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I am submitting herewith a dissertation written by Richard Dean Lewis entitled "Neuropsychological Validation of Diagnosed Learning Disabilities in Male Adolescents." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

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NEUROPSYCHOLOGICAL VALIDATION OF DIAGNOSED LEARNING DISABILITIES IN MALE ADOLESCENTS

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Degree

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ABSTRACT

The study reported herein was undertaken in order to examine the adjunctive utility of the Luria-Nebraska Neuropsychological Battery as a diagnostic system for the identification of that catagory of disorders referred to generically as specific learning disabilities. Current assessment procedures, based on the discrepancy model, have been criticized as being psychometrically inadequate for diagnostic purposes.

The research sample included 30 students identified by the host school system as learning disabled (LD) and 30 students randomly selected from the nonhandicapped school population who served as a comparison group. All students in the research sample were male, between the ages of 13 and 17 years, enrolled in either the 8th, 9th, or 10th grade, and of average or near average intelligence. The two groups were matched for age, grade in school, and IQ. Following the administration of the test battery to all 60 students, various combinations of summary scale T-scores were examined in order to assess the test battery's ability to discriminate the groups and classify students in accordance with actual group membership.

Statistical analyses confirmed the discriminative sensitivity of the battery with 12 of the summary scales as well as with a subset of these scales, excluding from the 12 those most typically elevated for individuals with poor educational histories (i.e., Expressive Speech, Writing, Reading, and Arithmetic). Discriminant function analysis correctly classified 90% of the students with acceptable false positive (6.7%) and false negative (13.3%) rates. Additionally, the accuracy of established rules for the interpretation of test profile characteristics recommended for use in the identification of individuals with brain dysfunction was demonstrated for the LD diagnosis. Although the battery was found to be sensitive to differences between adolescents with and without LD, the application of single or combined indicators of LD did not significantly improve upon the accuracy of LD classifications made by the 1982 Tennessee State Department of Education criteria alone.

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CHAPTER I

INTRODUCTION

The purpose of this research is to assess the diagnostic accuracy of the Luria-Nebraska Neuropsychological Battery (Golden, Hammeke, & Purisch, 1979) for adolescents diagnosed as having a specific learning disability (LD). The study was undertaken to examine the utility of the Luria-Nebraska Neuropsychological Battery (LNNB) as an adjunct to current diagnostic procedures which have been criticized for being questionably reliable and valid.

Coles (1978) suggested that problems in the identification of LD stem from the inability of most tests and assessment procedures to identify accurately persons with the syndrome. Peterson and Hart (1978) suggested that procedural inconsistencies evidenced by clinicians in the analysis and interpretation of diagnostic data exacerbate such problems. Problems with the discriminant value of the LD diagnosis have resulted in criticism that the term LD is a "catch-all" label or "wastebasket" catagory (Lynn, 1979).

At present, the most widely used set of definitional and diagnostic criteria for the identification of LD are

those mandated by the U.S. Office of Education (1977). According to these guidelines the diagnosis of LD requires the presence of a severe discrepancy between measured intelligence and achievement in specific areas of academic skill. The validity of this criterion has been questioned by many (e.g., Norman & Zigmond, 1980). Criticism of this criterion includes numerous concerns with its unacceptably high rate of false positive misclassifications (Lambert & Sandoval, 1980; Shepard, 1980; Ysseldyke & Algozzine, 1979). As a consequence, Shepard (1980) cautions against use of the U.S. Office of Education guidelines as the sole criterion for the LD diagnosis. Several authors have suggested that clinicians should use other criteria to corroborate a diagnostic decision with regard to the LD classification (Campbell, 1979; Torgeson, 1979). The problem with this recommendation is that professionals in the field have yet to agree on what constitutes acceptable corroborating evidence to confirm independently the LD diagnosis. Moreover, little well-designed research has addressed this problem.

Recently, clinical and school psychologists have become increasingly interested in the methods of clinical neuropsychology in the hope that such procedures may be diagnostically useful with the LD population (Gaddes, 1980). Research supporting the use of such assessment

procedures for the LD diagnosis is meager. A promising strategy for neuropsychological assessment is the LNNB. The LNNB effectively discriminates individuals with brain dysfunction from those with normal brain functions (Golden, Hammeke, & Purisch, 1980). Since LD is assumed by some (Clements, 1966; Selz, 1977) to reflect an underlying brain dysfunction, it was hypothesized that the LNNB would discriminate and accurately classify individuals with and without LD. It was also hypothesized that the LNNB would be a useful adjunct to current diagnostic procedures based on the discrepancy model.

Learning Disability: The Concept

Historically, the concept of LD has been used to explain the impaired academic performance of children of average or above average intellectual ability. Deficits in one or more areas of information processing mediated by the central nervous system have been viewed as being of major etiological significance for the occurance of LD (Levine, Brooks, & Shonkoff, 1980). Since most LD children evidence no external signs of structural brain damage, the academic deficits have been interpreted as a manifestation of subtle functional disturbances (Dalby, 1979). Thus, most definitions of LD have emphasized the role of neuropsychological factors in their descriptions of the relevant symptoms (Gaddes, 1980).

During the past two decades, a number of explanations have linked the LD syndrome with deviations of central nervous system functions. Summarizing the results of a task force on terminology and identification procedures relevant to the minimal brain dysfunction syndrome (a precursor to the term--LD), Clements (1966) stated:

> These deviations may manifest themselves by various combinations of impairment in perception, conceptualization, language, memory, and control of attention, impulse or motor function. (p. 9)

Others have explained LD in terms of central processing (Chalfant & Schefflin, 1966), attentional (Tarver & Hallahan, 1974; Ross, 1976), and language deficiencies (Vellutino, 1979).

Reviewing historical and current explanations of LD, Blanck (1978) noted that no single etiological explanation sufficiently accounted for the heterogeneity of the LD population. Adelman (1979) summarized the most current and widely accepted view of the LD syndrome by stating that the term is used to refer to a heterogeneous group of individuals who differ with regard to presenting symptoms, etiology, performance capabilities, and prognosis.

Learning Disability: Definition and Diagnostic Criteria

In 1968, the National Advisory Committee on Handicapped Children (NACHC) proposed the following definition of LD:

> 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 language. 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, and developmental aphasia. 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.

In 1977, the U.S. Office of Education offered a similar definition of LD to be used by state and local education agencies in determining eligibility for special education services under this diagnostic catagory. Concurrently, diagnostic criteria for the LD classification were set forth:

(a) A team may determine that a child has a specific learning disability if:
  (1) The child does not achieve commensurate with his or her age and ability levels in one or more of the areas listed below, when provided with learning experiences appropriate for the childs age and ability levels; and
  (2) The team finds that a child has a severe discrepancy between achievement and intellectual ability in one or more of the following areas:
    (i) Oral expression;
    (ii) Listening comprehension;
    (iii) Written expression;
    (iv) Basic reading skill;

(v) Reading comprehension;
(vi) Mathematics calculation; or
(vii) Mathematics reasoning.

(b) The team may not identify a child as having a specific learning disability if the severe discrepancy between ability and achievement is primarily the result of:
(1) A visual, hearing or motor handicap;
(2) Mental retardation;
(3) Emotional disturbance; or
(4) Environmental, cultural, or economic disadvantage. (p. 65083)

The Problem

Although widely adopted for use by state education agencies to identify students as LD, both the NACHC and U.S. Office of Education (USOE) definitions have been severely criticized. Hammill (1976) stated that the NACHC definition lacked the operational precision necessary for the identification of individuals who should be classified as LD. Larsen, Rogers, and Sowell (1976) stated that the concept of psychological processes, contained within the NACHC definition, was particularly unclear. They suggested that there was some question as to whether such processes could be reliably measured and whether persons with LD could be accurately identified with measures available at the time.

Problems in the identification of LD have also stemmed from a lack of operational precision in the USOE diagnostic criteria (Torgeson, 1979). Because the USOE criteria fail to mention the standards to be used to

determine discrepancy, problems of reliability have resulted (Beatty, 1977; Harber, 1980). Consequently, there has been considerable inconsistency in the application of the guidelines. This has led to much public criticism directed towards educators and psychologists responsible for the identification of the LD population in the schools (Lynn, 1979).

Research examining the general use of the USOE guidelines has raised questions regarding the acceptability of the discrepancy criterion. In a survey of 1,966 LD children enrolled in Child Service Demonstration Centers, Norman and Zigmond (1980) reported that many (52%) such children did not evidence severe levels of discrepancy when a formula-based criterion was applied to their IQ and achievement test scores. It was also found that reading and math achievement levels of students in grades one, two, and three did not differ from ability-based expectations for most children sampled. Discrepancies of two or more grade levels were generally not evidenced until children had reached age 12. Furthermore, it was noted that the percentage meeting the discrepancy criterion increased with age, from 34% at age 6 to 72% at age 17. The authors suggested that factors other than the discrepancy criterion were probably operative in the majority of the initial decisions to diagnose the children surveyed as LD. The authors failed to offer any further

comment as to what other factors may have been operative in such decisions.

The question of diagnostic consistency in the standards employed by clinicians for the classification of LD students was also examined by Peterson and Hart (1978). These investigators evaluated a state-wide system for the identification of handicapped children. Multiple discriminant function analysis was used to examine assessment and demographic information of 477 children (who had been identified by their teachers as potential candidates for placement in special education programs). Data from this group of students was examined to determine whether classification decisions could be predicted (for the categories of mental retardation, learning disability, emotionally handicapped, culturally disadvantaged, slow learner, and a no problem group). Although state guidelines for the identification of LD mandated the use of a discrepancy criterion, this variable was found to be a poor discriminator. Furthermore, it was noted that the LD group could not be accurately identified by the statistical procedure. The authors concluded that the diagnosis of LD was unreliable and fraught with problems stemming from either weaknesses in the guidelines used to differentiate the syndrome or from the lack of agreement among clinicians as to what constitutes a learning disability.

In a recent investigation of the IQ and achievement characteristics of 50 fourth-grade LD children, Ysseldyke, Algozzine, Shinn, and McGue (1982) reported that many LD children were not identified in accordance with USOE guidelines. They reported that discrepancies of 1, 1.5, and 2 standard deviations were evidenced by 72%, 48%, and 0% of their sample, respectively. Additionally, it was noted that a sample of 49 low achieving students (who had scored at or below the 25th percentile on the Iowa Tests of Basic Skills) evidenced comparable IQ-achievement discrepancies. The authors thus concluded that the diagnosis of LD is prone to considerable error.

Shepard (1980) suggested that the use of a discrepancy criterion may result in the classification of too many normal children as LD. In a prevalence study of LD, Lambert and Sandoval (1980) reported that 43% of their control sample, who consisted of average to above average achievers, evidenced a significant IQ-achievement discrepancy when a formula-based criterion was applied to their test scores.

Diagnostic error should be avoided as much as possible. Errors in the false positive direction result in the unnecessary provision of costly educational programs to children whose needs do not justify such services. Also, this type of error should be avoided

because the psychological impact of the LD label on the truly normal child may lower self-esteem or create an excuse for nonperformance. Errors in the false negative direction also need to be avoided as they result in the application of inappropriate educational services and the denial of more appropriate services.

In an attempt to remedy problems stemming from inconsistencies in the diagnostic practices of clinicians, a more precise set of guidelines have been introduced at the state and local level in Tennessee. These guidelines specify the tests that may be used for the assessment of students, the extent of discrepancy which must be present for the LD diagnosis, and the procedures to be used to determine discrepancy (Tennessee State Department of Education, 1982). It should be noted that the guidelines also specify conditions under which the discrepancy criterion may be overridden as it is acknowledged that the model is flawed and that clinical judgement should be used to determine the LD diagnosis in many instances. The net effect of this effort to improve the reliability and/or accuracy of the USOE guidelines is open to question as the same clinical standards of judgement will probably not be applied uniformly across cases when the discrepancy criterion is superseded.

It should be recognized that attempts to improve the reliability and/or accuracy of the USOE guidelines by

specifying the use of more exacting criteria will most likely result in limited success since the discrepancy model, upon which the guidelines are based, is beset by major flaws itself. Statistical and conceptual problems associated with the discrepancy model will be discussed at some length to illustrate its limitations.

Statistical problems of reliability seriously limit the ability to make an accurate determination of the discrepancy between ability and achievement. Since both intelligence and achievement test scores are subject to measurement error, the determination of differences between these measures must be couched in terms of the variation which results from test score inaccuracy. The standard error of measurement creates a problem in the determination of difference scores. Theoretically, it can operate either to mask a true difference so that it appears less significant or to exaggerate a difference so that it appears more significant. Although one can create parameters to deal with measurement error, it is impossible to determine which effect may be operating on a given set of scores and adjust one's criteria accordingly.

A second statistical problem in determining the significance of a given discrepancy is the unreliability of difference scores themselves. Salvia and Clark (1973) cautioned against basing diagnostic decisions on difference scores since such scores are considerably less

reliable than the scores from which they are determined. Salvia and Clark noted that the accuracy of the difference between the scores of two measures is a function of (a) the correlation between the two tests, (b) the standard deviations of the tests, (c) their reliabilities, and (d) differences between the standardization samples. Since the majority of intelligence and achievement tests have not been co-normed, the variance, which may be attributed to the final condition (d), is usually unknown. Thus, differences between intelligence and achievement test scores may be created or obscured by the inaccuracies which result from the aforementioned statistical processes. It is important to note that most problematic are those that result from the use of tests that have not been co-normed. At present, very few co-normed tests of ability and achievement exist which have been demonstrated as diagnostically sensitive for the LD catagory.

The statistical phenomenon of regression towards the mean creates further problems for the clinician who uses the discrepancy model in the diagnosis of LD. Regression towards the mean is a problem encountered when the scores on two tests are positively, but less than perfectly correlated (as are intelligence and achievement tests). The regression phenomenon influences the distribution of test scores in a given population. Because of its

influence, children with low IQ scores will tend to have relatively higher achievement status than IQ status, although they will still tend to score below the mean on achievement tests. Conversely, children with high IQ scores will tend to have relatively lower achievement status than IQ status, although they will still tend to score above the mean on achievement tests (McLeod, 1979). Therefore, regression effects can mask IQ-achievement discrepancies in low IQ children and create or exaggerate such discrepancies in high IQ children. The magnitude of the regression effect on the scores obtained by any given individual can not be determined unless the intelligence and achievement tests have been co-normed (Shepard, 1980).

Conceptual problems associated with the discrepancy model also complicate the LD diagnosis. Of particular importance is the assumption that IQ represents an index of expected achievement. Ross (1976) questioned the validity of this assumption because prior learning affects how well one does on tests of intelligence. It is widely acknowledged that many items on tests of intelligence assess actual achievement (Sattler, 1982). Campbell (1979) noted that a problem for the interpretation of IQ-achievement differences stems from the overlap existing between these two types of measures. Campbell stated that, since such tests share from 10% to 50% of their variance, many LD children may be misidentified as normal

because of poor performance on similar sections of each type of test. The shared variance could conceivably reduce a discrepancy between scores to nonsignificant levels. For example, Lloyd, Sabatino, Miller, and Miller (1977) noted that the performance of LD children who display reading problems tends to be low on sections of intelligence tests which measure language abilities. For this reason, these authors questioned the value of the discrepancy model and especially the use of the IQ as an index of expected achievement for children with language problems.

Assuming that the IQ is a valid index of expected achievement for most people, a problem of interpretation may result from the use of intelligence tests which yield more than one IQ. The problem with the use of such measures then becomes one of deciding which IQ is the most valid predictor. For example, with the Wechsler scales the decision must be made as to which of the IQ scores provided should be used as the most appropriate index of expected achievement. This may not present as much of a problem when the IQ's are similar in magnitude as when they are highly discrepant. Arbitrary decisions regarding which IQ to use in the determination of IQ-achievement differences may result in a high rate of misclassification or diagnostic error. In cases where large verbal-performance differences exist, the Full Scale

IQ loses significance as a meaningful index of ability (Kaufman, 1979). Myklebust (1968) recommended using the higher of the IQ's as an estimate of expected achievement. However, others have contended that this recommendation has no logical basis or empirical support (Hanna, Dyck, & Holen, 1979). Some (Black, 1974; Holroyd & Wright, 1965) have suggested that large verbal-performance differences may be diagnostically significant as they have been frequently observed among neurologically-impaired populations. However, research findings have generally refuted the diagnostic significance of such differences for the LD classification (Dyckman, Peters, & Ackerman, 1973; Kaufman, 1976; Vance, Gaynor, & Coleman, 1976).

In general, attempts to increase the reliability of the LD diagnosis by quantification of the IQ-achievement criterion through the use of formulas have not been very successful. All formulas developed for such a purpose have been criticized as either mathematically unsound or impractical (Shepard, 1980). They also have been noted to produce inequitable diagnostic decisions across age and ability levels (Elliot, 1981).

The formula-based approach recently implemented by the Tennessee State Department of Education (1982) and recommended for use by others (e.g., Wilson, Cone, Busch, & Allee, 1983) involves computing differences between

achievement test standard scores and the IQ of the intelligence test. An advantage of this method of quantifying discrepancy over most others is that it takes into account variations associated with age, ability, and grade level factors. A major weakness of the subtraction method is that it does not account for the effects on test scores from regression to the mean.

The use of regression equations has been proposed as a more reliable and mathematically sound approach to quantifying the IQ-achievement discrepancy (Cone & Wilson, 1981). This method involves the use of multiple regression formulas (developed from the standardization data of co-normed tests of ability and achievement). Shepard (1980) noted that this method is statistically superior to the subtraction method as it accounts for effects on test scores resulting from both measurement error and regression to the mean. However, in addition to being impractical (as so few co-normed tests of ability and achievement currently exist), it has also been criticized as being of questionable validity since it tends to yield a high rate of false positive misclassifications (O'Donnell, 1980).

In summary, application of the discrepancy model of diagnosis for the classification of LD is open to

criticism on both conceptual and statistical grounds. The U.S. Office of Education guidelines, based on the discrepancy model of assessment, are prone to error. Recent attempts to improve the reliability of the LD diagnosis by the application of more stringent criteria (as was recently done on a state-wide basis in Tennessee), may have limited success due to the fact that the model upon which the criteria are based is flawed. To rectify the problems of diagnosis with the LD classification, Shepard (1980) recommends that:

> It is a good general rule when dealing with fallible measures never to trust a diagnosis unless it is independently confirmed by other measures. . . . Since errors are of different kinds in each measurement approach, they are not likely to be consistent; therefore when results concur there is some assurance that the conclusion is valid. The requirement for independent confirmation calls for some double testing but it distinctly precludes the practice of repeatedly testing until a discrepancy is found and then recommending the LD classification. . . . Knowing the flaws in diagnostic tests and the discrepancy model, experts must avoid abusing the factor of chance by overinterpreting single indicators of LD. . . . Diagnostic practices should be better tailored to reflect how subject to error they are. (p. 89)

Recently, some (Gaddes, 1980; Hynd & Obrzut, 1981; Selz, 1977; Selz & Reitan, 1979) have advocated for the use of neuropsychological tests for the identification of those children and adolescents with specific learning disabilities. It has been claimed by some that such types of tests may be useful as adjunctive diagnostic

indicators of LD. However, empirical support for such claims is meager.

LD and Neuropsychological Assessment

To date, research with neuropsychological assessment procedures has focused largely on the sensitivity of individual tests or test batteries to the presence of brain dysfunction. It was not until the 1970's that research in clinical neuropsychology examined the applicability of neuropsychological assessment procedures to the diagnosis of LD. Limited data do exist which suggest that LD children and adolescents manifest cognitive impairments on neuropsychological tests (Gaddes, 1980; Horton, 1981; Rourke, 1975).

Reitan and Boll (1973) investigated the neuropsychological correlates of the minimal brain dysfunction syndrome (MBD) among children in the 5 to 8 year age range. Their sample included four groups of subjects: 25 brain-damaged children, 25 normal controls, and 44 children who met Clements (1966) criteria for the MBD syndrome, 25 of whom were referred because of academic problems and 19 of whom were referred because of behavior problems. Responses to the Reitan-Indiana, the Wechsler Intelligence Scale for Children (WISC), the Wide Range Achievement Test (WRAT), a modification of the Halstead-Wepman Aphasia Screening Test, a sensory-perceptual exam,

and measures of motor ability were examined for between-group differences. On most measures the means of the MBD group fell between those of the normal and brain-damaged groups. Few statistically significant differences were found between the two MBD groups or between the MBD and control groups. Blind judgements by Dr. Reitan were made of individual performances to determine whether children could be accurately classified using the categories of normal, mildly impaired, and abnormal. Of the controls 64% were judged to have normal brain functions, whereas 36% were judged to be mildly impaired. Of the MBD group 80% were judged to be mildly impaired, whereas 20% were judged to be abnormal. Of the brain-damaged group 4% were judged to be mildly impaired and 96% were judged to be abnormal. The authors of the study conceptualized the MBD syndrome as characterized by a state of mildly impaired brain function. Therefore, a classification of MBD children as mildly impaired was viewed as a correct classification.

Although this study did attempt to determine whether scores on various neuropsychological tests differed between groups, the statistics used (i.e., analysis of variance) could not provide information regarding the percentage of individuals accurately classified by a procedure or what is commonly referred to in the literature as the hit rate. Thus, comparative statements

regarding the relative diagnostic efficacy of each method of analysis could not be made. Another limitation of this study was the reliance upon blind judgement as the sole method of obtaining hit rates. Since no mention was made of the method or rules by which classification decisions were made, replication or cross-validation by individuals other than the authors was made impossible.

Selz (1977) investigated the neuropsychological test performance of children in the 9 to 14 year age range. Three groups of subjects were included in this study: 25 normal controls, 25 brain-damaged children, and 25 LD children. The LD children were selected on the basis of the following criteria: having a minimum of one area of achievement at least one year below grade placement (as measured by the WRAT), having average or near average intelligence (as measured by the WISC), and having no evidence of structural brain-damage (as determined by a neurological exam and medical history). Three classification procedures were used to estimate hit rates: (a) discriminant function analysis, (b) blind judgements of individual test performances made by Dr. Reitan, and (c) a system of neurodiagnostic rules derived from pilot research (based on four methods of clinical inference--level of performance, right-left differences, patterns of performance, and pathognomonic signs). It involved an examination of case records of individuals who had been

given a battery of neuropsychological tests (the Halstead-Reitan Neuropsychological Battery, the WISC or Wechsler-Bellevue, the Trailmaking Test, the Reitan-Kløve Sensory-Perceptual Exam, and the Strength of Grip Test). Groups were matched for age but not for sex, IQ, or grade in school.

A comparison of the diagnostic accuracy of the various classification methods is presented in Table 1. An examination of the overall number of correct classifications indicated that the groups were classified with a degree of accuracy that surpassed that which would have resulted from random assignment to groups. The rules method of classification was the least accurate of the three, although it was 73.3% accurate. Errors for both discriminant analysis and the rules methods tended to be in the direction of classifying subjects as less impaired than their actual group membership would have implied. Errors for the blind judgement method tended to be in the opposite direction, that of classifying subjects as more impaired than their actual group membership would have implied. Kappa, the proportion of agreement after chance agreement is removed (Cohen, 1960), indicated that agreement between actual group membership and that which would be predicted by the various classification methods was highest with the blind judgements and discriminant analysis methods and lowest with the rules system method.

Table 1. A Comparison of Classification Methods in the Prediction of Group Membership as Reported by Selz (1977)

Method	Group[a]	Predicted Group[b,c] Control	LD	BD
Discriminant Analysis				
	Control	23 (92)	2 (8)	0 (0)
	LD	5 (20)	19 (76)	1 (4)
	BD	4 (16)	3 (12)	18 (72)
Blind Judgement				
	Control	20 (80)	5 (20)	0 (0)
	LD	0 (0)	19 (76)	6 (24)
	BD	1 (4)	2 (8)	22 (88)
Rules System				
	Control	24 (96)	1 (4)	0 (0)
	LD	8 (32)	14 (56)	3 (12)
	BD	4 (16)	4 (16)	17 (68)

Note. Numbers in parentheses are percentages of group so classified.

[a] n = 25 for each group.

[b] Overall correct classifications for each method = 80.0%, 81.3%, and 73.3%.

[c] Kappa for each method = .70, .72, and .59.

Inspection of these results with respect to the various groups indicated different rates of accuracy for each method used to predict group membership. For the control subjects each method tended to yield relatively high rates of accuracy (92%, 80%, & 96%). However, for the LD subjects hit rates were lower (76%, 76%, & 56%), especially with the rules system of classification. In the discriminant analysis and rules system of classification, errors tended to be in the direction of classifying the LD subjects as controls. This finding would suggest that these methods of analysis were not as accurate as the blind judgement method in discriminating between LD and control subjects. Selz suggested that each method of classification involved a different weighting of the data in arriving at a prediction of group membership but failed to further discuss this issue.

Despite the relatively low hit rate obtained with the rules system for the LD group, Selz and Reitan (1979) concluded that the rules were sensitive to differences between normal, LD, and brain-damaged children. This conclusion was refuted by Amante (1980) who argued that the study was confounded by serious methodological problems. In particular, Amante noted that the LD group was selected using inappropriate criteria, that it was poorly described, and that it was possibly unrepresentative of LD children. In another review of this study,

Knights and Stoddart (1981) noted that Selz neglected to address the problem of base rates (as it has been suggested that having experimental and control groups of equal size may yield inflated estimates of diagnostic accuracy when base rates or prior probabilities are unbalanced). Additionally, failure to control for subject differences in socioeconomic status, sex, IQ, and educational level further confounded Selz' findings. It has been suggested that these variables may be of significance in neuropsychological research and should be addressed or controlled (Parsons & Prigatano, 1978).

In an attempt to identify valid predictive precursors of reading disability, Satz, Taylor, Friel, and Fletcher (1978) conducted an extensive longitudinal study of 458 students in a Florida public school system using a variety of neuropsychological measures. Students were initially assessed in kindergarten and later assessed in grades two through five. At the end of second grade, the students were assigned to one of four groups (severely disabled, mildly disabled, average, and superior) on the basis of their reading achievement. Discriminant function analysis of the initial test data yielded an overall hit rate of 78%. An 89% hit rate was obtained for the severely disabled group. Cross-validation with a group of 175 students yielded similar figures. The five best

predictors (finger localization, alphabet recitation, visual form recognition and discrimination, the Beery Visual-Motor Integration Test, and the Peabody Picture Vocabulary Test) were 85% accurate for the severely disabled group, 88% accurate for the mildly disabled group, 67% accurate for the average group, and 100% accurate for the superior group.

In addressing the diagnostic accuracy of neuropsychological tests for the diagnosis of LD, Gaddes (1981) stated that some test batteries have little or no success in discriminating LD from normal students while others have demonstrated hit rates ranging from 75% to 90%. It was noted that higher rates of accuracy have typically been reported for those studies which have included both severely disabled and superior students in the subject sample (as in Satz, et al., 1978).

In summary, research examining the diagnostic accuracy of neuropsychological tests for the diagnosis of LD has yielded encouraging findings, especially with young children in the elementary grades. To date, very little research has been reported concerning the diagnostic accuracy of neuropsychological tests for adolescents.

Recently, the LNNB was developed as a procedure to identify individuals with brain dysfunction/damage. Hit rates ranging from 85% to 93% have been reported for the differentiation of normal controls and brain-damaged

adults (Golden et al., 1980). The accuracy of the test for the LD diagnosis has not yet been examined. As Zwick (1983) noted, the determination of diagnostic accuracy is the initial question to be answered in the evaluation of any diagnostic system. Therefore it would appear that research addressing this issue is necessary before the test battery may be used for the LD diagnosis.

As previously noted, the limitations of the USOE guidelines and the discrepancy model of assessment create a need for an alternative diagnostic system which might be used to corroborate conclusions regarding the existence of LD. One aim of this research is to assess the potential of the LNNB in fulfilling this need. The LNNB may have certain advantages over the discrepancy model of assessment. It provides a comprehensive assessment of psychological processes, a feature relevant for the diagnosis of LD. It also avoids many of the statistical and conceptual pitfalls associated with the discrepancy model (i.e., regression effects and the determination of difference scores) as all of the test scales are directly comparable. It also assesses skill areas included in the USOE guidelines for which few well-standardized measures currently exist (viz., Expressive Speech for the area of Oral expression, Receptive Speech for the area of Listening comprehension, and Writing for the area

of Written expression). The LNNB also includes measures of reading and mathematical skill which may be used for diagnostic purposes.

It has generally been recommended that diagnostic research in the area of LD (and in particular the neuropsychology of LD) should conform to certain standards in order to facilitate replication and to control for confounds resulting from known characteristics of LD populations. Problems in this area have been noted to result from:

1. failure to specify the exact criteria used to select subjects;
2. failure to reduce the heterogeneity of the LD sample through the use of restrictive selection criteria;
3. failure to describe or note major demographic and psychometric characteristics of both LD and comparison groups;
4. failure to equate groups on such variables as IQ, sex, age, socioeconomic status, educational level, and racial or ethnic background;
5. failure to consider effects on subject performance stemming from variations in examiner characteristics (Amante, VanHouten, Grieve, Bader, & Margules, 1977; Lovitt & Jenkins, 1979; Parsons & Prigatano, 1978; Torgeson & Dice, 1980).

This research was designed to maximize replicability and to minimize the influence of potential confounds. All of the aforementioned problems were accounted for in an attempt to improve upon previous research efforts in this area.

It was hypothesized that the Luria-Nebraska Neuropsychological Battery would be sensitive to differences between male adolescents with and without LD. It was also hypothesized that the battery would be effective in the classification of LD and non-LD students and demonstrate validity as an adjunct to current diagnostic procedures based on the discrepancy model.

CHAPTER II

METHOD

Subjects

This research was conducted in a suburban public school system of approximately 27,000 students. Of that number approximately 2,500 students (9%) were certified as LD. Approximately 1,800 (72%) of the LD students in the system were male.

The research sample included 30 LD and 30 non-LD students. Both LD and non-LD students were considered eligible for selection if, according to school records, they were male; Caucasian; currently enrolled in the 8th, 9th, or 10th grade; between 13 and 17 years of age; and had an IQ within the 80 to 120 range. The Full Score IQ of the WISC-R (Wechsler, 1974) was used to select LD students. The Deviation IQ of the Otis-Lennon Mental Ability Test (Otis & Lennon, 1969) was used to select nonhandicapped students for the non-LD group. Students with poor school attendance (viz., 15 or more days absent between 8/30/81 and 12/31/81) were excluded from the study to facilitate data collection procedures.

LD students. The LD students had been certified as such by school psychologists in accordance with USOE

guidelines. In an attempt to screen out inaccurately classified LD students and reduce the heterogeneity of the sample, two additional selection criteria were specified:

1. Placement in a special education program (in a resource or comprehensive development class option) for at least three consecutive years and recertification as LD;
2. Academic functioning below the fifth grade level in at least one area of achievement (as measured by the most recent administration of the WRAT).

Examination of census, attendance, and special education records identified a total of 102 LD students who met all selection criteria. To facilitate data collection procedures, students from schools which contributed fewer than two LD students to this pool were excluded. This reduced the potential LD student pool to 91 students. The parents of these 91 students were sent explanatory letters requesting the participation of their children in the study. Thirty-four of the 91 permission forms were returned. Thirty LD students were selected from the 34 that were available to form the research sample. The basis for the final selection of subjects was matching with a member of the non-LD group on the variables of age, IQ, and grade in school.

Table 2 presents by achievement area the number of students in the LD sample who evidenced academic functioning below the fifth grade level (as measured by the WRAT). A review of this data indicated that 15 (50%) of the 30 LD students had WRAT scores meeting this selection criterion on three subtests, while 6 (20%) and 9 (30%) students met this criterion on two and one subtest(s), respectively.

Table 3 presents the demographic, cognitive, and academic characteristics of the 30 LD students in the research sample. In addition to IQ and achievement test characteristics, Table 3 also presents data on the IQ-achievement differences evidenced by the LD students. These difference scores were derived by subtracting WRAT standard scores from WISC-R Full Score IQ's. The individual IQ and achievement test scores, from which these difference scores were derived, are presented in Appendix A. Complete data was available on WISC-R IQ and WRAT scores. However, WISC-R subtest scale scores were available on only 24 of the 30 LD students in the research sample.

Non-LD students. Non-LD students were selected for inclusion in the study using a stratified random sampling procedure (Cochran, 1971). In order to maximize randomness, every second nonhandicapped student (encountered

Table 2. Number of LD Students Meeting Achievement Level Criterion by Academic Skill Area(s)

Skill Area(s)[a]	No.[b]
Reading/Spelling/Arithmetic	15 (50)
Reading/Arithmetic only	3 (10)
Reading/Spelling only	2 (7)
Spelling/Arithmetic only	1 (3)
Arithmetic only	5 (17)
Spelling only	2 (7)
Reading only	2 (7)

Note. Numbers in parentheses are percentages of students meeting the achievement criterion.

[a]As defined by performance on the WRAT.

[b]$n = 30$

Table 3. Demographic, Cognitive, and Academic Characteristics of LD Group

Variable	n	M	SD
Age (in months)	30	183.50	11.04
Education (grade)[a]	30	8.96	.76
WISC-R Data			
Full Score IQ	30	91.10	7.79
Verbal IQ	30	87.86	10.08
Performance IQ	30	96.40	11.51
Subtest Scores			
Information	24	8.00	2.11
Similarities	24	8.17	2.30
Arithmetic	24	7.26	2.26
Vocabulary	24	8.47	2.23
Comprehension	24	9.17	2.34
Digit Span	23	6.52	2.33
Picture Complet.	24	10.34	2.08
Picture Arrang.	24	11.52	2.04
Block Design	24	9.08	1.92
Object Assembly	24	10.87	3.37
Coding	24	6.60	2.27
WRAT Standard Scores			
Reading	30	76.73	14.43
Spelling	30	72.33	18.76
Arithmetic	30	75.36	16.16
IQ-Achievement			
IQ-Reading	30	14.43	12.26
IQ-Spelling	30	18.76	11.38
IQ-Arithmetic	30	16.16	8.95

[a] n = 9, 13, and 8 students in grades 8, 9, and 10, respectively.

in an examination of student records) who met all selection criteria was deemed eligible to participate, pending parental permission. Ninety-one students were selected on the basis of pre-specified IQ and grade level strata (determined by an analysis of the IQ and grade level characteristics of the 91 LD students selected for potential inclusion in the study). The selection ratios and quotas (the number of students selected for each IQ and grade level stratum) are presented in Table 4.

The parents of the 91 nonhandicapped students (selected by this procedure) were sent explanatory letters requesting the participation of their children in the study. Thirty-three of the 91 permission forms were returned. Students were screened for evidence of neurologically-related problems and previous special education placement by an examination of parental responses to a questionnaire about their children's medical and educational history. One student was excluded from the study because of a history of head trauma. The research sample of 30 non-LD students was chosen from the 32 available students on the basis of matching with a student from the LD group.

Table 5 presents information on major demographic and cognitive characteristics of the 30 non-LD students in the research sample. Achievement characteristics of this group, stanine scores reported for the Total Battery

Table 4. Number of Nonhandicapped Students Selected Within IQ and Grade Level Strata

	Grade Level Strata			
IQ Strata	8	9	10	
80-85	3	8	10	(21)
86-90	5	8	11	(24)
91-95	3	8	9	(20)
96-100	5	7	6	(18)
101-105	2	0	0	(2)
106-110	1	2	0	(3)
111-115	0	3	0	(3)
	(19)	(36)	(36)	

Note. Numbers in parentheses are column and row subtotals.

Note. Total selected = 91.

Table 5. Demographic and Cognitive Characteristics of Non-LD Group

Variable	n	M	SD
Age (in months)	30	183.40	12.12
Education (grade)[a]	30	8.96	.76
Otis-Lennon DIQ	30	92.53	7.79

[a] n = 9, 13, and 8 students in grades 8, 9, and 10.

of the most recently administered California Achievement Test (CAT), are presented in Table 6. Scores obtained by the LD group are also included for comparison. A complete set of CAT scores was unavailable for either group. A review of the data presented in Table 6 indicated that the majority of non-LD students (67%) obtained Total Battery scores that fell within the middle three stanines.

Group comparisons. With regard to achievement characteristics, Table 6 reports data indicating that the LD students tended to obtain scores predominantly within the lowest three CAT stanines. A tabulation of the data indicated that 72% of the LD students obtained Total Battery scores which fell in this range. Only 25% of the non-LD students obtained scores in the lowest three CAT stanines. It should be noted that no non-LD student obtained a score which fell within the lowest stanine (based on available data), whereas 5 (19%) of the LD students did. Although not presented in Table 6, this pattern of scores held across CAT subtests. To compare the distributions of scores presented in Table 6, it was necessary to group CAT stanines into cells of three, as frequencies were too small to perform an analysis of the data with individual stanines. Thus, stanines 1 to 3, 4 to 6, and 7 to 9 were combined to examine between-group differences in the distribution of CAT scores. A two (group) by three (stanine interval) chi-square comparison

Table 6. Number of LD and Non-LD Students Falling Within Each CAT Stanine for the Total Battery

	Group			
	LD[a]		Non-LD[b]	
Stanine	No.	%	No.	%
1	5	19	0	0
2	10	38	2	7
3	4	15	5	18
4	5	19	4	14
5	2	8	11	39
6	0	0	4	14
7	0	0	1	4
8	0	0	0	0
9	0	0	1	4

Note. Administered to 8th, 9th, and 10th grade students on 3/82, 3/81, and 11/81, respectively.

[a] n = 26 (7, 12, and 7 students in grades 8, 9, and 10).

[b] n = 27 (9, 13, and 6 students in grades 8, 9, and 10).

of the distribution of scores revealed significant differences, χ^2 (2) = 25.31, $p < .01$.

According to the results of independent samples t tests, differences between groups on the variable of age were not significant, t (58) = .18, $p > .05$. Age differences between matched pairs of students were no greater than 12 months. IQ differences were also not significant, t (58) = -.95, $p > .05$. IQ differences between matched pairs of students were no greater than 10 points. Matching on grade level was exact.

A Hollingshead Four Factor Index of Social Status (Hollingshead, 1976) was computed for each student based on information obtained from parents. All social strata were represented by students from both groups. A majority (53%) of LD students obtained scores which fell within the lower middle and middle strata, whereas a majority (66%) of non-LD students obtained scores which fell within the middle and upper middle strata. A Kolmogorov-Smirnov Two Sample Test indicated no significant difference between groups with respect to the distribution of scores, z = 1.291, $p > .05$.

Return Rate Monitoring

To assess the existence or extent of selection bias between those LD and non-LD students whose parents did

or did not return permission forms, various indices were monitored.

Overall return rates (of permission forms) for the LD and non-LD groups were 37% and 36%, respectively. No significant differences were determined to exist between the IQ's of those LD students whose parents returned forms and those whose parents did not, t (89) = .30, $p > .05$. Similarly, no differences were found between the IQ's of non-LD group students whose parents returned forms and those whose parents did not, t (89) = .30, $p > .05$.

Return rates for both groups of students were also monitored with respect to grade level. That is, figures were determined as to how many permission forms were returned by parents of LD and non-LD students in the 8th, 9th, and 10th grades. Return rates were highest for 8th grade students (47%), next highest for 9th grade students (38%), and lowest for 10th grade students (25%). However, the difference between the return rate of the LD group and that of the non-LD group was no greater than 3% for any grade level.

In conclusion, the data derived from an analysis of return rates would indicate that whatever selection biases may have occurred in obtaining parental permission for students to participate in the study did not relate to the variables of interest.

Measures

All students were administered the LNNB according to standardized procedures presented in the test manual (Golden et al., 1980).

The LNNB consists of 269 items organized into 14 summary scales: Motor, Rhythm, Visual, Tactile, Receptive Speech, Expressive Speech, Writing, Reading, Arithmetic, Memory, Intellectual Processes, Pathognomic, Right Hemisphere, and Left Hemisphere. For this study, summary scores were computed for all 60 students on 12 of the 14 summary scales. Scores were not computed for the Right and Left Hemisphere scales as these scales are used for the purposes of lateralization/localization of brain dysfunctions and are entirely made up of items in the Motor and Tactile scales. It was felt that these scales would contribute little information relevant to the study of LD beyond that provided by analyses including the Motor and Tactile scales.

The following is a brief description of each of the 12 summary scales used in this research.

Motor. This scale consists of 51 items which measure right and left hand motor speed, drawing skill and speed, oral motor skill, bilateral coordination, the ability to perform kinesthetically-based movements, the ability to imitate simple motor movements using visual referents, and the verbal control of motor movement.

Rhythm. This scale consists of 12 items which measure rhythm and pitch perception, including both expressive and receptive components.

Tactile. This scale consists of 22 items which measure the ability to localize and discriminate cutaneous sensation.

Visual. This scale consists of 14 items which measure visual perception and visual-spatial organization.

Receptive Speech. This scale consists of 33 items which measure the ability to discriminate among phonemes and to comprehend relational concepts, prepostional concepts, word meanings, and logical grammatical relationships.

Expressive Speech. This scale consists of 42 items which measure phonetic and polysyllabic reading skills, oral language skills involving word and sentence repitition, the generation of speech at various levels of complexity, and the ability to make use of complex systems of grammatical expression.

Writing. This scale consists of 13 items which measure the ability to perform phonic analyses with words of various levels of complexity as well as the ability to spell, copy, and generate written language.

Reading. This scale consists of 13 items which measure simple (phonemic) and complex (word, sentence, and paragraph) reading skills.

Arithmetic. This scale consists of 22 items which measure the ability to read, write, and recognize numerals as well as the ability to perform basic mathematical calculations under various conditions.

Memory. This scale consists of 13 items which measure short-term and intermediate memory functions.

Intellectual Processes. This scale consists of 34 items which measure general verbal and nonverbal intellectual abilities, numerical reasoning, and computational speed.

Pathognomonic. This scale consists of 34 items located throughout the battery which have been found to be effective in the discrimination of normal controls from neurologic populations (Golden et al., 1980).

LNNB scale characteristics. LNNB scores include item scale scores and summary scale T-scores. Item scale scores are derived from raw score data and are scored as either 0, 1, or 2. A score of 0 is indicative of performance on an item most typically demonstrated by a normal subject. A score of 2 is indicative of performance

on an item most typically obtained by a brain-damaged subject. A score of 1 denotes performance on an item within a borderline or intermediate region. Item scores within scales are summed to yield raw scores for the summary scales. These raw scores are then converted into the summary scale T-scores for each major scale ($\underline{M}$ = 50, $\underline{SD}$ = 10). High scores on the LNNB reflect pathological functioning.

According to Moses, Golden, Ariel, and Gustavson, (1983), interpretation of the test may be performed at various levels of complexity. At the most basic level of interpretation, the main concern is with the identification of brain dysfunction in a given individual. Summary scale (T-score) data may be used to determine the existence of dysfunction with 85% to 90% accuracy in adult neurologic populations by applying various rules for interpretation.

The initial step in determining the presence or absence of brain dysfunction is to ascertain the critical level which represents the highest scale score on the test that can be considered normal (Moses et al., 1983). The critical level is determined using a formula which considers the age and educational background of an individual. The number of scales falling above the critical level is examined to ascertain the existence of dysfunction. Such scores are viewed as indicators of

impairment and are noted with regard to their frequency, their degree of elevation above the critical level, and the scale(s) on which they occur. Rules have been formulated to identify individuals with brain dysfunction based on an analysis of the scale profile.

Rules for interpretation. For the purposes of this research, the following rules for interpretation, derived from those developed with the test for the identification of brain dysfunction, were examined to determine their ability to discriminate LD and non-LD students. Variants of one rule (Rule 5) were also examined to determine optimal cutting points for the classification of LD students (note 5a and 5b).

Rule 1 classified students as LD if three or more scales exceeded the critical level, not counting the Writing and Arithmetic scales. All others were classified as non-LD (Golden et al., 1980).

Rule 2 classified students as LD if three or more scales exceeded the critical level, including the Writing and Arithmetic scales. All others were classified as non-LD (Moses et al., 1983).

Rule 3 classified students as LD if the range between the highest and lowest scales exceeded 30 points, not using the Writing or Arithmetic scales if either was the highest scale. All others were classified as non-LD (Moses et al., 1983).

Rule 4 classified students as LD if the range between the highest and lowest scales exceeded 30 points, using all 12 scales. All others were classified as non-LD (Moses et al., 1983).

Rule 5 classified students as LD if a minimum of 8 scales exceeded a cutting score defined by the critical level minus 10 points. All others were classified as non-LD (Moses et al., 1983).

Rule 5a classified students as LD if a minimum of 6 scales exceeded a cutting score defined by the critical level minus 10 points. All others were classified as non-LD.

Rule 5b classified students as LD if a minimum of 5 scales exceeded a cutting score defined by the critical level minus 10 points. All others were classified as non-LD.

Procedures

All 60 students were administered the test in their schools during regular school hours. Data collection occurred between mid-April 1982 and late May 1982. The test battery was administered individually by the experimenter and five volunteer examiners. Two of the five volunteer examiners were senior undergraduate psychology majors who received research credit for their participation. The other three volunteers were

first-year School Psychology doctoral students who had completed training in the administration of psychological and educational tests.

Training on the test battery was done by the experimenter. Training extended over a period of two months with each examiner receiving over 10 hours of training. Both large group demonstrations and individual training sessions were used. During individual sessions, the experimenter served as a subject, a trainer, and as a reliability check for scoring. Training was continued until examiners were able to administer and score the test battery according to standardized procedures, as provided in Golden et al. (1980). All testing in the schools was scheduled by the experimenter.

During the data collection period each examiner evaluated 10 students (5 LD and 5 non-LD) in a random sequence. Students were randomly assigned to examiners. Except for the experimenter, examiners were unaware of student group membership or the purpose of the study. Scoring of items that did not require the manual was performed by the examiners during testing or immediately after each session. Scoring on items which required the manual was done by a trained clerical assistant after all data was collected. The assistant was also kept unaware of the purpose of the research and student group membership. Scoring reliability was checked by the

experimenter and agreement was noted on approximately 97% of the items.

CHAPTER III

RESULTS

Data were computer analyzed using SPSS programs (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

Preliminary Analyses

As a subset of data was collected by the experimenter, preliminary analyses were performed to examine the likelihood of effects stemming from the experimenter having apriori knowledge of student group membership and the research hypothesis. It was hypothesized that such an effect would be manifested in a difference between that data collected by the experimenter and that collected by the other examiners. Analyses were run separately for the LD and non-LD groups (using summary scale T-scores) as it was hypothesized that the effect would be observed within student groups. In all 24 comparisons, tests for homogeneity (Box F) and analysis of variance (ANOVA) failed to reach statistical significance at the .05 level. Thus, it was concluded that the data collected by the experimenter did not significantly differ from that collected by the other examiners and could be used in further analyses.

Another set of preliminary analyses was performed to assess the likelihood of effects stemming from uncontrolled examiner characteristics. It was hypothesized that such effects would be manifested in differences between that data collected by each examiner. Analyses were run separately for the LD and non-LD groups (using summary scale T-scores) as it was hypothesized that differences in the data collected by each examiner would be evident within student groups. In this way, a check on the assumption that examiners were, in fact, blind to the students' group status and the research hypothesis was made. In all 24 comparisons ANOVA failed to reach significance at the .05 level. Thus, it was concluded that the data gathered by individual examiners did not differ significantly and that effects stemming from uncontrolled examiner characteristics were negligible.

Complete Battery Analyses

Correlational analysis examined the interrelationships among the 12 summary scales. Table 7 presents the resulting correlation matrix. Pearson *r*'s ranged from .08 (between Tactile and Memory) to .83 (between Writing and Reading). All coefficients were in a positive direction. Of the 66 coefficients 44 and 12 reached significance at the .01 and .001 levels, respectively. High positive correlations were also evident between the

Table 7. Correlation Matrix for 12 Luria-Nebraska Summary Scales

Scale	1	2	3	4	5	6	7	8	9	10	11	12
1. Motor	—	54**	46**	44**	20	52**	47**	51**	29	46**	40*	66**
2. Rhythm		—	28	52**	39*	60**	52**	49**	52**	56**	56**	47**
3. Tactile			—	34*	33*	20	27	13	33*	08	31	56**
4. Visual				—	41*	46**	44**	42*	49**	57**	53**	47**
5. Receptive Speech					—	39*	29	33*	41*	33*	54**	29
6. Expressive Speech						—	78**	78**	62**	59**	66**	58**
7. Writing							—	83**	64**	56**	70**	68**
8. Reading								—	61**	60**	66**	57**
9. Arithmetic									—	49**	69**	43*
10. Memory										—	63**	45**
11. Intellectual Processes											—	53**
12. Pathognomonic												—

*$p < .01$.

**$p < .001$.

Expressive Speech scale and both the Writing and Reading scales (.78).

Table 8 presents the means, standard deviations, and results from *t*-tests for the LD and non-LD groups on each of the summary scales. The LD group obtained higher mean scores on all 12 scales. Group differences reached statistical significance at the .01 level on 10 of the 12 scales. No significant difference between groups was found on the Tactile and Receptive Speech scales.

Appendix B presents the means, standard deviations, and *t*-test comparisons between groups for the 269 items which comprise the battery. Differences between groups reached statistical significance at the .05 level on 75 items. On all 75 such items the LD group obtained higher mean scores than did the non-LD group.

To determine the extent of between-group differences, multivariate analysis of variance (MANOVA) was used. This procedure adjusts for correlations between dependent variables and also adjusts for bias which results from having more than one dependent variable (Huck, Cormier, & Bounds, 1974).

A MANOVA on T-scores from the 12 summary scales was significant by the Wilk's Lambda criterion, F (12, 47) = 6.76, $p < .01$. Based on the results of this analysis, it was determined that a statistically significant difference existed between the LD and non-LD groups on the 12

Table 8. Means, Standard Deviations, and *t* Values for LD and Non-LD Students on 12 Luria-Nebraska Summary Scales

	Non-LD[a]		LD[a]		
Scale	*M*	*SD*	*M*	*SD*	*t*[b]
Motor	39.36	4.95	43.70	5.96	3.06**
Rhythm	44.06	9.84	59.23	15.66	4.49**
Tactile	44.63	7.26	46.50	7.08	1.01
Visual	45.53	6.39	50.50	7.41	2.78**
Receptive Speech	42.86	6.90	45.40	8.29	1.29
Expressive Speech	40.06	4.33	56.00	11.35	7.18**
Writing	55.53	6.99	71.43	7.28	8.63**
Reading	50.93	7.74	66.90	9.67	7.05**
Arithmetic	50.50	7.31	66.36	14.94	5.22**
Memory	45.43	6.93	52.56	7.49	3.83**
Intellectual Processes	56.00	7.52	66.80	8.87	5.08**
Pathognomonic	43.23	6.88	50.06	7.28	3.73**

[a] $n = 30$.

[b] $df = 58$.

*$p < .01$.

**$p < .001$.

summary scales. The assumption of equality of dispersions was not met, F (78, 10622) = 1.54, $p < .05$. However, MANOVA is robust to violations of this assumption (Cooley & Lohnes, 1971).

Discriminant function analysis was used as a follow-up procedure to examine which variables contributed to the significant difference between groups. The single discriminant function yielded a canonical correlation of .79. The equation was significant according to Bartletts' Chi-square, $\chi^2(12) = 52.19$, $p < .001$. An examination of the standardized discriminant function coefficients presented in Table 9 indicated the presence of one large contributor to group differences (Writing) and several lesser contributors (Expressive Speech, Receptive Speech, Pathognomonic, and Rhythm).

Discriminant function analysis was also used to obtain an empirical measure of the success in discrimination by comparing predictions of group membership (derived from the values of the discriminant function) with actual group membership. Table 10 presents data on the accuracy of classifications (hit rates) made by the discriminant function analysis. It should be noted that the overall accuracy of the 12 scale battery was high (90%) with

Table 9. Standardized and Unstandardized Discriminant Function Coefficients for the 12 Summary Scales

	Coefficients	
Scale	SDFC	UDFC[a]
Motor	.04445	.81133
Rhythm	.27056	.20678
Tactile	-.05174	-.72127
Visual	.00577	.83315
Receptive Speech	-.31117	-.40769
Expressive Speech	.32343	.37651
Writing	.72175	.99858
Reading	.13898	.15855
Arithmetic	.16308	.13862
Memory	-.14487	-.20074
Intellectual Processes	.08463	.10285
Pathognomonic	-.29017	-.40942

[a]Constant for the UDFC = -6.94707.

Table 10. Accuracy of Classifications Predicted by Discriminant Function Analysis With 12 of the Luria-Nebraska Summary Scales

	Predictions	
Actual Group	Correct	Incorrect
Non-LD[a]	28 (93.3)	2 (6.7)
LD[a]	26 (86.7)	4 (13.3)
Overall[b, c]	54 (90.0)	6 (10.0)

Note. Numbers in parentheses are percentages of students so classified.

[a] $n = 30$.

[b] $n = 60$

[c] Kappa = .80.

well-balanced false positive (6.7%) and false negative (13.3%) rates.

Stepwise selection was used to empirically determine those scales which made the most important contributions to existing group differences as well as the diagnostic accuracy of classifications made by that set of scales selected by the procedure. Using the Wilk's Lambda method, variables were considered for selection if their partial F ratios were larger than 1.0. Table 11 presents the scales selected by the stepwise procedure in the order that they were included in the discriminant function analysis. It also presents both the standardized and unstandardized discriminant function coefficients of these selected scales. Results of the stepwise selection procedure verified the findings of the previously mentioned discriminant function analysis with 12 scales. That is, stepwise analysis indicated one large contributor and four lesser contributors to existing group differences. Table 12 presents data on the accuracy of classifications made from a discriminant function analysis which included only those scales selected by the stepwise procedure. The diagnostic accuracy of the stepwise procedure closely approximated that obtained with the full battery. With the exception of one additional non-LD student being misclassified, no

Table 11. Summary of Stepwise Discriminant Function Analysis

Order of Selected Scales	Discriminant Function Coefficient	
	Standardized	Unstandardized[a]
Writing	.84779	.11877
Expressive Speech	.39777	.45141
Pathognomonic	-.32122	-.45323
Rhythm	.27638	.21123
Receptive Speech	-.25947	-.33995

[a]Constant for the unstandardized discriminant function coefficient = -7.18502.

Table 12. Accuracy of Classifications Predicted by Scales Selected by Stepwise Discriminant Function Analysis

	Predictions	
Actual Group	Correct	Incorrect
Non-LD[a]	27 (90.0)	3 (10.0)
LD[a]	26 (86.7)	4 (13.3)
Overall[b,c]	53 (88.3)	7 (11.7)

Note. Numbers in parentheses are percentages of students so classified.

[a] $\underline{n} = 30$.

[b] $\underline{n} = 60$.

[c] Kappa = .77.

difference was observed between the two procedures with regard to individual classifications.

Partial Battery Analyses

Because a comparatively poorer performance would be expected from the LD group on those summary scales which assess writing, reading, and arithmetic skills, a separate set of analyses was done to determine the diagnostic sensitivity of the test battery without certain scales. Specifically, the Writing, Reading, and Arithmetic scales were omitted from the data set to determine the sensitivity of the remaining scales to group differences. Additionally, in the subsequent set of analyses (referred to as the partial battery analyses), the Expressive Speech scale was both included as well as excluded from the data set because it contains a number of items which require reading skill.

A MANOVA on the T-score data of the partial battery, including data from the Expressive Speech scale, was significant by the Wilk's Lambda criterion, F (9, 50) = 6.47, $p < .01$. The assumption of equal dispersions was not met, F (45, 11051) = 1.66, $p < .05$. A MANOVA on the partial battery, excluding data from the Expressive Speech scale was also significant by the Wilk's Lambda criterion, F (8, 51) = 4.70, $p < .01$. Here, the assumption of equality of dispersions was met, F (36, 11319) = 1.41,

$p > .05$. Thus, it was determined that a significant difference existed between groups on that subset of summary scales containing little or no academic content.

Table 13 presents the results of a discriminant function analysis on the T-score data of the partial battery. Analyses were performed which either included or excluded the scores from the Expressive Speech scale. An examination of the standardized discriminant function coefficients from the analysis which included the Expressive Speech scale indicated the presence of one large contributor to between-group differences (Expressive Speech) and several lesser contributors (Intellectual Processes, Receptive Speech, and Rhythm). In the analysis which omitted data from the Expressive Speech scale, the Intellectual Processes scale became a major contributor, the Rhythm scale increased considerably in importance, and both the Pathognomonic and Tactile scales contributed to a greater extent than they did in previously mentioned analyses.

Discriminant function analysis was used to obtain hit rates for the partial battery. Table 14 presents figures on the accuracy of classifications made by discriminant function analysis with the partial battery (including and excluding data from the Expressive Speech scale). The data indicate that the overall accuracy of

Table 13. Standardized and Unstandardized Discriminant Function Coefficients for the Partial Battery, With and Without the Expressive Speech Scale

	With Expres. Sp.		W/Out Expres. Sp.	
Scale	SDFC	UDFC[a]	SDFC	UDFC[b]
Motor	-.09041	-.16499	.02911	.53128
Rhythm	.28247	.21588	.48140	.36792
Tactile	-.06965	-.97087	-.28765	-.40100
Visual	.01139	.16459	-.01807	-.26111
Receptive Speech	-.46966	-.61534	-.38607	-.50583
Expressive Speech	.78269	.91114		
Memory	-.11229	-.15560	-.02319	-.32135
Intellectual Processes	.46952	.57062	.74617	.90683
Pathognomonic	.07892	.11135	.38229	.53941

[a]Constant for the UDFC = -4.98785.

[b]Constant for the UDFC = -5.86284.

Table 14. Accuracy of Classifications Predicted by Discriminant Function Analysis for the Partial Luria-Nebraska, With and Without the Expressive Speech Scale

	Predictions	
Actual Group	Correct	Incorrect
With Expressive Speech		
Non-LD[a]	28 (93.3)	2 (6.7)
LD[a]	21 (70.0)	9 (30.0)
Overall[b, c]	49 (81.7)	11 (18.3)
Without Expressive Speech		
Non-LD[a]	26 (86.7)	4 (13.3)
LD[a]	25 (83.3)	5 (16.7)
Overall[b, c]	51 (85.0)	9 (15.0)

Note. Numbers in parentheses are percentages of students so classified.

[a] $n = 30$.

[b] $n = 60$.

[c] Kappa = .63 and .70 for analyses with and without the Expressive Speech scale, respectively.

the battery remained high. The decreases observed in the figures for overall accuracy (to either 81.7% or 85% for analyses which either included or excluded data from the Expressive Speech scale) were insignificant when compared with figures obtained in the complete battery analysis. Removing the Expressive Speech scale from the analysis had no substantial effect on either the overall accuracy of the partial battery or on the separate accuracy noted for each group.

Analysis of Rules for Interpretation

An analysis was done to determine whether or not groups differed on a set of variables which have been identified as interpretatively significant for the detection of brain dysfunction (Golden et al., 1980; Moses et al., 1983). These variables included:

1. the number of scales which exceeded the critical level (including or excluding the Writing and the Arithmetic scales in the count);

2. the range between the highest and lowest scales (including or excluding the Writing and the Arithmetic scales if either was the highest score for an individual);

3. the number of scales exceeding a cutting score defined by the critical level minus 10 points. Table 15 presents means, standard deviations, and the results of *t*-test comparisons between groups for these

Table 15. Means, Standard Deviations, and *t* Values for Luria-Nebraska Profile Characteristics of Interpretative Significance

Variable	LD Group[a]		Non-LD Group[a]		
	M	(*SD*)	*M*	(*SD*)	*t*[b]
Number of scales exceeding critical level	4.26	(1.92)	0.70	(1.14)	8.70*
Number of scales exceeding critical level, not counting Writing and Arithmetic	2.70	(1.68)	0.43	(0.77)	6.70*
Summary scale range based on all 12 scales	37.33	(9.03)	24.20	(5.41)	6.83*
Summary scale range with Writing and/or Arithmetic excluded if highest score(s)	32.96	(9.10)	22.83	(5.83)	5.13*
Number of summary scales exceeding critical level minus 10 points	7.20	(2.18)	3.40	(2.48)	6.29*

[a] $n = 30$.

[b] $df = 58$.

*$p < .001$.

variables. In all instances differences were highly significant. The LD group evidenced a greater mean number of scales above the critical level, a larger mean range of T-scores, and a greater mean number of scales falling above a cutting score defined by the critical level minus 10 points. Table 16 reports the number of LD and non-LD students obtaining a given number of scales elevated above the critical level. It should be noted that both the Writing and the Arithmetic scales were included in the count of scales reported in this table. Table 17 presents the frequency with which elevations occurred on the various summary scales. This table indicates that the Writing and Intellectual Processes scales were most often elevated for both groups of students.

An analysis was performed to determine the diagnostic accuracy of the rules for interpretation of test profile data (derived from those recommended for use in the detection of brain dysfunction). Table 18 presents the results of this analysis. Overall hit rates obtained with the rules ranged from 68.3% (Rule 5) to 90% (Rule 2). Kappa's ranged from .37 (Rule 5) to .80 (Rule 2). The application of Rule 2 yielded the highest overall accuracy and the most balanced ratio of false positives to false negatives.

Table 16. Frequency of LD and Non-LD Students With Summary Scale Elevations on the Luria-Nebraska Neuropsychological Battery

Number of Scale Elevations	LD Group[a]		Non-LD Group[a]	
	No.	(%)	No.	(%)
0	0	(0.0)	19	(63.3)
1	2	(6.7)	5	(16.7)
2	2	(6.7)	4	(13.3)
3	9	(30.0)	0	(0.0)
4	4	(13.3)	2	(6.7)
5	6	(20.0)	0	(0.0)
6	2	(6.7)	0	(0.0)
7	4	(13.3)	0	(0.0)
8	0	(0.0)	0	(0.0)
9	1	(3.3)	0	(0.0)

[a] n = 30.

Table 17. Frequency of Summary Scale Elevations on the Luria-Nebraska Evidenced by LD and Non-LD Students

Scale	LD Group[a]		Non-LD Group[a]	
Motor	1	(3.3)	0	(0.0)
Rhythm	11	(36.6)	1	(3.3)
Tactile	0	(0.0)	1	(3.3)
Visual	4	(13.3)	0	(0.0)
Receptive Speech	0	(0.0)	0	(0.0)
Expressive Speech	10	(33.3)	0	(0.0)
Writing	29	(96.6)	6	(20.0)
Reading	21	(70.0)	3	(10.0)
Arithmetic	19	(63.3)	3	(10.0)
Memory	5	(16.6)	1	(3.3)
Intellectual Processes	24	(80.0)	6	(20.0)
Pathognomonic	3	(10.0)	0	(0.0)

Note. Numbers in parentheses are the percentages of students in each group who evidenced elevated scores on a particular scale.

[a] $n = 30$.

Table 18. Diagnostic Accuracy Obtained With Rules for Interpretation of Luria-Nebraska Profile Characteristics

	Predictions	
Actual Group[a, b]	Correct	Incorrect
Rule 1 (3 or more elevations, not including Writing & Arithmetic = LD)		
Non-LD	30 (100.0)	0 (0.0)
LD	14 (46.7)	16 (53.3)
Overall[c]	44 (73.3)	16 (26.7)
Rule 2 (3 or more elevations, using 12 scale battery = LD)		
Non-LD	28 (93.3)	2 (6.7)
LD	26 (86.7)	4 (13.3)
Overall[c]	54 (90.0)	6 (10.0)
Rule 3 (range 31 or more points, not including Writing &/or Arithmetic if highest score(s) = LD		
Non-LD	26 (86.7)	4 (13.3)
LD	19 (63.3)	11 (36.7)
Overall[c]	45 (75.0)	15 (25.0)

Table 18 (Continued)

Actual Group[a, b]	Predictions			
	Correct		Incorrect	
Rule 4 (range 31 or more points with 12 summary scales = LD)				
Non-LD	24	(80.0)	6	(20.0)
LD	26	(86.7)	4	(13.3)
Overall[c]	50	(83.3)	10	(16.7)
Rule 5 (8 or more scales exceeding critical level minus 10 points = LD)				
Non-LD	26	(86.7)	4	(13.3)
LD	15	(50.0)	15	(50.0)
Overall[c]	41	(68.3)	19	(31.7)
Rule 5a (6 or more scales exceeding critical level minus 10 = LD)				
Non-LD	26	(86.7)	4	(13.3)
LD	22	(73.3)	8	(26.7)
Overall[c]	48	(80.0)	12	(20.0)
Rule 5b (5 or more scales exceeding critical level minus 10 = LD)				
Non-LD	23	(76.7)	7	(23.3)
LD	26	(86.7)	4	(13.3)
Overall[c]	49	(81.7)	11	(18.3)

Table 18 (Continued)

Note. Numbers in parentheses are percentages of students so classified by a particular Rule.

[a] n = 30 for both LD and non-LD groups.

[b] n = 60 for combined groups.

[c] Kappa's = .47, .80, .50, .67, .70, .37, .60, & .63 for Rules 1, 2, 3, 4, 5, 5a, & 5b, respectively.

Combined Classification Analysis

As no single classification system for the diagnosis of LD demonstrates perfect accuracy, and as diagnostic conclusions reached by different indicators may conflict, an analysis was performed to determine whether a combination of indicators might improve on the diagnostic accuracy obtained by single classification methods. As the purpose of this study was to examine whether the LNNB possessed utility as an adjunct to currently implemented diagnostic procedures based on the discrepancy model, various combinations of classification methods were examined in light of their ability to augment the accuracy of recently developed criteria requiring a standard deviations difference between scores on ability and achievement measures (Tennessee State Department of Education, 1982). It should be noted that 24 of the 30 LD students in the study sample met the criterion of having at least one WRAT standard score minimally 16 points below the Full Scale IQ of the WISC-R. Thus, 80% met this particular criterion although all 30 LD students evidenced at least a 12 point discrepancy in one or more areas. Classifications made by the standard score discrepancy method (SSD) were examined in combination with methods used for the analysis of LNNB data. Of the classification methods used with LNNB data, only

those that demonstrated high hit rates (at least 80%) and well-balanced false positive to false negative ratios were selected for inclusion. Thus, of those methods that were examined singly, only discriminant function analysis (DFA), Rule 2, and Rule 4 were examined in combination with the SSD method.

The following combinations were examined in light of their ability to classify students in the study sample.

1. Combination A (consisting of DFA and Rule 2 in combination with the SSD method). For this combination, classification decisions were based on the agreement between any 2 of the 3 single methods.
2. Combination B (consisting of DFA and Rule 4 in combination with the SSD method). For this combination, classification decisions were based on the agreement between any 2 of the 3 single methods.
3. Combination C (consisting of Rule 2 and Rule 4 in combination with the SSD method). For this combination, classification decisions were based on the agreement between any 2 of the 3 single methods.
4. Combination D (consisting of DFA, Rule 2, and Rule 4 with the SSD method). Classification

decisions were based on the agreement between any 3 of the 4 single methods.

Table 19 presents a summary of the hit rates obtained by the various combined methods. For Combinations B, C, and D, the accuracy rates for the non-LD group could not be determined due to the unavailability of standard score discrepancy (SSD) data. Combination A yielded the highest accuracy for the LD group and correctly classified 4 more students than did the SSD method by itself. However, a chi-square test of the difference in diagnostic accuracy between the SSD method and Combination A indicated no significant difference, $\chi^2(1) = 2.66$, $p > .05$. Based on the results of this analysis, it would appear reasonable to assume that no combined method of classification significantly improved upon the diagnostic accuracy obtained with single indicators of LD.

Follow-up Comparisons

As a follow-up to analyses examining the diagnostic accuracy of single and combined indicators of LD, an analysis was performed comparing LNNB summary scale scores of those LD students whose IQ-achievement discrepancies reached a level of one standard deviation difference with those whose discrepancies did not. This was done to determine whether the LNNB was sensitive to differences between LD students with and without IQ-achievement

Table 19. Summary of Diagnostic Accuracy Obtained by Combined Classification Methods

	Predictions	
Actual Group	Correct	Incorrect
Combination A		
Non-LD[a]	28 (93.3)	2 (6.7)
LD[a]	28 (93.3)	2 (6.7)
Overall[b,c]	56 (93.3)	4 (6.7)
Combination B		
Non-LD	NA	NA
LD[a]	26 (86.7)	4 (13.3)
Combination C		
Non-LD	NA	NA
LD[a]	26 (86.7)	4 (13.3)
Combination D		
Non-LD	NA	NA
LD[a]	25 (83.3)	5 (16.7)

Note. Numbers in parentheses are percentages of students so classified. NA means that hit rates were not available.

[a] $n = 30$.

[b] $n = 60$.

[c] Kappa = .84.

discrepancies that met the 1982 Tennessee criteria for certification as LD.

Of the 30 LD students in the research sample, the 24 (80%) that met the discrepancy criterion in at least one area of achievement (irrespective of which area) had a significantly higher mean on the Reading scale than the 6 (20%) that did not meet the criterion in any area, t (28) = -2.17, $p < .05$. LD students with IQ-reading achievement discrepancies of at least 16 points (n = 17) were found to have a significantly higher mean on the Reading scale than those with smaller discrepancies, t (28) = -2.12, $p < .05$. LD students with IQ-spelling achievement discrepancies of at least 16 points (n = 22) were found to have a significantly higher mean on the Writing scale than those with smaller discrepancies, t (28) = -2.46, $p < .05$. No significant differences were found between groups of LD students with IQ-arithmetic discrepancies that were either below 16 points or at least 16 points (n = 15 and 15).

CHAPTER IV

DISCUSSION

One major purpose of this research was to assess the diagnostic sensitivity of the Luria-Nebraska Neuropsychological Battery for the LD classification. It was hypothesized that the battery would be effective in the identification of LD and in the discrimination of a group of adolescents with LD from a matched group of non-LD students.

Relative to this hypothesis, the results of this study were consistently positive. Using summary scale score data, the test battery discriminated between groups of students with and without LD. The summary scale data also yielded high rates of diagnostic accuracy by the application of discriminant function analysis or various interpretative rules.

More specifically, multivariate analysis of variance ascertained that differences between group centroids reached statistical significance (at the .001 level) for the analysis which included data from 12 of the 14 summary scales. Stepwise discriminant function analysis empirically identified one major contributor to existing group differences (Writing) and several lesser contributors.

Differences between groups remained highly significant even when those scales most typically elevated for individuals with poor school histories were omitted from the analysis (i.e., Expressive Speech, Writing, Reading, and Arithmetic).

Correct classification of 90% of the students could be achieved by discriminant function analysis with 12 summary scales. When corrected for agreement due to chance, 80% agreement was obtained between those classification decisions made by discriminant function analysis and actual group membership. Discriminant function analysis with 12 summary scales was observed to yield a fairly well-balanced ratio of false positives (6.7%) to false negatives (13.3%). The stepwise procedure (which selected five scales for the discriminant function analysis) was able to correctly classify 88.3% of the students. Only one individual classification decision was observed to be different from decisions made by the 12 scale analysis. Single rules for the interpretation of individual test profile data, derived from established rules recommended for use in the identification of brain dysfunction by various sources (e.g., Golden et al., 1980; Moses et al., 1983), differed in rates of accuracy. The percentages of correct classifications, obtained by

the singular application of the various rules for interpretation of test profile data, ranged from a low of 68.3% (Rule 5) to a high of 90% (Rule 2). When corrected for agreement due to chance, rates for agreement between those classifications made by the various rules for interpretation and actual group membership ranged from a low of 37% to a high of 80% (again Rule 5 as contrasted with Rule 2). The most accurate single rule for the classification of students was Rule 2, drawn from Moses et al. (1983), which classified students as LD if three or more summary scales exceeded an individual's critical level. Not only did this rule yield the highest overall rate of correct classifiactions when compared with the other rules for interpretation, but it also yielded the most acceptable and well-balanced ratio of false positives (6.7%) to false negatives (13.3%). It should be noted that these findings will require cross-validation.

The results of this study compared favorably with those reported in validation and cross-validation research on the effectiveness of the battery in discriminating between brain-damaged and normal individuals. Such studies have reported hit rates of 93% using discriminant function analysis of summary scale data and 86% using a rule for classification similar to Rule 2 of this study (Golden, Hammeke, & Purisch, 1978; Golden, Moses,

Fishburn, Engum, Lewis, Wisniewski, Conley, Berg, & Graber, 1981; Moses & Golden, 1979). The accuracy obtained in this study via the application of Rule 2 compared favorably with that reported by Malloy and Webster (1981) in their examination of the test battery's accuracy for mildly impaired subjects presenting equivocal neurological data. They reported obtaining 80% accuracy with a similar rule for classification.

In comparing the results of this study with those reported by Selz (1977) for the identification of LD using the Halstead-Reitan Neuropsychological Battery (see Table 1), the data indicated that the Luria-Nebraska yielded higher and more balanced hit rates. This was especially true with regard to comparisons made between the rates of diagnostic accuracy obtained with each test battery thru the use of interpretative rules. Inspection of the data in Tables 1 and 18 indicates that the accuracy of the Luria-Nebraska for the LD classification surpassed that reported by Selz by 30.7% (comparing the accuracy obtained by Rule 2 with Selz' rules for interpretation). However, it should be recognized that the results of these studies are not directly comparable. The LD subjects examined by Selz were younger than those in this study. Selz specifically excluded individuals from the LD group with evidence of structural brain

damage, whereas no attempt was made to do so in this research. Furthermore, the LD groups may have differed on important cognitive, academic, and/or demographic variables. The extent of these differences cannot be determined since Selz did not adequately describe these characteristics of her LD sample. Also, as the problem of base rates was not specifically addressed by Selz, comparisons between the two studies must be made with caution. Differences in the sample size and in the number of groups may have effects on the diagnostic accuracy obtained with discriminant function analysis.

Research attempts to determine the efficacy of psychological tests for varied populations have often been criticized for failing to address the problem of base rates or antecedent probabilities (Knights & Stoddart, 1981). The argument has been advanced by some that the diagnostic accuracy of a test depends to some extent upon the base rates of a given pathology in the population and that the accuracy of a test should be evaluated in view of its ability to make a greater number of correct decisions than could be made from a knowledge of the base rates alone (Gordon, 1977; Meehl & Rosen, 1955).

In a recent file study of 400 randomly selected referrals made to the psychological service unit of the

host school system over a five year period (1973-1978), it was determined that 45.5% of such referrals resulted in a classification of LD (Cook, 1979). Thus, by using this locally-determined base rate alone, a hit rate of 45.5% could be obtained by classifying all referrals as LD. The hit rates reported in this study, using either single or combined indicators of LD, surpassed the base rate figure by a wide margin.

A major purpose of this study was to assess the utility of the Luria-Nebraska as an adjunct to diagnostic procedures based on the discrepancy model (i.e., 1982 Tennessee State Department of Education criteria). With regard to the identification of LD, the highest rate of diagnostic accuracy obtained by application of single indicators (86.7% by either discriminant function analysis, Rule 2, or Rule 4), did not significantly differ from the accuracy obtained by the application of the Tennessee criteria (which was 80% accurate), χ^2 (1) = 2.00, $p > .05$. Also, the accuracy of the best combination of LD indicators (93.3% by a combination of the 1982 Tennessee criteria, discriminant function analysis, and Rule 2--Combination A) did not significantly improve upon the accuracy that was obtained by the Tennessee criterion alone. It should be noted that statistical significance would have been reached (at the .05 level) if one

additional LD student, misclassified by the Tennessee criterion, had been correctly classified by Combination A. As it was, four of the six LD students who did not meet the 1982 Tennessee criteria were correctly classified by Combination A. No differences were found between the two LD students not correctly classified by either Combination A or the Tennessee criterion and the four who were correctly classified by Combination A. No differences were found between these two students and the rest of the LD sample when Luria-Nebraska summary scales were examined.

It should be recognized that these findings are limited by the accuracy of the original classifications which defined the research groups. It is possible that LD students in the sample may not have actually been LD despite all attempts that were made to reduce this possibility by the specification of rather strict selection criteria. The possibility that the non-LD group contained LD students was realized when one such student was certified LD by the school system following the completion of this study. At the time that this study was initiated, this student was being considered for referral because of suspected problems in reading and written expression. Information received from the school system after the

completion of its assessment indicated that the student had scores meeting the 1982 Tennessee criteria for certification as LD in both of these areas. Both discriminant analysis and Rule 4 classified this student as LD, whereas Rule 2 did not (elevations above the critical level were only evidenced on the Reading and Writing scales). This student met all selection criteria for the LD group with the exception of the criterion which required recertification as LD and special education placement for at least three years. If one were to dismiss this criterion and adjust hit rates for the occurance of this event, an increase in accuracy would be seen for classifications made by discriminant function analysis to 97%, 87%, and 92% for non-LD, LD, and combined groups, respectively. Hit rates for classifications made by Rule 4 would increase to 83%, 87%, and 85% for non-LD, LD, and combined groups, respectively. A decrease in accuracy would be noted for Rule 2 to 93%, 84%, and 88% for the non-LD, LD, and combined groups, respectively. Hit rates for Combination A would increase to 97%, 94%, and 95% for the non-LD, LD, and combined groups, respectively. With regard to the identification of LD, these changes in accuracy for single as well as combined indicators would not affect conclusions regarding the adjunctive utility of the Luria-Nebraska.

Interpretative Implications

Several interpretative implications may be derived from the results of this study concerning the use of the Luria-Nebraska with LD students. These implications are largely drawn from that set of analyses concerning the diagnostic accuracy of the various rules for classification. It should be cautioned that the following discussion of these implications rests on results that are tentative (i.e., awaiting cross-validation) rather than conclusive in nature.

Moses et al. (1983) recommended that special considerations should be made for the interpretation of test data from the LNNB with persons who have poor educational histories. In addressing the neuropsychological evaluation of individuals with suspected or known brain-damage, Moses et al. stated that persons with poor educational backgrounds will often evidence elevations on several of the test scales as a result of educational rather than neuropsychological deficiencies. The authors suggested that, in such cases, elevations on the Writing and/or Arithmetic scales might best be ignored in determining a diagnosis or the extent of neuropsychologically-related dysfunction. This practice of ignoring such scale elevations was especially recommended when they primarily stemmed from problems

experienced on those items which assess spelling and/or arithmetical calculation skill(s).

The findings of this study suggest that ignoring elevations on the Writing and/or Arithmetic scale(s) may be inappropriate for the assessment of LD. In this study omission of these scales from the count of scales exceeding the critical level lowered the overall diagnostic accuracy of the test battery by 16.7%. Omission of these scales resulted in a drop in accuracy of 40% for the LD group alone. Thus, it appears that both the Writing and the Arithmetic scales should be included in the count of scales exceeding the critical level for differentiating LD students.

The results of discriminant function analysis on the 12 scale battery underlined the diagnostic significance of the Writing scale for the differentiation of LD. This scale was found to be the largest contributor to the significant difference between groups. Also, as 96.6% of the LD group obtained elevations on this scale (as compared with 20% of the comparison group), a poor performance on the Writing scale may be of major diagnostic significance for the differentiation of the LD syndrome.

In the differentiation of brain dysfunction, Golden et al. (1980) suggested that test profiles should be considered normal if scale elevations occurred exclusively

on either the Writing or the Arithmetic scales (or exclusively on both scales). The results of this study support the applicability of this interpretation for the differentiation of LD. Results also suggest that it may be appropriate to consider as normal elevations on the Intellectual Processes scale when they occur in the absence of other scale elevations or when they occur exclusively with an elevation on either the Writing or the Arithmetic scale (but not with both). Support for this interpretation lies in the finding that 20% of the non-LD group obtained elevations on this scale, and that two of six such students obtained an elevated score on the Intellectual Processes scale in combination with two or more elevated scales. This interpretation may be most applicable with students of below average intelligence as the Intellectual Processes scale was found to be significantly correlated with IQ ($\underline{r}$ = -.48) at the .001 level. For students of average or above average intelligence, elevations on the Intellectual Processes scale should probably be viewed with greater concern.

Moses et al. (1983) stated that brain dysfunction may be accurately detected with the test battery using a rule for interpretation of profile data based upon the range of summary scale T-scores. More specifically, the authors stated that a range exceeding 30 points should be

viewed as indicative of brain dysfunction, irrespective of other considerations. An exception to this rule was noted for instances when the highest scale scores were obtained on either the Writing or Arithmetic scales (or on both scales) as a result of problems experienced with those items which assess spelling and/or arithmetic calculation skill(s). In such cases the authors recommended omitting these scales from the range determination.

The results of this study suggest that both the Writing and Arithmetic scales should be included in the calculation of the range for the differentiation of LD. Omitting these scales from the range determination (if either was the highest scale score obtained by an individual) lowered the overall diagnostic accuracy of the test battery by 8.3%. A drop in accuracy of 23.4% was noted for the LD group alone.

Moses et al. (1983) suggested that subtle forms of brain dysfunction may be detected by an analysis of the distribution of summary scale T-scores. More specifically, the authors stated that the possibility of brain dysfunction should be considered in instances where 2/3 or more of the summary scale T-scores exceed a cutting score defined by the critical level minus 10 points.

The results of this study suggest that the applicability of this method of profile analysis may be limited for the differentiation of LD. The application of a rule

based on this method of analysis (Rule 5) yielded the lowest overall rate of correct classifications among those rules that were examined. By using the criterion suggested by Moses et al. (i.e., 8 or more of the 12 scales above the cutting score as evidence of LD), diagnostic accuracy was high for the non-LD group (86.7%) but unacceptably low for the LD group (50%). By lowering the criterion number of scales to six or more (Rule 5a) or five or more (Rule 5b), higher rates of overall accuracy were obtained, yet the ratios of false positives to false negatives remained poorly balanced. This method of profile analysis will need further investigation to determine whether it may be useful for the differentiation of LD.

In summary, the results of this study suggest that certain modifications of a few established interpretative rules originally validated for the detection of brain dysfunction may yield high rates of diagnostic accuracy for the LD classification. The need for modification of the original rules for interpretation was found to be particularly evident for those methods of profile analysis based upon the determinations of range and the number of scales exceeding the critical level. Results underlined the interpretative significance of both the Writing and Arithmetic scales for such analyses.

Practical Applications

Although the findings of this study suggest that test results from the Luria-Nebraska did not significantly augment the diagnostic accuracy of Tennessee criteria (which utilize analysis of IQ-achievement discrepancy), the use of combined indicators of LD has been recommended as a more conceptually sound approach to diagnosis (Shepard, 1980). In general, it has been suggested that the use of a combined indicator approach could make allowances for the diagnostic error which occurs as a result of imperfect accuracy. With regard to the classification of LD, further research is needed before the potential additive utility of the Luria-Nebraska is dismissed.

It is acknowledged that further research is needed (i.e., cross-validation) before the battery could be used with some degree of confidence for the diagnosis of LD. Situations may exist where additional data is desired before a diagnostic decision is made. In such cases, the Luria-Nebraska may be a useful complement to those procedures typically included in the LD test battery. The Luria-Nebraska may be useful in cases when questions arise concerning the validity of conclusions derived from an analysis of IQ-achievement discrepancy.

With regard to the efficient use of test results, it is suggested that the use of the test battery should

extend beyond the determination of a diagnosis. Although accurate diagnosis is an essential step in the evaluation process, the ultimate purpose of neuropsychological assessment is to gain a greater understanding of an individual's spectrum of abilities (Boll, 1977; Rourke, 1976). It is acknowledged that the prescriptive utility of the Luria-Nebraska for the LD population has not been specifically researched. However, in the hands of a trained clinician, the battery may yield useful information for educational planning. With each individual assessment, the clinician should have a clear sense of purpose in mind as the potential for misuse exists. Care should be taken in the interpretation of data from the battery as generalizations derived from data based on adult brain-damaged populations may not be applicable to learning disabled populations.

Limitations

Certain problems associated with the design of this research need to be briefly addressed. As limited resources were available for the implementation of this study, certain methodological problems were unavoidable. This was especially true with regard to the procedures used herein to select students for the research

sample. A completely randomized selection procedure was not possible as the subject pool was too small for either group. Additionally, error may have been introduced by the use of different measures of intelligence in forming the research groups.

With regard to the selection of students for the LD group, an examination of their cognitive characteristics (as reported in Table 3) revealed that this group had intelligence test scores similar to those reported in the literature for other LD samples. The mean WISC-R Full Scale IQ of the LD group closely approximated that reported by Norman and Zigmond (1980) in their national survey. Also, the pattern of WISC-R subtest scale scores for the LD group was similar to that which has been frequently observed in other studies of LD students (Dykman, Peters, & Ackerman, 1973; Rugel, 1974; Vance, Gaynor, & Coleman, 1976). Thus, the cognitive characteristics of this research sample did tend to support the external validity of this study.

With regard to the selection of the non-LD students, it may be noted from an examination of their cognitive and academic characteristics (as reported in Tables 5 and 6) that they tended to be overrepresented at the low average to average range of IQ and achievement. Thus, they were not entirely representative of the school population. However, the possibility exists that

they were representative of that portion of the school population which is referred for assessment to determine the existence of LD. The normality of this group may also be questioned on the grounds that these students were not systematically screened for the presence of LD.

As for the selection of students using both the OLMAT and the WISC-R, it is acknowledged that basing selection procedures on different measures of intelligence was less than ideal. However, obtaining WISC-R data from a sufficiently large sample of non-LD students for the purpose of matching on IQ was beyond the resources of this project. Alternatively, basing the selection of LD students on OLMAT DIQ scores would have yielded results of questionable validity. An examination of the relationship between the OLMAT DIQ and the WISC-R Full Scale IQ indicated that the OLMAT significantly underestimated the Full Scale IQ of the LD group by a mean difference of 11.47 points, t (18) = 5.03, $p < .01$. It was judged that the OLMAT would be an appropriate measure for the selection of students for the non-LD group as it has been found to be adequately correlated with other measures of scholastic aptitude in children with normal educational backgrounds. Research on the strength of the relationship of the OLMAT DIQ and the WISC-R or WISC Full Scale IQ has reported correlations ranging from .74 to .83 (Covin, 1976; Skripol, 1970). Thus, it was felt that the

approach to the selection of subjects taken herein was the best available option under adverse circumstances.

Suggested Improvements and Future Research

One strategy which might constitute an improvement upon the approach taken in this study would be to base subject selection procedures on the same measure of intelligence for both groups. If this is not feasible, then it may be advantageous to administer both the WISC-R and the WRAT to non-LD students. Thus, one might obtain an indication of the error variance introduced by the use of different measures of intelligence, and one could also determine the efficacy of the discrepancy model for the entire research sample. Such data might also be used to screen the non-LD group for the presence of LD.

Another strategy which might constitute an improvement upon this study would be the use of a completely randomized selection procedure to form the non-LD group. After administering the WISC-R to this group, one could statistically parcel out the effects of intelligence thru the use of analysis of covariance.

The possibilities for further research on the diagnostic accuracy of the Luria-Nebraska with the LD population are numerous. As previously mentioned, the most pressing need at present is for the cross-validation of this research effort. Beyond this, the accuracy of

the test battery for the diagnosis of LD needs to be investigated for research samples which include females, persons of different cultural, ethnic, or racial backgrounds, and individuals of borderline or above average intelligence.

Comparative research is needed on the classificatory accuracy obtainable with other diagnostic systems. More specifically, research comparing the discrepancy model of assessment, the LNNB, and procedures such as the Halstead-Reitan Neuropsychological Battery, using subjects of similar ages and backgrounds, might be beneficial in determining the relative advantages/disadvantages of each system. Research might also be done on the efficacy of the LNNB using groups defined by different criteria. Certainly, ascertaining the diagnostic accuracy of the children's version of the Luria-Nebraska might aid efforts to identify those with LD in the lower grade levels. Longitudinal research may then be initiated, using both the child and adult versions of the battery, to examine the changes in the course of the syndrome as well as changes in diagnostic accuracy over time. Such efforts may have important ramifications for improving the design, implementation, and evaluation of treatment programs as as well as for furthering the development of theory and an understanding of the LD syndrome.

LIST OF REFERENCES

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Adelman, H. S. Diagnostic classification of LD: A practical necessity and a procedural problem. Learning Disability Quarterly, 1979, 2, 56-62.

Amante, D. A critique of a proposed set of neurodiagnostic rules. Journal of Consulting and Clinical Psychology, 1980, 48(4), 525-527.

Amante, D., VanHouten, W. W., Grieve, J. H., Bader, C. A., & Margules, P. H. Neuropsychological deficit, ethnicity, and socioeconomic status. Journal of Consulting and Clinical Psychology, 1977, 45(4), 524-535.

Beatty, J. R. Identifying decision-making policies in the diagnosis of learning disabilities. Journal of Learning Disabilities, 1977, 10(4), 13-21.

Black, F. W. WISC verbal-performance discrepancies as indicators of neurological dysfunction in pediatric patients. Journal of Clinical Psychology, 1974, 30, 165-167.

Blanck, M. Review of "Toward an understanding of dyslexia: Psychological factors in specific reading disability." In A. L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 1978.

Boll, T. J. A rationale for neuropsychological evaluation. Professional Psychology, 1977, 8(1), 65-71.

Campbell, S. B. Problems for clinical diagnosis. Journal of Learning Disabilities, 1979, 12(8), 13-18.

Chalfant, J., & Schefflin, M. Central processing dysfunctions in children: A review of research (NINDS Monograph No. 9). Bethesda, MD.: U. S. Dept. HEW, 1969.

Clements, S. D. Minimal brain dysfunction in children: Terminology and identification (NINDS Monograph No. 3, Public Health Service Publication No. 1415). Washington D.C.: U.S. Govt. Printing Office, 1966.

Cochran, W. G. Sampling techniques. New York: Wiley, 1971.

Cohen, J. A coefficient of agreement for nominal scales. Educational and Psychological Measurement, 1960, 20(1), 37-39.

Coles, G. S. The learning disabilities test battery: Empirical and social issues. Harvard Educational Review, 1978, 48(3), 313-340.

Cone, T., & Wilson, L. Quantifying a severe discrepancy: A critical review. Learning Disability Quarterly, 1981, 4, 359-371.

Cook, J. A. Referrals to psychological services of Knox County Schools: Descriptions and outcomes. Unpublished doctoral dissertation, University of Tennessee, 1979.

Cooley, W. W., & Lohnes, P. R. Multivariate data analysis. New York: Wiley, 1971.

Covin, T. M. Correlations between the Pintner, Otis-Lennon, Peabody and Wechsler Intelligence Scale for Children-Revised. Psychological Reports, 1976, 39, 1058.

Dalby, J. T. Deficit or delay: Neuropsychological models of developmental dyslexia. Journal of Special Education, 1979, 13(3), 239-263.

Dykman, R. A., Peters, J. E., & Ackerman, P. T. Experimental approaches to the study of minimal brain dysfunction: A follow-up study. Annals of the New York Academy of Sciences, 1973, 205, 93-108.

Elliot, M. Quantitative evaluation procedures for learning disabilities. Journal of Learning Disabilities, 1981, 14(2), 84-87.

Gaddes, W. H. Learning disabilities and brain function: A neuropsychological approach. New York: Springer-Verlag, 1980.

Gaddes, W. H. An examination of the validity of neuropsychological knowledge in educational diagnosis and remediation. In G. W. Hynd & J. E. Obrzut (Eds.), Neuropsychological assessment and the school-aged child. New York: Grune & Stratton, 1981.

Golden, C. J., Hammeke, T. A., & Purisch, A. D. Diagnostic validity of a standardized neuropsychological battery derived from Luria's neuropsychological tests. Journal of Consulting and Clinical Psychology, 1978, 46(6), 1258-1265.

Golden, C. J., Hammeke, T. A., & Purisch, A. D. Luria-Nebraska Neuropsychological Test Battery. Lincoln, Nebraska: University Press, 1979.

Golden, C. J., Hammeke, T. A., & Purisch, A. D. A manual for the administration and interpretation of the Luria-Nebraska Neuropsychological Battery. Los Angeles: Western Psychological Services, 1980.

Golden, C. J., Moses, J. A., Fishburn, F. J., Engum, E., Lewis, G. P., Wisniewski, A., Conley, F. K., Berg, R. A., & Graber, B. Cross-validation of the Luria-Nebraska Neuropsychological Battery for the presence, lateralization, and localization of brain damage. Journal of Consulting and Clinical Psychology, 1981, 49(4), 491-507.

Gordon, N. G. Base rates and the decision-making model in clinical neuropsychology. Cortex, 1977, 13, 3-10.

Hammill, D. D. Defining "LD" for programmatic purposes. Academic Therapy, 1976, 12(1), 29-37.

Hanna, G. S., Dyck, N. J., & Holen, M. C. Objective analysis of achievement-aptitude discrepancies in LD classification. Learning Disability Quarterly, 1979, 2, 32-38.

Harber, J. R. Issues in the assessment of language and reading disorders in learning disabled children. Learning Disability Quarterly, 1980, 3, 20-28.

Hollingshead, A. B. The four-factor index of social status. Private publication, Yale University, 1976.

Holroyd, J., & Wright, F. Neurological implications of WISC verbal-performance discrepancies as in a psychiatric setting. Journal of Consulting Psychology, 1965, 29, 206-212.

Horton, A. M. Behavioral neuropsychology in the schools. School Psychology Review, 1981, 10(3), 367-372.

Huck, S. W., Cormier, W. H., & Bounds, W. G. Reading statistics and research. New York: Harper & Row, 1974.

Hynd, G. W., & Obrzut, J. E. School neuropsychology. Journal of School Psychology, 1981, 19(1), 45-50.

Johnson, D., & Myklebust, H. R. Learning disabilities: Educational principles and practices. New York: Grune & Stratton, 1967.

Kaufman, A. S. Verbal-performance IQ discrepancies on the WISC-R. Journal of Consulting and Clinical Psychology. 1976, 44(5), 739-744.

Kaufman, A. S. Intelligent testing with the WISC-R. New York: Wiley, 1979.

Knights, R. M., & Stoddart, C. Profile approaches to neuropsychological diagnosis in children. In G. W. Hynd & J. E. Obrzut (Eds.), Neuropsychological assessment and the school-aged child. New York: Grune & Stratton, 1981.

Lambert, M. M., & Sandoval, J. The prevalence of learning disabilities in a sample of children considered hyperactive. Journal of Abnormal Child Psychology, 1980, 8(1), 33-50.

Larsen, S. C., Rogers, D., & Sowell, V. The use of selected perceptual tests in differentiating between normal and learning disabled children. Journal of Learning Disabilities, 1976, 9(2), 32-37.

Levine, M. D., Brooks, R., & Shonkoff, J. P. A pediatric approach to learning disorders. New York: Wiley, 1980.

Lloyd, J., Sabatino, D., Miller, T., & Miller, S. Proposed federal guidelines: Some open questions. Journal of Learning Disabilities, 1977, 10(2), 69-71.

Lovitt, T. C., & Jenkins, J. R. Learning disabilities research: Defining populations. Learning Disability Quarterly, 1979, 2, 46-50.

Lynn, R. Learning disabilities. New York: MacMillan, 1979.

Malloy, P. F., & Webster, J. S. Detecting mild brain impairment using the Luria-Nebraska Neuropsychological Battery. Journal of Consulting and Clinical Psychology, 1981, 49(5), 768-770.

McLeod, J. Educational underachievement: Toward a defensible psychometric definition. Journal of Learning Disabilities, 1979, 12(5), 42-50.

Meehl, P. E., & Rosen, A. Antecedent probability and the efficiency of psychometric signs, patterns, or cutting scores. Psychological Bulletin, 1955, 52(3), 194-216.

Moses, J. A., & Golden, C. J. Cross-validation of the discriminative effectiveness of the standardized Luria-Nebraska Neuropsychological Battery. International Journal of Neuroscience, 1979, 9, 149-155.

Moses, J. A., Golden, C. J., Ariel, R., & Gustavson, J. L. Interpretation of the Luria-Nebraska Neuropsychological Battery (Vol. 1). New York: Grune & Stratton, 1983.

Myklebust, H. R. Progress in learning disabilities (Vol. 1). New York: Grune & Stratton, 1968.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. SPSS Statistical package for the social sciences (2nd ed.). New York: McGraw-Hill, 1975.

Norman, C. A., & Zigmond, N. Characteristics of children labeled and served as learning disabled in school systems affiliated with Child Service Demonstration Centers. Journal of Learning Disabilities, 1980, 13(9), 16-21.

Obrzut, J. E. Neuropsychological assessment in the schools. School Psychology Review, 1981, 10(3), 331-342.

O'Donnell, L. E. Intra-individual discrepancy in diagnosing specific learning disabilities. Learning Disability Quarterly, 1980, 3, 10-18.

Otis, A. S., & Lennon, R. T. Otis-Lennon Mental Ability Test. New York: Harcourt, Brace, & World, 1969.

Parsons, O. A., & Prigatano, G. P. Methodological considerations in clinical neuropsychological research. Journal of Consulting and Clinical Psychology, 1978, 46(4), 608-619.

Peterson, C. R., & Hart, D. H. Use of multiple discriminant function analysis in evaluation of a statewide system for the identification of educationally handicapped children. Psychological Reports, 1978, 43, 743-755.

Reitan, R. M., & Boll, T. J. Neuropsychological correlates of minimal brain dysfunction. Annals of the New York Academy of Sciences, 1973, 205, 65-88.

Ross, A. O. Psychological aspects of learning disabilities and reading disorders. New York: McGraw-Hill, 1976.

Rourke, B. P. Brain-behavior relationships in children with learning disabilities. American Psychologist, 1975, 30, 911-920.

Rourke, B. P. Issues in the neuropsychological assessment of learning disabled children. Canadian Psychological Review, 1976, 17(2), 89-102.

Salvia, J., & Clark, J. Use of deficits to identify the learning disabled. Exceptional Children, 1973, 39(4), 305-309.

Sattler, J. M. Assessment of childrens intelligence and special abilities (2nd ed.). Boston: Allyn & Bacon, 1982.

Satz, P., Taylor, H. G., Friel, J., & Fletcher, J. M. Some developmental and predictive precursors of reading disabilities: A six year follow-up. In A. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 1978.

Selz, M. A neuropsychological model of learning disability: Classification of brain function in 9-14 year old children. Unpublished doctoral dissertation, University of Washington, 1977.

Selz, M., & Reitan, R. M. Rules for neuropsychological diagnosis: Classification of brain function in older children. Journal of Consulting and Clinical Psychology, 1979, 47(2), 258-264.

Shepard, L. An evaluation of the regression method for identifying children with learning disabilities. Journal of Special Education, 1980, 14(1), 79-91.

Skripol, J. N. Correlation of the Otis-Lennon Intermediate and the Wechsler Intelligence Scale for Children. Unpublished masters thesis, Springfield College, 1970.

Tarver, S., & Hallahan, D. Attentional deficits in children with learning disabilities: A review. Journal of Learning Disabilities, 1974, 7(9), 560-565.

Tennessee State Department of Education. Student evaluation manual. 1982.

Torgeson, J. K. What shall we do with psychological processes? Journal of Learning Disabilities, 1979, 12(8), 16-22.

Torgeson, J. K., & Dice, C. Characteristics of research on learning disabilities. Journal of Learning Disabilities, 1980, 13(9), 5-9.

U.S. Office of Education. Assistance to states for education of handicapped children: Procedures for evaluating specific learning disabilities. Federal Register, 1977, 42, 65082-65085.

U.S. Office of Education. National Advisory Committee on Handicapped Children: First annual report. Washington D.C.: Author, 1968.

Vance, H. B., Gaynor, P., & Coleman, M. Analysis of cognitive abilities for learning disabled children. Psychology in the Schools, 1976, 13(4), 477-483.

Vellutino, F. R. Dyslexia: Theory and research. Cambridge: MIT Press, 1979.

Wechsler, D. Manual for the Wechsler Intelligence Scale for Children - Revised. New York: Psychological Corperation, 1974.

Wilson, L. R., Cone, T. E., Busch, R., & Allee, T. A critique of the expectancy formula approach: Beating a dead horse? Psychology in the Schools, 1983, 20(2), 241-249.

Ysseldyke, J. E., & Algozzine, B. Perspectives on assessment of learning disabled students. Learning Disability Quarterly, 1979, 2, 3-14.

Ysseldyke, J. E., Algozzine, B., Shinn, M., & McGue, M. Similarities and differences between low achievers and students classified learning disabled. Journal of Special Education, 1982, 16(1), 73-85.

Zwick, R. Assessing the psychometric properties of psychodiagnostic systems: How do the research diagnostic criteria measure up? Journal of Consulting and Clinical Psychology, 1983, 51(1), 117-131.

APPENDIXES

APPENDIX A

IQ AND ACHIEVEMENT DATA FOR LD STUDENTS

Table 20. Individual Test Score Data, IQ-Achievement Differences and Means

Student	WISC-R FSIQ	WRAT Reading			WRAT Spelling			WRAT Arithmetic		
		GR	SS	D	GR	SS	D	GR	SS	D
1.	82	3.0	65	17	2.7	62	20	3.0	66	16
2.	90	9.0	110	-20	6.0	85	5	4.8	76	14
3.	86	4.8	74	12	3.6	71	15	4.6	78	8
4.	89	3.7	70	19	3.3	72	17	3.6	70	19
5.	92	7.3	104	-12	6.2	95	- 3	4.1	77	15
6.	87	2.8	73	14	2.2	68	19	3.0	74	13
7.	85	6.5	97	-12	7.2	102	-17	3.2	69	16
8.	88	5.0	75	13	6.0	84	4	3.9	74	14
9.	88	3.4	63	25	2.4	65	23	3.6	72	16
10.	84	3.1	61	23	2.7	67	17	3.9	74	10
11.	110	4.0	68	42	3.3	69	41	6.2	88	22
12.	89	4.5	73	16	2.7	66	23	4.3	73	16
13.	84	4.1	71	13	3.3	69	15	3.0	63	21
14.	83	4.7	73	10	3.6	71	12	5.3	82	1
15.	93	4.7	73	20	2.7	68	25	5.0	97	- 4
16.	104	6.2	87	17	3.3	69	35	4.6	75	29
17.	109	4.5	77	32	3.0	72	37	4.3	75	35
18.	104	4.3	87	17	3.3	74	30	3.6	72	32

Table 20. (continued)

Student	WISC-R FSIQ	WRAT Reading			WRAT Spelling			WRAT Arithmetic		
		GR	SS	D	GR	SS	D	GR	SS	D
19.	89	4.7	77	12	2.7	68	19	4.6	77	12
20.	95	6.0	85	10	4.1	75	20	4.3	73	22
21.	83	3.7	70	13	2.4	67	16	3.6	70	13
22.	84	3.6	66	18	2.4	64	20	3.0	63	21
23.	94	5.0	75	19	3.0	68	26	5.6	84	10
24.	99	6.4	87	12	5.7	82	17	4.6	78	21
25.	92	5.0	75	17	4.1	75	17	5.3	79	13
26.	88	3.4	65	23	2.7	66	22	2.3	59	29
27.	87	4.5	82	5	3.6	74	13	5.3	89	- 2
28.	89	4.3	73	16	3.9	71	18	5.6	80	9
29.	84	3.1	69	15	2.4	65	19	3.6	72	12
30.	104	4.5	77	27	2.7	66	38	5.3	82	32
Mean	91.10		76.73	14.43		72.33	18.76		75.36	16.16

Note. GR = Grade Rating, SS = Standard Score, D = IQ-Achievement difference (derived from WISC-R FSIQ minus WRAT Standard Score).

APPENDIX B

ITEM SCORE COMPARISONS

Table 21. Means, Standard Deviations, and *t* Values for Luria-Nebraska Item Scores

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
Motor Scale					
1.	0.36	(0.49)	0.30	(0.59)	-0.47
2.	0.70	(0.46)	0.83	(0.59)	0.97
3.	0.06	(0.25)	0.20	(0.40)	1.52
4.	0.20	(0.40)	0.50	(0.63)	2.19*
5.	0.00	(0.00)	0.06	(0.36)	1.00
6.	0.00	(0.00)	0.00	(0.00)	0.00
7.	0.20	(0.61)	0.46	(0.86)	1.38
8.	0.20	(0.61)	0.13	(0.50)	-0.46
9.	0.06	(0.36)	0.06	(0.36)	0.00
10.	0.00	(0.00)	0.06	(0.36)	1.00
11.	0.00	(0.00)	0.06	(0.36)	1.00
12.	0.00	(0.00)	0.00	(0.00)	0.00
13.	0.06	(0.36)	0.06	(0.36)	0.00
14.	0.06	(0.36)	0.00	(0.00)	-1.00
15.	0.00	(0.00)	0.06	(0.36)	1.00
16.	0.00	(0.00)	0.06	(0.36)	1.00
17.	0.00	(0.00)	0.26	(0.69)	2.11*
18.	0.00	(0.00)	0.13	(0.50)	1.44
19.	0.00	(0.00)	0.06	(0.36)	1.00
20.	0.00	(0.00)	0.06	(0.36)	1.00
21.	0.26	(0.52)	0.30	(0.46)	0.26
22.	0.23	(0.56)	0.30	(0.65)	0.42
23.	0.56	(0.67)	0.63	(0.49)	0.44
24.	0.03	(0.18)	0.13	(0.50)	1.02
25.	0.26	(0.69)	0.46	(0.83)	0.99
26.	0.46	(0.86)	0.46	(0.86)	0.00
27.	0.06	(0.36)	0.40	(0.81)	2.05*
28.	0.00	(0.00)	0.00	(0.00)	0.00
29.	0.00	(0.00)	0.13	(0.50)	1.44
30.	0.40	(0.81)	0.66	(0.95)	1.16

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
31.	0.20	(0.61)	0.33	(0.71)	0.78
32.	0.06	(0.36)	0.00	(0.00)	-1.00
33.	0.13	(0.34)	0.30	(0.59)	1.32
34.	0.00	(0.00)	0.03	(0.18)	1.00
35.	0.06	(0.36)	0.00	(0.00)	-1.00
36.	0.46	(0.68)	0.46	(0.62)	0.00
37.	0.33	(0.66)	0.16	(0.53)	-1.08
38.	0.70	(0.59)	0.93	(0.69)	1.40
39.	0.40	(0.67)	0.30	(0.46)	-0.67
40.	0.16	(0.37)	0.26	(0.52)	0.85
41.	0.26	(0.58)	0.36	(0.66)	0.62
42.	0.50	(0.68)	0.40	(0.62)	-0.59
43.	0.36	(0.61)	0.20	(0.40)	-1.24
44.	0.60	(0.62)	1.00	(0.73)	2.26*
45.	0.30	(0.53)	0.53	(0.57)	1.63
46.	0.16	(0.46)	0.60	(0.62)	3.07**
47.	0.36	(0.55)	0.43	(0.62)	0.44
48.	0.16	(0.37)	0.06	(0.25)	-1.20
49.	0.03	(0.18)	0.16	(0.53)	1.30
50.	0.20	(0.61)	0.00	(0.00)	-1.80
51.	0.06	(0.25)	0.23	(0.43)	1.83
Rhythm Scale					
52.	0.23	(0.50)	0.36	(0.49)	1.04
53.	0.53	(0.77)	1.06	(0.86)	2.51*
54.	0.40	(0.49)	0.86	(0.62)	3.19**
55.	0.36	(0.49)	0.66	(0.71)	1.90
56.	0.46	(0.86)	0.60	(0.93)	0.58
57.	0.00	(0.00)	0.53	(0.90)	3.25**
58.	0.13	(0.34)	0.33	(0.54)	1.69
59.	0.16	(0.37)	0.40	(0.62)	1.76
60.	0.56	(0.67)	0.76	(0.85)	1.00
61.	0.43	(0.62)	0.63	(0.66)	1.20
62.	0.36	(0.49)	0.80	(0.40)	3.73**
63.	0.66	(0.88)	1.30	(0.91)	2.73**
Tactile Scale					
64.	0.30	(0.53)	0.30	(0.59)	0.00
65.	0.26	(0.52)	0.16	(0.46)	-0.79

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
66.	0.30	(0.53)	0.20	(0.48)	-0.76
67.	0.30	(0.65)	0.16	(0.46)	-0.92
68.	0.06	(0.25)	0.06	(0.36)	0.00
69.	0.00	(0.00)	0.16	(0.37)	2.41*
70.	0.70	(0.75)	0.73	(0.64)	0.19
71.	0.70	(0.75)	0.80	(0.55)	0.59
72.	0.00	(0.00)	0.03	(0.13)	1.00
73.	0.03	(0.18)	0.00	(0.00)	-1.00
74.	0.23	(0.43)	0.40	(0.62)	1.21
75.	0.30	(0.59)	0.30	(0.53)	0.00
76.	0.13	(0.50)	0.33	(0.75)	1.20
77.	0.00	(0.00)	0.26	(0.69)	2.11*
78.	0.60	(0.93)	0.73	(0.98)	0.54
79.	0.26	(0.69)	0.60	(0.93)	1.57
80.	0.00	(0.00)	0.00	(0.00)	0.00
81.	0.00	(0.00)	0.00	(0.00)	0.00
82.	0.23	(0.56)	0.20	(0.40)	-0.26
83.	0.20	(0.40)	0.23	(0.43)	0.31
84.	0.23	(0.54)	0.13	(0.43)	-0.82
85.	0.43	(0.50)	0.43	(0.50)	0.00
Visual Scale					
86.	0.00	(0.00)	0.00	(0.00)	0.00
87.	0.30	(0.46)	0.50	(0.57)	1.48
88.	0.50	(0.68)	0.80	(0.55)	1.87
89.	1.03	(0.49)	0.93	(0.78)	-0.59
90.	0.03	(0.18)	0.00	(0.00)	-1.00
91.	0.10	(0.30)	0.26	(0.45)	1.68
92.	0.40	(0.56)	0.53	(0.73)	0.79
93.	0.60	(0.49)	0.63	(0.49)	0.26
94.	0.83	(0.64)	0.93	(0.69)	0.58
95.	0.33	(0.60)	0.50	(0.68)	1.00
96.	0.23	(0.43)	0.53	(0.62)	2.16*
97.	1.16	(0.64)	1.60	(0.56)	2.77**
98.	0.46	(0.57)	0.86	(0.92)	2.58*
99.	0.93	(0.90)	0.80	(0.92)	-0.56
Receptive Speech Scale					
100.	0.00	(0.00)	0.00	(0.00)	0.00
101.	0.00	(0.00)	0.00	(0.00)	0.00

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
102.	0.00	(0.00)	0.03	(0.18)	1.00
103.	0.00	(0.00)	0.03	(0.18)	1.00
104.	0.13	(0.34)	0.16	(0.37)	0.36
105.	0.03	(0.18)	0.36	(0.49)	3.49***
106.	0.13	(0.50)	0.00	(0.00)	-1.44
107.	0.13	(0.50)	0.06	(0.36)	-0.58
108.	0.00	(0.00)	0.00	(0.00)	0.00
109.	0.33	(0.75)	0.53	(0.90)	0.93
110.	0.00	(0.00)	0.00	(0.00)	0.00
111.	0.20	(0.40)	0.43	(0.50)	1.97*
112.	0.03	(0.18)	0.10	(0.30)	1.03
113.	0.03	(0.18)	0.00	(0.00)	-1.00
114.	0.06	(0.36)	0.00	(0.00)	-1.00
115.	0.00	(0.00)	0.06	(0.36)	1.00
116.	0.06	(0.35)	0.06	(0.35)	0.00
117.	0.20	(0.61)	0.13	(0.50)	-0.46
118.	0.00	(0.00)	0.00	(0.00)	0.00
119.	0.00	(0.00)	0.13	(0.50)	1.44
120.	0.20	(0.61)	0.46	(0.86)	1.38
121.	0.00	(0.00)	0.00	(0.00)	0.00
122.	0.53	(0.90)	0.40	(0.81)	-0.69
123.	0.13	(0.50)	0.20	(0.61)	0.46
124.	0.13	(0.50)	0.00	(0.00)	-1.00
125.	0.13	(0.50)	0.20	(0.61)	0.46
126.	0.00	(0.00)	0.00	(0.00)	0.00
127.	0.56	(0.62)	0.33	(0.54)	-1.54
128.	0.86	(1.08)	1.00	(1.01)	0.51
129.	0.13	(0.50)	0.46	(0.86)	1.83
130.	0.33	(0.75)	0.40	(0.81)	0.33
131.	0.80	(0.99)	0.66	(0.99)	-0.53
132.	0.76	(0.77)	0.90	(0.88)	0.62
Expressive Speech Scale					
133.	0.00	(0.00)	0.00	(0.00)	0.00
134.	0.06	(0.25)	0.16	(0.37)	1.20
135.	0.00	(0.00)	0.03	(0.18)	1.00
136.	0.00	(0.00)	0.00	(0.00)	0.00
137.	0.00	(0.00)	0.16	(0.46)	1.98*
138.	0.06	(0.25)	0.40	(0.67)	2.53*
139.	0.00	(0.00)	0.06	(0.36)	1.00

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
140.	0.00	(0.00)	0.40	(0.81)	2.69**
141.	0.00	(0.00)	0.00	(0.00)	0.00
142.	0.00	(0.00)	0.10	(0.30)	1.80
143.	0.26	(0.34)	0.13	(0.50)	-0.89
144.	0.06	(0.26)	0.56	(0.50)	4.85***
145.	0.00	(0.00)	0.46	(0.86)	2.97**
146.	0.00	(0.00)	0.03	(0.18)	1.00
147.	0.00	(0.00)	0.03	(0.18)	1.00
148.	0.30	(0.46)	0.90	(0.75)	3.69***
149.	0.90	(0.66)	1.70	(0.53)	5.15***
150.	0.00	(0.00)	0.06	(0.30)	1.00
151.	0.80	(0.99)	1.46	(0.90)	2.72**
152.	0.00	(0.00)	0.13	(0.50)	1.44
153.	0.00	(0.00)	0.40	(0.81)	2.69**
154.	0.00	(0.00)	0.20	(0.61)	1.80
155.	0.30	(0.53)	0.80	(0.84)	2.73**
156.	0.23	(0.50)	0.30	(0.59)	0.47
157.	0.13	(0.34)	0.33	(0.47)	1.69
158.	0.00	(0.00)	0.06	(0.25)	1.44
159.	0.10	(0.30)	0.13	(0.34)	0.40
160.	0.00	(0.00)	0.00	(0.00)	0.00
161.	0.00	(0.00)	0.40	(0.81)	2.69**
162.	0.00	(0.00)	0.06	(0.36)	1.00
163.	0.00	(0.00)	0.33	(0.79)	2.41*
164.	0.06	(0.25)	0.13	(0.43)	0.73
165.	0.76	(0.72)	0.60	(0.67)	-0.92
166.	0.23	(0.50)	0.06	(0.25)	-1.62
167.	0.13	(0.34)	0.46	(0.68)	2.39*
168.	0.06	(0.36)	0.10	(0.30)	0.38
169.	0.73	(0.82)	1.13	(0.73)	1.98*
170.	0.73	(0.64)	1.16	(0.69)	2.51*
171.	1.10	(0.54)	1.60	(0.49)	3.70***
172.	0.66	(0.95)	1.53	(0.86)	3.68***
173.	0.26	(0.69)	1.33	(0.95)	4.94***
174.	0.26	(0.69)	1.33	(0.95)	4.94***
Writing Scale					
175.	0.90	(0.88)	1.30	(0.75)	1.89
176.	0.60	(0.85)	1.83	(0.46)	6.95***
177.	0.03	(0.18)	0.06	(0.25)	0.58
178.	0.03	(0.18)	0.23	(0.56)	1.84

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
179.	1.53	(0.86)	2.00	(0.00)	2.97**
180.	0.06	(0.36)	0.20	(0.61)	1.03
181.	0.00	(0.00)	0.00	(0.00)	0.00
182.	0.03	(0.18)	1.03	(0.96)	5.58***
183.	0.73	(0.45)	1.43	(0.50)	5.68***
184.	1.66	(0.54)	1.96	(0.18)	2.85**
185.	0.46	(0.68)	1.70	(0.65)	7.17***
186.	0.70	(0.53)	1.23	(0.43)	4.26***
187.	0.56	(0.89)	1.00	(0.98)	1.78
Reading Scale					
188.	0.16	(0.37)	0.76	(0.81)	3.65***
189.	0.10	(0.30)	0.83	(0.83)	4.52***
190.	0.00	(0.00)	0.00	(0.00)	0.00
191.	0.00	(0.00)	0.00	(0.00)	0.00
192.	0.60	(0.72)	1.40	(0.89)	3.81***
193.	0.23	(0.50)	1.20	(0.80)	5.57***
194.	0.03	(0.18)	0.00	(0.00)	-1.00
195.	0.46	(0.68)	1.46	(0.77)	5.30***
196.	1.50	(0.77)	1.93	(0.36)	2.77**
197.	0.06	(0.36)	0.26	(0.52)	1.72
198.	0.10	(0.30)	0.33	(0.66)	1.76
199.	0.96	(0.71)	1.83	(0.37)	5.84***
200.	1.20	(0.80)	1.83	(0.37)	3.90***
Arithmetic Scale					
201.	0.00	(0.00)	0.00	(0.00)	0.00
202.	0.66	(0.95)	1.56	(0.81)	3.91**
203.	0.00	(0.00)	0.00	(0.00)	0.00
204.	0.06	(0.25)	0.16	(0.37)	1.20
205.	0.00	(0.00)	0.16	(0.37)	2.41*
206.	0.00	(0.00)	0.00	(0.00)	0.00
207.	0.20	(0.55)	1.33	(0.92)	5.78***
208.	0.00	(0.00)	0.10	(0.30)	1.80
209.	0.00	(0.00)	0.03	(0.18)	1.00
210.	0.00	(0.00)	0.00	(0.00)	0.00
211.	0.00	(0.00)	0.00	(0.00)	0.00
212.	0.26	(0.45)	0.46	(0.62)	1.42
213.	0.06	(0.25)	0.06	(0.25)	0.00

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
214.	0.00	(0.00)	0.26	(0.69)	2.11*
215.	0.36	(0.61)	0.70	(0.75)	1.88
216.	0.13	(0.50)	0.20	(0.61)	0.46
217.	0.80	(0.90)	1.00	(1.01)	0.77
218.	0.20	(0.48)	0.36	(0.71)	1.05
219.	0.06	(0.25)	0.40	(0.62)	2.72**
220.	0.20	(0.61)	1.20	(0.99)	4.69***
221.	0.33	(0.47)	0.93	(0.64)	4.11***
222.	0.73	(0.58)	1.26	(0.64)	3.37***
Memory Scale					
223.	0.20	(0.40)	0.70	(0.53)	4.07***
224	0.83	(0.59)	0.76	(0.56)	-0.44
225.	0.00	(0.00)	0.73	(0.98)	4.10***
226.	0.80	(0.99)	1.00	(1.01)	0.77
227.	0.33	(0.47)	0.50	(0.63)	1.15
228.	0.33	(0.75)	0.46	(0.86)	0.64
229.	0.63	(0.66)	0.63	(0.71)	0.00
230.	0.16	(0.46)	0.53	(0.68)	2.44*
231.	0.66	(0.75)	0.76	(0.85)	0.48
232.	0.90	(0.60)	1.00	(0.52)	0.68
233.	0.60	(0.62)	0.86	(0.57)	1.73
234.	0.06	(0.25)	0.13	(0.50)	0.64
235.	0.50	(0.73)	0.76	(0.81)	1.33
Intellectual Processes Scale					
236.	0.56	(0.67)	0.93	(0.78)	1.94*
237.	1.20	(0.92)	1.36	(0.85)	0.73
238.	1.10	(0.96)	1.36	(0.92)	1.09
239.	0.50	(0.73)	0.53	(0.62)	0.19
240.	0.86	(1.00)	0.86	(1.00)	0.00
241.	0.30	(0.65)	0.60	(0.77)	1.63
242.	0.86	(1.00)	1.26	(0.98)	1.56
243.	1.40	(0.93)	1.93	(0.36)	2.92**
244.	0.66	(0.60)	0.80	(0.40)	1.00
245.	1.43	(0.62)	1.43	(0.62)	0.00
246.	0.73	(0.90)	1.43	(0.72)	3.30**
247.	0.73	(0.69)	1.10	(0.84)	1.84
248.	0.93	(0.36)	1.40	(0.49)	4.14***
249.	1.26	(0.45)	1.30	(0.59)	0.24

Table 21. (continued)

Item	Non-LD Group[a] M	(SD)	LD Group[a] M	(SD)	t[b]
250.	1.23	(0.50)	1.50	(0.50)	2.04*
251.	0.06	(0.36)	0.40	(0.81)	2.05*
252.	0.00	(0.00)	0.26	(0.69)	2.11*
253.	0.06	(0.36)	0.53	(0.90)	2.63*
254.	0.83	(0.83)	0.93	(0.74)	0.49
255.	0.00	(0.00)	0.13	(0.50)	1.44
256.	0.73	(0.74)	1.13	(0.86)	1.93
257.	0.20	(0.61)	0.13	(0.50)	-0.46
258.	0.00	(0.00)	0.00	(0.00)	0.00
259.	0.36	(0.61)	0.86	(0.77)	2.77**
260.	0.00	(0.00)	0.20	(0.61)	1.80
261.	0.16	(0.37)	0.63	(0.85)	2.75**
262.	1.20	(0.99)	1.00	(1.01)	-0.77
263.	0.56	(0.85)	0.76	(0.89)	0.88
264.	1.60	(0.81)	1.93	(0.36)	2.05*
265.	0.80	(0.61)	0.90	(0.60)	0.64
266.	1.60	(0.81)	1.93	(0.36)	2.05*
267.	0.73	(0.69)	0.86	(0.62)	0.78
268.	0.80	(0.99)	1.33	(0.95)	2.11*
269.	0.36	(0.49)	0.56	(0.50)	1.56

[a] $n = 30$.

[b] $df = 58$.

*$p < .05$.

**$p < .01$.

***$p < .001$.

APPENDIX C

INDIVIDUAL STUDENT CLASSIFICATIONS

Table 22. Classification of LD and Non-LD Students by Standard Score Discrepancy Method, Discriminant Function Analysis, and Rules for the Interpretation of Luria-Nebraska Profiles

	Classification Method								
			Rules						
Student	SSD[a]	DFA[b]	1	2	3	4	5	5a	5b
LD Group									
1.	X	X	X	X	X	X	X	X	X
2.	0	0	0	0	0	X	0	0	X
3.	0	X	0	X	X	X	X	X	X
4.	X	X	X	X	X	X	X	X	X
5.	0	X	0	X	X	X	X	X	X
6.	X	X	X	X	0	X	X	X	X
7.	X	X	0	X	X	X	0	X	X
8.	0	X	X	X	X	X	X	X	X
9.	X	X	0	X	X	X	0	X	X
10.	X	X	X	X	X	X	X	X	X
11.	X	X	0	0	X	X	0	0	0
12.	X	X	0	X	X	X	0	0	X
13.	X	X	X	X	X	X	X	X	X
14.	0	X	X	X	0	X	X	X	X
15.	X	X	X	X	X	X	X	X	X
16.	X	X	0	X	0	0	0	X	X
17.	X	X	0	0	0	0	0	0	0
18.	X	X	0	X	X	X	0	0	X
19.	X	X	X	X	X	X	X	X	X
20.	X	0	0	X	0	0	0	X	X
21.	X	X	X	X	X	X	X	X	X
22.	X	X	X	X	X	X	X	X	X
23.	X	X	X	X	X	X	0	X	X
24.	X	0	0	X	0	0	0	0	X
25.	X	X	0	X	0	0	0	X	X
26.	X	X	0	X	X	X	0	0	0
27.	0	0	0	X	0	0	0	X	X

Table 22. (continued)

	Classification Method								
			Rules						
Student	SSD[a]	DFA[b]	1	2	3	4	5	5a	5b
28.	X	X	X	X	X	X	X	X	X
29.	X	X	X	X	X	X	0	X	X
30.	X	X	0	0	0	X	0	0	0
Non-LD Group									
31.	X	0	X	0	X	X	X	X	0
32.		X	X	X	0	0	0	0	X
33.		X	X	X	X	X	X	X	X
34.		X	X	X	X	X	X	X	X
35.		X	X	X	X	X	X	X	X
36.		X	X	X	X	X	X	X	X
37.		X	X	X	X	X	X	X	X
38.		X	X	X	X	X	X	X	X
39.		X	X	X	X	X	X	X	X
40.		X	X	X	X	X	X	X	X
41.		X	X	X	X	X	0	0	0
42.		X	X	0	X	X	0	0	0
43.		X	X	X	X	X	X	X	X
44.		X	X	X	X	X	X	X	X
45.		X	X	X	X	X	X	X	X
46.		X	X	X	X	X	X	X	X
47.		X	X	X	X	X	X	X	0
48.		X	X	X	X	X	X	X	X
49.		X	X	X	X	X	X	X	X
50.		X	X	X	X	X	X	X	X
51.		X	X	X	X	X	0	0	0
52.		X	X	X	X	X	X	X	X
53.		X	X	X	X	X	X	X	0
54.		X	X	X	0	0	X	X	X
55.		X	X	X	0	0	X	X	X
56.		X	X	X	X	X	X	X	X
57.		X	X	X	X	X	X	X	X
58.		X	X	X	X	X	0	0	0
59.	0	0	X	X	X	X	X	X	X
60.		X	X	X	X	X	X	X	X

Table 22. (continued)

Note. X denotes a correct classification, O denotes an incorrect classification.

[a]IQ-Achievement discrepancies were unavailable for 28 of the non-LD group students.

[b]Classifications derived by discriminant function analysis were those obtained with the 12 scale battery.

APPENDIX D

CLASSIFICATION FUNCTION COEFFICIENTS

Table 23. Classification Function Coefficients for 12 Scale Analysis

Scale	LD Group[a]	Non-LD Group[b]
Motor	1.130225	1.109252
Rhythm	-0.195344	-0.248000
Tactile	0.472272	0.490917
Visual	0.319820	0.317666
Receptive Speech	0.291112	0.396505
Expressive Speech	-0.141226	-0.238558
Writing	1.295744	1.037602
Reading	-0.615451	-0.102531
Arithmetic	-0.181461	-0.539821
Memory	0.390790	0.442684
Intellectual Processes	0.117570	0.909814
Pathognomonic	-0.728985	-0.623146

[a]Constant for LD Group = -80.88088.

[b]Constant for Non-LD Group = -62.92221.

Table 24. Classification Function Coefficients for Scales Selected by Stepwise Procedure

Scale	LD Group[a]	Non-LD Group[b]
Rhythm	0.684993	0.150073
Receptive Speech	0.438625	0.524715
Expressive Speech	-0.464063	-0.160720
Writing	1.193563	0.8927759
Pathognomonic	0.148258	0.263033

[a]Constant for LD Group = -57.72079.

[b]Constant for Non-LD Group = -39.52576.

APPENDIX E

PERMISSION FORM/QUESTIONNAIRE

Dear Parent:

Your child,_____, qualifies to participate in a research project being done this year with selected students in the Knox County School system. Your child was selected on the basis of school records so that appropriate comparisons could be made between groups of students who are or are not enrolled in special education programs. The project is a study of how these types of students perform on a set of experimental evaluation procedures which provide information on various language, sensory-perceptual, motor and intellectual abilities. It is felt that this set of procedures will add to our understanding of children's learning abilities and assist us in designing improved educational programs for all children.

The evaluation itself requires approximately 2½ hours of your child's time. Should your child miss any work during that time he/she will, of course, be allowed to make it up. Teachers will be notified of this in advance. There is a possibility that not all children who are allowed to participate in the project will actually be included because of certain procedures which are necessary in this type of research. You will be notified if this were the case.

If you allow your child to participate and he/she is included in the project, the results of your child's performance would be kept strictly confidential. You would be informed of these results by letter or by personal conference if you so wish. It is important that you understand that this information would be shared with you first. Only with written permission would the information be released to appropriate school personnel (who are required by law to maintain its confidentiality). In order to aid us in more fully understanding the results of the evaluation and help us in developing sound programming recommendations for children, it will be necessary to have access to achievement and intelligence test data which are already within student files. This information will also be kept confidential.

If you wish to allow your child to participate in this project, please sign below, complete the attached questionnaire and return this form as soon as possible in the enclosed stamped self-addressed envelope. Of course, you would be free to withdraw your consent to include your child in this project at any time without any negative consequenses for your child. If you have any questions, I would be glad to answer them for you. I can usually be reached after 5 PM at 588-1253.

I hereby give permission to allow my child to participate in the project described above.

_____ / _____

Parent or Guardian (date)

Note: This information is needed for the purpose of this research. All information will be considered confidential. No information regarding the identity of any participants would be made available to anyone (including the school system) without your prior permission.

Childs Name:_____

Person completing form:_____

(A) General Information (circle one)

1. Has your child missed more than 15 days of school this year? yes no

2. Will your child be at the same school until June 1982? If not, indicate below where he/she will be _____ yes no

3. Do you wish to be informed of the results of the evaluation? If yes, indicate below how you wish to be informed. yes no

____by letter/report ___personal conference

(B) Family Background

1. Father's present occupation:_____

_____

2. Mother's present occupation:_____

_____

3. Please indicate below the highest level of school completed by the father and mother of this child (if presently living at home).

Level of School Completed	Father	Mother
Less than 7th grade	___	___
Junior High (9th grade)	___	___
Partial High School (10th or 11th)	___	___
High School graduate	___	___

Level of School Completed	Father	Mother
Partial College (at least 1 year or specialized training)	___	___
Standard College or University graduate (4 year college)	___	___
Graduate professional training	___	___

C. Medical Background

1. To the best of your knowledge, has this child had any of the following problems. If so, please comment on the back of this sheet (give dates).

___prematurity

___difficulties associated with the pregnancy

___difficulties associated with birth/delivery

___difficulties following birth (soon after)

___high fever (over 103°)

___infections (meningitis, encephalitis, etc.)

___pneumonia

___seizures

___poisoning or the ingestion of toxic substances (lead, drugs, chemicals, gasoline etc.)

___serious head or spinal injury

___ear infections

___visual difficulties

___slow growth or development

2. Has your child received any special treatments (diet, medications, counseling) outside school?

If so, describe_____

_____

3. If your child is not enrolled in a special education program, answer the following questions.

(a) Has your child ever been enrolled in any special education programs (note: this does not include Title I programs) ___yes ___no

(b) Has your child ever been evaluated because of

either learning or behavioral difficulties? If so please describe the purpose of such testing, results, and recommendations to the best of your knowledge.

Sincerely,

Richard D. Lewis
Project Director

VITA

Richard Dean Lewis was born in Hartford, Connecticut on November 17, 1954. He was the third child in a family of three children born to Milton E. and Theda J. Lewis (presently Caldwell). He attended several public schools in the greater Hartford region, graduating from Simsbury High School in June 1972. The following September he entered Hartwick College in Oneonta, New York and in June 1976 received a Bachelor of Arts degree in Psychology. The following year he was employed as a Psychiatric Aide II at Cedarcrest State Hospital in Newington, Connecticut. He entered the School Psychology training program at the University of Tennessee, Knoxville in September, 1977. After an internship in the Knoxville City School system and three years of graduate study, he received the Master of Arts degree in Psychology. He was employed as a School Psychologist for a two year period with the Knox County School system where he conducted the research for the doctoral dissertation. The author is currently employed by the Union County School system as a School Psychologist. He resides in Knoxville, Tennessee at 6029L Grace Lane.