	25	11	12	9	12	11	6	61
8.42	25.36	88	5	58	40	30	5	6	4	6	21	6	11	9	8	10	2	46
8.25	25.36	109	2	63	39	33	5	6	4	7	22	9	12	9	12	10	7	59
9.08	29.43	88	4	55	33	32	4	6	5	6	21	6	11	11	4	6	4	42