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EFFICACY OF THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN-THIRD EDITION FOR IDENTIFYING LEARNING DISABILITIES IN A CLINIC SAMPLE

BY

GREG SCHOEPP ©

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Efficacy of the Wechsler Intelligence Scale for Children-Third Edition for Identifying Learning Disabilities in a Clinic Sample** submitted by Greg Schoepp in partial fulfillment of the requirements for the degree of Master of Education in School Psychology.

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ABSTRACT

The role of intelligence testing in diagnosing learning disabilities continues to generate a controversial debate and the revision of a notable intelligence test undoubtedly contributes to this contentious issue. The manual for the Third Edition of the Wechsler Intelligence Scale for Children (WISC-III) claims the test is useful for diagnostic assessment in a variety of special groups. The intent of this study was to investigate the convergent and discriminative validity of the WISC-III for differentiating between four groups of learning disabled children experiencing difficulties in reading, math, spelling, or a combination of all three academic areas.

Available WISC-III literature, relevant WISC-R interpretation information for learning disabilities assessment, and classification research of specific learning disability subtypes were reviewed to highlight expected WISC-III patterns of performance for learning disabled children. The WISC-III protocols of 188 Education Clinic clients between the ages of 6 and 16 were analyzed using Pearson Product Moment correlations and oneway analysis of variance techniques. These results were compared to the test authors' technical data, WISC-R findings, and learning disability subtyping research.

Correlations with the Wide Range Achievement Test - Revised, Wechsler Individual Achievement Test, and Canada QUick Individual Educational Test provided evidence of convergent validity with measures of achievement. Evidence for the discriminative ability of the WISC-III for differentiating learning disabled from normally achieving subjects was shown but the ability of the WISC-III to effectively discriminate between the four learning disabled groups was not supported.

Test users, as a result, are cautioned against the use of the WISC-III to make a learning disability diagnosis without background facts, information from observations, and other pertinent test data. Practical implications in the use and interpretation of this instrument were provided. Suggestions for future research were made.

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CHAPTER ONE

INTRODUCTION

Background

Researchers have investigated the Wechsler Scales for decades in hopes of pinpointing profiles that characterize various types of learning disabilities where there is a significant disparity between a student's observed ability and his or her demonstrated achievement primarily in language or mathematics. Even using more powerful statistical techniques such as meta-analysis that integrate and synthesize a large body of knowledge, no dominant theories of learning disabilities have emerged from the Wechsler Scale for Children-Revised (WISC-R). Kronick (1988) argues that society's need to label individuals has arisen from a too narrow interpretation of what and how students should learn and the limited tools utilized to measure learning. The emphasis on testing and describing children with disabilities has detracted from the important area of intervention.

An avalanche of research follows the introduction of a revised intelligence measure to validate the test authors' claims. Given the inconsistent results from previous studies on Wechsler scales and learning disability diagnosis, a question is raised over the necessity and usefulness of such research. With the WISC-R and now the WISC-III still extensively used for the assessment and diagnosis of a learning disability, it is imperative that the effectiveness of test revisions be evaluated.

The WISC-III is the third revision of the Wechsler Intelligence Scale for Children which was published in 1949 and the WISC-R has long been used in psychoeducational assessment for educational placement and planning, as well as diagnosing exceptional individuals in the schools. Despite opposition to the use of standardized intellectual measures, the question remains why the WISC-R and now the WISC-III are still the foundation for a learning disability diagnosis in many school boards. The answer to this question lies in the effectiveness of the instrument in the hands of a skilled practitioner. IQs obtained from the WISC-III and other similar standardized intelligence tests are helpful in work with handicapped and nonhandicapped children. Intelligence tests provide a measure of the child's developmental strengths and limitations, thus enabling concerned individuals to develop and implement appropriate programs that utilize the child's various developmental levels. In addition to providing norm-referenced comparisons and, more importantly, the child's own pattern of intellectual strengths and weaknesses can be ascertained. Kaufinan (1979) advocates the real value in intelligence testing lies in an intraindividual focus where the examiner goes beyond the normative to the individual's functioning. Hypotheses can be generated that aid in understanding a student's cognitive processing strengths and limitations. Research that examines the WISC-III's proficiency for diagnosing learning disabilities is needed because of its certain widespread use.

Presently, the WISC-III manual is the primary source of data pertaining to the test. Numerous goals were reported for the revision of the WISC-R (Wechsler, 1991) including updated norms and a revised factor structure with the addition of a fourth factor, Processing Speed, to aid in interpretation of test scores. Children with special needs (Learning Disabilities, Attention Deficit Hyperactivity Disorder, Mental Retardation, Conduct Disorder, Speech Impairments, Hearing Impairments, Epilepsy) comprised only 12% of the WISC-III standardization sample, yet, the test will probably be used extensively for assessing children with learning problems since the categorical approach to describing special needs students is still being widely used across Canada for both administration and program purposes (Bachor & Crealock, 1986). Wechsler (1991) maintained the results of independent studies on exceptional groups indicated the WISC-III is useful in diagnostic assessment, but, the results were based on relatively small samples and are not intended to be normative.

The recent release of the WISC-III raised personal questions about the effectiveness of the instrument for diagnosing learning problems. How beneficial will it be for assessing learning problems? Will it be useful for identifying various types of learning problems? Do scores on subtests translate into specific abilities or skills in the classroom that can be remediated?

Current research in the literature other than test reviews used the WISC-III standardization sample to validate the studies in the manual (Kamphaus & Platt, 1992; Sattler, 1992). Dumont and Faro (1993) investigated a short form of the test for children with learning disabilities. Fullerton (1993) explored the factor structure of the WISC-III in a small clinic sample and concluded the factor scores of the test should not be used with children with exceptionalities until further research was completed. The limited availability of WISC-III research made it evident that a descriptive study was appropriate for investigating Wechsler's claims about the test's potential for diagnostic assessment of learning disabilities.

Purpose of the Study

The updated WISC-III will undoubtedly attract the attention of the educational community for making important diagnoses and recommendations but little is known of its technical adequacy. In general, the intent of this study was to establish the efficacy of the WISC-III for differentiating different types of learning disabilities.

The WISC-III is often used in conjunction with an achievement test during assessment of learning disabilities to determine whether a discrepancy exists between aptitude and achievement. Although there are countless studies confirming the relationship of the WISC-R to various achievement measures, there is limited evidence of convergent validity in the manual. Only one sample of students with learning disabilities was reported that showed correlations from .11 to .62 with an individually administered achievement test (WRAT-R). This study will investigate the relationship between three achievement tests and the WISC-III to confirm or deny construct-related evidence.

The diagnostic utility of the WISC-III populations with learning disabilities was an important area to investigate. Wechsler (1991) maintained the test was useful for assessing intellectual functioning in a wide range of groups and that the Freedom From Distractibility and Processing Speed Index Scores may yield different information than the IQ scores. Results from two samples exhibiting learning disabilities in the manual revealed differences in IQ and index scores as well as groups of subtest scores that were depressed or elevated. One of the samples with learning disabilities had unspecified learning problems while the other sample had a developmental reading disorder as the primary diagnosis. Specific spelling and arithmetic learning disabilities were not investigated in separate samples. The present study was conducted to confirm or deny construct-related evidence of discriminative validity of the WISC-III for specific reading, spelling, math, or combined reading/math/spelling disabilities.

Sample

The sample for this study was comprised of clinic referrals from the Education Clinic at the University of Alberta (U of A). Voluntary clinic referrals are received from schools, medical settings, family members, or the individuals, themselves.

Focus Questions

The following questions formed the basis of the study:

1. What are the correlations between the WISC-III and individually administered achievement measures for children with and without learning disabilities, specifically the Wide Range Achievement Test-Revised (WRAT-R), Wechsler Individual Achievement Test (WIAT), and Canada QUick Individual Educational Test (QUIET)?
2. Are the mean scores significantly different on the WRAT-R, WIAT, and QUIET for children exhibiting different types of learning disabilities compared to those who do not show a learning problem? Do the achievement tests differentiate between four types of learning disabilities?
3. Are there significant differences on the mean scores of the WISC-III IQ, Index, and subtest scores for children with and without learning disabilities?

4. What patterns of high and low WISC-III scores are found for the four types of learning disabilities? Are these patterns of scores similar to those reported in the literature for the WISC-R and those found in the WISC-III Manual?

Delimitations

1. The group without learning disabilities in this study was created from a clinical referral population. Although many of the children tested at the U of A Education Clinic had intelligence and achievement scores in the average range, the referral was a result of parental dissatisfaction or concern with some aspect of their child's functioning at school and/or home.
2. Learning disability for the purpose of this study refers to learning difficulties within the academic tasks of reading single words, math calculations, or written spelling as measured by standardized achievement instruments. The learning disability was determined by a discrepancy of at least one standard deviation between the WISC-III Full Scale IQ score and one or more of the three achievement scores in reading, math, or spelling from the WRAT-R, WIAT, or QUIET.
3. The study was descriptive in nature and the theoretical basis of the test was not discussed in detail. Analysis focused on mean test scores obtained by specific groups and any significant differences in these scores. An investigation of the test's underlying structure, using factor analysis, was not attempted.

Limitations of the Study

1. There was an inadequate number of appropriate subjects for the creation of the control and LD groups by random sampling. All sampling was non-random or "convenience sampling". Each of the four LD groups were not matched to the control for age, gender, and grade, although there were no significant differences between groups on these variables. Caution must be exercised if trying to generalize the results outside of a clinic referral population.

2. Demographic information for race and socio-economic status was usually not available from the client files. It is known, however, that a majority of the Education Clinic referrals were from white, middle class homes which also limits generalizing the results of the study.
3. The ability-achievement discrepancy was calculated using three different achievement tests reportedly measuring similar constructs.
4. The use of more than one experimenter may account for individual differences in the administration and scoring on all tests given.
5. The WIAT Mathematics Reasoning subtest was used in place of Numerical Operations due to the greater availability of scores.

Overview of the Study

Chapter 1 presents a short discussion of the issues surrounding the use of intelligence tests in assessment, gives a brief description of the WISC-III, and outlines the purpose of this study. Three main topics are addressed in Chapter 2, the literature review. First, the WISC-III revisions and related current learning disability research findings are presented. Second, consistent findings from two decades of learning disability and WISC-R research is discussed. Finally, current learning disability research including learning disability subtypes from achievement classification models and a brief overview of the information-processing approach is presented. The second chapter concludes with detailed research questions. Chapter 3 outlines the research design and procedures that were used, describes the participants, procedures, and instruments, and lists the limitations of this research. Chapter 4 is a presentation of the results. The relationship of these results to the research questions and considerations for assessing children with learning disabilities are examined in Chapter 5, as well as recommendations for future research.

CHAPTER 2

REVIEW OF THE LITERATURE

Background to the WISC-III

History of the Wechsler Scales

A brief outline of the historical development of Wechsler's scales is useful for understanding the origins of his tests' contents. Reasons for the WISC-R revisions and current research on the WISC-III were also included in this section.

A history of David Wechsler's work must mention the 1905 Binet-Simon scale and its 1908 revision as an important scientific breakthrough that had significant influence on the subsequent development of psychological instruments including the Wechsler scales. Wechsler assembled a test battery in the mid-1930s that was comprised of subtests developed primarily by Binet and World War I psychologists. During his two years in military service, Wechsler utilized the Binet scales as well as the Army Alpha and Beta tests. The Alpha tests consisted of verbal functions and were composed of the following subtests: Information, Comprehension, Similarities, Arithmetic, and Vocabulary. The Beta tests, developed by Yerkes, were made of the Picture arrangement, Picture completion, Object assembly, Block design, and Digit symbol subtests. Wechsler added Digits to these verbal tasks, combined the verbal and non-verbal subtests into one scale, employed Thurstone's idea of converting raw scores into standard scores, and used Yerkes' concept of a point scale assessment of intelligence rather than Binet's concept of mental age (Frank, 1983).

With the renewed focus on IQ testing as a means of childhood assessment following World War I, Wechsler devoted his energy to developing an instrument for adolescents and adults. While working as the Chief Psychologist at Bellevue Hospital in New York, Wechsler refined the Bellevue Scales, his modification of the Army Scales, and in 1939 the first form of the test appeared as the Wechsler-Bellevue Scales of Intelligence.

An alternate form of the Wechsler-Bellevue in 1946 was not largely successful but a downward extension of this scale to cover the age range of 5 to 15 instead of 10 to 59 produced the successful 1949 Wechsler Intelligence Scale for Children (WISC). From a subsequent revision of the Wechsler-Bellevue, Form I, the Wechsler Adult Intelligence Scale (1955) emerged which was again revised and released in 1981 as the WAIS-R. The WISC was subsequently revised as the WISC-R in 1974. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was developed in 1967 and later revised in 1989 (WPPSI-R).

Wechsler's view of intelligence focuses on its global nature. His pragmatic view of intelligence considers it to be part of the larger whole of an individual's personality and he did not attempt to measure primary abilities or create hierarchies of relative importance (Sattler, 1992). According to Wechsler (1991), intelligence scales "sample broadly from a full array of cognitive abilities and thus reflect the multifaceted characteristics of intellectual ability" (p. 3). In addition, nonintellective factors such as planning and goal awareness, anxiety, and persistence, are important factors that must be considered in any assessment.

Reasons for WISC-R Revisions

Wechsler (1991) cited several reasons for the WISC-R revisions that led to the publication of the WISC-III.

1. The primary goal for the revision was to update the norms because of the tendency for average IQ scores to gradually increase over time. Periodic norm updates ensure that children's abilities are more accurately measured.
2. Further investigation of the factor scores was desired so the Symbol Search subtest was added to better distinguish the third factor, Freedom From Distractibility. A new fourth factor, Processing Speed, emerged with the addition of this new subtest .
3. Minor changes in administration procedures and scoring rules were made.
4. Subtest content was improved by attempting to minimize content bias through empirical analysis and an ethnic minority standardization sample of 400 children.

5. To extend accurate measurements both upward and downward, new subtest items were created.

Since an indepth description of the revisions was not intended, a detailed description of the changes is found in the second chapter of the test manual. Furthermore, standardization, reliability, and validity information about the WISC-III were placed in the next chapter on research design.

The major features of the WISC and WISC-R remain in the WISC-III with more than 73% of the WISC-R items (excluding the Coding subtest) retained either in original or slightly modified form. The essential structure of the test remains with the general factor or *g* and the two major factors, Verbal and Performance. The revision concerns in this study are the new test's diagnostic utility for identifying learning problems because the manual claims the factor based index scores and certain subtest profiles differentiate groups of children.

Current Literature on the WISC-III

The limited available literature concerning the WISC-III consisted mainly of reviews and only four published studies were located. The literature was summarized and critiqued to outline the relevant points for this study. Wechsler (1992) reported intercorrelations for the WIAT Basic Reading, Mathematics Reasoning, Spelling subtests and the WISC-III IQ scores. Mathematics Reasoning correlated more stronger with the IQs than the other two WIAT subtests. Spelling had the lowest correlations with the IQ scores.

The WRAT-R demonstrated weak to moderate correlations with the WISC-III IQ scores (Wechsler, 1991). Correlation coefficients between the Reading, Spelling, and Arithmetic subtests and Full Scale IQ (FSIQ) were .53, .28, and .58 respectively. With the WRAT-R subtests, the Verbal IQ (VIQ) correlated more highly, .41 to .62, than the Performance IQ (PIQ), .11 to .40. Similar correlation trends were noted with the WISC-R (Smith & Smith, 1986; Smith, Smith, & Dobbs, 1991). Strong correlations were noted between the Math subtest and Processing Speed (PS) and Freedom From Distractibility

(FD) index scores, .73 and .68 respectively. Reading correlated strongly with the FD index, .67.

Reviews and research using the WISC-III standardization sample outlined concerns about the statistical and clinical integrity of the Freedom From Distractibility (FD) and Processing Speed (PS) factor based index scores (Kaufman, 1993; Little, 1992; Sattler, 1992). A maximum-likelihood factor analysis of all 11 age groups was conducted by Sattler (1992) for comparison with the manual's results on four age group clusters. Since he found the FD Index did not emerge in 4 of the 11 age groups (ages 6, 8, 10, and 16) and a principal components analysis revealed similar findings, Sattler recommended the FD factor be disregarded until further evidence supports its use. Kaufman (1993) stated that further research was required to determine what both the new subtest, Symbol Search and the new four factor model measure since the manual indicated that LD children had lower scores on the new fourth Processing Speed factor. The increased emphasis on speed of responding was a concern for children who utilize a reflective cognitive style and it may also hinder the performance of LD children (Kaufman 1992, 1993). With a premium placed on problem-solving speed, the impact on an individual's IQ scores could be substantial. Related to this concern, were the lower scores produced by the WISC-III and the implications for educational placement of children. Post and Mitchell (1993) confirmed the manual's findings that the FSIQ, VIQ, and PIQ were 5 to 7 points lower on the WISC-III than the WISC-R. Since many school boards use a discrepancy between achievement and ability to determine eligibility for special education programs, there may be a decrease in the number of LD children eligible for services while the number of students identified as mentally handicapped may increase.

Studies on different populations of children were limited. Dumont and Faro (1993) devised a short form of the WISC-III for LD children based on the Information, Vocabulary, Block Design, Picture Completion, and Coding subtests. The subtests chosen were of interest to this study because of the useful clinic information offered for an LD sample. In a sample of 45 Canadian children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), Saklofske, Schwean, Yackulic, and Quinn (1994) found that ADHD children had lower scores on the FD and PS factor index scores. A limitation in the study was the high proportion of boys (89%), although the condition is more prevalent in males than females. The findings by Saklofske et al. (1994) matched the results of a sample of 68 ADHD children cited in the manual whose lowest index scores were in FD and PS.

The WISC-III manual also indicated that children with unspecified LDs (n = 65) and reading-disordered children (n = 34) had slightly lower VIQ than PIQ scores, scored higher on the Perceptual Organization (PO) than Verbal Comprehension (VC) index, and exhibited depressed FD and PS index scores. Also reported for these LD groups was evidence of an ACID profile (lower scores in Arithmetic, Comprehension, Information, Coding). In contrast to the manual studies, Fullerton (1994) found in a clinical sample that the FD and PS factors were questionable after a maximum-likelihood factor analysis. Although the sample was quite small (n = 90) which limited the credibility of her findings, the results raised more questions about the adequacy of interpreting factor based scores for identifying LD.

Conclusion

A review of the current literature revealed several concerns about the WISC-III. The most relevant issue for this study centered on the new four factor structure and what it reportedly measures. Space is now provided on the front of the test protocol for calculating the index scores which may contribute to their increased use in interpreting test profiles. It would be beneficial to reveal whether the VIQ and PIQ scores and the four index scores vary for different LD populations to help make more accurate diagnoses. Ultimately, further factor analytic studies on larger samples of various populations will be needed to verify the factor structure but it is currently necessary to first confirm or deny the presence of varying IQ and index scores in different LD populations.

Another area for exploration is the manual's claim of the ACID profile in LD populations. Although too much emphasis on a particular pattern of subtest scores may hinder examination of other possibilities, preliminary research would be helpful to confirm or deny the manual's claim of this subtest profile.

WISC-R and Learning Disabilities

The following section addresses the extensive body of research on LD and the WISC-R to illuminate the consistent findings after nearly two decades of studies. First, the arguments for and against the use of discrepancy definitions are discussed followed by an outline of the controversy over the use of the WRAT-R in assessment research. The final section explores LD performance patterns on the WISC-R identified in reviews of several studies.

<u>Discrepancy Definition of Learning Disabilities</u>

One of the most controversial issues still debated in the identification process of LD is the topic of definition. Siegel (1989) elicited a storm of support and protest from colleagues when she stated IQ was unnecessary for identifying LD. At the heart of the debate is the questioned efficacy of the ability-achievement discrepancy. The merits and drawbacks of discrepancy formulas, a discrepancy between ability and achievement measured by standardized tests, are briefly discussed because they were the method chosen for forming the learning disabled groups in this study.

There appears to be a significant gap between research findings and the reality of the schools where the eligibility and placement decisions for children are made. A number of researchers questioned the use of discrepancy definitions, especially in the area of reading LD, due to the debated relationship between intelligence and achievement (Kavale, 1988; Siegel, 1989, 1992; Stanovich, 1991). On the other hand, school psychologists must administer intelligence tests because not all students' instructional needs can be met in regular education (Kaufman, Harrison & Ittenbach, 1990; Meyen, 1989). Certain children require some form of special education which involves identifying students whose learning problems require intervention.

Currently, the most commonly used definition for LD is a discrepancy-based one (Frankenberger & Fronzaglio, 1991). Not without faults, the discrepancy definition has the advantages of combining objective measures with more subjective judgments, providing a means of choosing research samples with the same percentage of discrepancy for comparison purposes, and placing no limits on intelligence level so underachievement of all children can be evaluated (Smith, 1991). Essentially, there are four types of discrepancy formulas used (Lerner, 1988): (a) deviation from grade level; (b) ability-achievement discrepancy based on age or grade; (c) ability-achievement based on standard scores; and (d) ability-achievement discrepancy based on regression analysis. Age and grade discrepancies were criticized for not taking into account the test's error of measurement and for a lack of comparability of norms across tests. According to Smith (1991), standard score definitions treat IQ and achievement score variability similarly at all age levels. The main criticism of standard scores is that they do not account for regression to the mean causing over-identification of children with above-average IQs and under-identification of children with below-average IQs (Braden & Weiss, 1988; Shaywitz, Fletcher, Holahan, & Shaywitz, 1992). Although regression analysis definitions are the most precise method, they are complicated and costly to develop (Shaywitz et al., 1992; Smith, 1991).

In this study, a discrepancy formula of the simple difference between standard scores was used because of the ease and flexibility of working with a large pool of cases (n = 338). A restricted IQ range of 85 to 115 served to reduce the effects of regression to the mean from extreme scores, however, the elimination of extreme high and low IQ scores did not remove the possibility that children with scores in the 85 to 94 IQ range were not identified with a learning disability because of the achievement scores' regression to the mean.

Wide Range Achievement Test -Revised Strengths and Limitations for Research

The WRAT was criticized for use as an indicator of academic achievement (Snart, Dennis, & Brailsford, 1983), yet a survey of current learning disabilities research shows that the WRAT-R is still commonly used as measure of reading, arithmetic, and spelling achievement. Arguments against the WRAT and the WRAT-R, include inadequate norming, little content validity, and too few behavioral samples of skills (Salvia & Ysseldyke, 1985).

Conversely, the WRAT was shown to discriminate between normal and disabled readers and to classify children into problem or no problem groups as effectively as more comprehensive tests (Hale & Saxe, 1983; Janzen, Boersma, Fisk, & Chapman, 1983). The use of single word reading taps the child's phonological ability which is the foundation for comprehension (Siegel & Heaven, 1986). As one of the research purposes included replication of previous correlation studies, the WRAT-R and similar instruments were utilized with the realization that limited skills were evaluated, especially in reading and arithmetic.

WISC-R and LD Research Findings

With very limited research available about learning disabilities and the WISC-III, it was necessary to review the literature concerning the WISC-R to determine if consistent findings would contribute to the scope of this study. Kaufman et al., (1990) provided a thorough review of WISC-R research that forms the basis of the following section divided into three topics: factor analysis; the Freedom From Distractibility factor; and subtest scatter.

Factor Analysis Findings. The most consistent, recurring finding from factor analysis was the robust Verbal Comprehension (VC) and Perceptual Organization (PO) factors. The composition of these two factors was remarkably similar from group to group and in all 11 age groups of the standardization sample (Kaufman et al., 1990). Thirty-one studies from 1978 to 1985 that included normal, handicapped, learning-disabled, psychiatrically impaired, emotionally handicapped, mentally handicapped, gifted, and ethnic minority children were included. Sattler (1992) also found that the Verbal and Performance constructs were applicable to minority children. The Information, Similarities, Vocabulary, Comprehension, and Arithmetic subtests consistently form the VC factor. Block Design and Object Assembly were the best measures of the PO factor which also included Picture Completion, Picture Arrangement, and Mazes.

The Verbal-Performance dichotomy was confirmed by Lawson and Inglis (1987, 1988a, 1988b) who developed the Learning Disability Index (LDI) through a modification of the factor scores. The Verbal Factorial IQ and Performance Factorial IQ provided a measure of the discrepancy between verbal and non-verbal cognitive abilities. Their findings may be limited by the sample of middle and upper class children whose socio-economic status might have influenced the Verbal-Performance splits.

Freedom From Distractibility Factor. The FD factor was apparent for each of the 11 age groups in the WISC-R standardization sample. Digit Span and Arithmetic loaded substantially at all ages, Coding B loaded moderately, and Coding A had minimal loadings (Kaufman et al., 1990; Sattler, 1992).

The factor seems to measure ability to remain attentive, sequencing, symbolic skills, or short-term memory (Kaufman et al., 1990; Sattler, 1992). Wielkiewicz's (1990) review of FD studies suggested that the third factor may reflect executive and short-term memory processes involved in planning, monitoring, and evaluating task performance. A subgroup of children with learning disabilities characterized by short-term memory problems, sequencing skill problems, and difficulty in sounding out words had lower FD factor scores.

Non-intellective influences were connected to the third factor. Because anxiety was related to the Arithmetic and Digit Span subtests, Coding can be used as a check on the anxiety hypothesis (Kaufman, 1979). Sex, occupational class, and urban/rural differences may also be significant for explaining discrepancies (Silver & Clampit, 1988).

In summary, the findings suggest that complex cognitive processes and/or behavioral dimensions affect the FD factor (Kaufman et al., 1990; Stewart & Moely, 1983). It is necessary to consider the child's background, observations of behaviors, nature of incorrect responses, and problem-solving methods before trying to explain scores on the so-called distractibility factor .

Subtest Scatter. No characteristic profile has distinguished children with and without learning disabilities. The subtest scaled score range with normal children has accounted for the inability to produce a "magic" profile. In the WISC-R standardization sample, the average scaled-score range for the full scale (10 subtests) was 7 (SD = 2) and was evident in all 11 age groups, males and females, blacks and whites, and children from different socioeconomic backgrounds. The average child had a subtest scaled score range of 6 to 13 or 7 to 14 (Kaufman et al., 1990).

Even though significant verbal-performance discrepancies and strengths and weaknesses in subtest profiles do not have diagnostic significance unless fluctuations occur infrequently in the normal population, they do have educational significance for planning placement and remediation. Between groups of exceptional children with school related problems, characteristic high and low subtest scores were apparent. Reading disabled children scored higher on Picture Completion, Object Assembly, and Block Design and they scored lower on Arithmetic, Coding, Information, and Digit Span (ACID). The ACID profile was also evident for children displaying learning disabilities (Kaufman et al., 1990; Sattler, 1992). Joschko and Rourke (1985) pointed out the limitations of ACID profiles based on mean scores after finding four learning disability subtypes in a sample of 181 children who all exhibited the ACID profile. They cautioned that mean scores may not be representative of the individual children constituting the group.

Table 2.1 represents the rank ordering of WISC-R and WISC subtests based on mean scores for children exhibiting learning disabilities. The first column includes 18 studies of children with learning disabilities reviewed by Kaufman et al. (1990), the second column is a collection of 30 studies of children with reading disorders (Sattler, 1992), and the third column is from a meta-analysis of 94 learning disability studies (Kavale & Forness, 1984). The subtests are ranked from easiest to most difficult.

TABLE 2.1

Rank Ordering of WISC-R and WISC Subtests

Kaufman (WISC-R)	Sattler (WISC-R)	Kavale & Forness (WISC)
1. OA	1. PC	1. PC
2. PC	2. PA	2. PA
3. PA	3. BD	3. OA
4. C	4. OA	4. C
5. BD	5. S	5. BD
6. S	6. C	6. S
7. V	7. V	7. V
8. Cd	8. Cd	8. M
9. A	9. DS	9. I
10. I	10. A	10. Cd
	11. I	11. A
		12. DS

I-Information, S-Similarities, A-Arithmetic, V-Vocabulary, C-Comprehension, DS-Digit Span, PC-Picture Completion, Cd-Coding, PA-Picture Arrangement, BD-Block Design, OA-Object Assembly, Mazes-M.

An examination of the table revealed that Picture Completion, Picture Arrangement, and Object Assembly were the easiest three subtests while the subtests that form the ACID acronym were the most difficult. It appears that children showing learning disabilities were strongest in perceptual organization, followed by verbal comprehension, and weakest in the distractibility factor.

In an effort to explain persistent profiles, Bannatyne (1974) developed a recategorization of the Wechsler subtests which is listed in table 2.2.

TABLE 2.2

Bannatyne's Categorizations

Verbal Conceptualization Ability	Spatial Ability	Sequencing Ability	Acquired Knowledge
Similarities	Picture Completion	Arithmetic	Information
Vocabulary	Block Design	Digit Span	Arithmetic
Comprehension	Object Assembly	Coding	Vocabulary

Verbal Conceptualization was most closely related to the VC factor, Spatial Ability to the PO factor, and Sequencing to the FD factor. Children with learning or reading disabilities frequently had a WISC-R pattern of Spatial > Conceptual > Sequential (Kaufman et al., 1990). Bannatyne's profiles were not effective for differential diagnosis. The proportion of individuals within learning disability groups displaying the characteristic pattern was generally small and the Spatial > Conceptual> Sequential pattern appeared in other populations of emotionally-impaired children, juvenile delinquents, and normal children. However, the subtest regroupings help make sense out of many WISC-R learning disability profiles and the Acquired Knowledge group is extremely valuable in interpreting profiles of children with a possible learning disability (Kaufman, 1981).

Conclusion

Despite the large body of research that identifies characteristic patterns of WISC-R performance for children with learning disabilities, the use of the test for differential diagnosis was not effective (Kaufman et al., 1990; Kavale & Forness, 1984; Macmann & Barnett, 1992). In the absence of a unique profile that was reliably diagnostic of a learning disability, the WISC-R should not be used in the absence of other tests and information to make a differential diagnosis. However, there are intraindividual differences that may indicate within-group trends specific to children with learning disabilities. Research to confirm the presence of these differences for the WISC-III is needed to validate the use of the test for diagnostic purposes.

Current Perspectives on Learning Disabilities Research

The history of the learning disability field is briefly chronicled to establish the current focus in learning disability research. Subtypes of learning disabilities based on achievement classification models from neuropsychological studies in the areas of reading, math, and spelling are examined. Findings from other models of subtyping studies are presented to summarize the research findings most relevant for this thesis. Information-processing theories related to intelligence, reading, math, and spelling are also discussed to highlight emerging alternate views to the psychometric assessment approach.

Evolution of the LD Field

The concept of learning disabilities evolved from a diverse background of theories and practices that continually reshape the direction of research today. Although learning disabilities became a recognized, fully funded handicapping condition in 1975 the study of children with learning difficulties can be traced back over 100 years (Hooper & Willis, 1989; Smith, 1991).

Research that translated into classroom practice and remediation surged in the 1960s with a focus on visual-perceptual and motor deficits. Into the 1970s, behavior modification techniques also moved from the laboratory to the classroom and flourished. The visual-motor emphasis gave way to auditory-perceptual, intersensory integration, and attention/memory deficits. In the 1980s, advances in knowledge regarding the neuropsychological underpinnings of learning and behavior provided an era of refinement and eclecticism as the field moved away from single-factor models to more multidimensional models. Computers earned a prominent place in learning disabilities remediation while classroom practices shifted to metacognitive strategies teaching children how to plan their learning. The 1990s saw a confirmation of the heterogeneity of learning disabilities as researches used the foundations from single-factor models to explore more refined definitions of learning disability subtypes through neuropsychological approaches. The advantage of this approach lies in the information obtained that highlights strengths and weaknesses in unique areas of functioning for facilitating the planning and implementation of intervention methods (Chittooran, D'Amato, Lassiter, & Dean, 1993).

Classification of learning disability subtypes originated with the clinical-inferential approach where measures of achievement and cognition in a post hoc model were the basis for homogeneous group separation. The subtypes were delineated by clinical decisions based on visual inspection of related test scores (Lyon & Risucci, 1988). In the 1980s, empirical classification employing multivariate quantitative methods gained popularity. In this approach, homogeneous subtypes are formed on the basis of multidimensional structures inherent in the data rather than on more subjective clinical decisions (Hooper & Willis, 1989).

Learning Disability Subtyping Research

Much of what is known about specific learning disabilities in reading, arithmetic, and spelling originated from the clinical-inferential classification approach using an achievement subtype model in which the basis of classification was determined by academic levels and patterns. Clinical-inferential and empirical classification achievement models are reviewed because they are most closely related to the thesis research. The two research approaches highlight specific areas of strengths and weaknesses in reading, math, and spelling disabled children. Other classification models are presented that contribute to our present knowledge of learning disability subtypes.

Reading Learning Disability Subtypes. Lerner (1988), Smith (1991), and Sattler (1992) characterized students with reading learning disabilities into three primary subtypes: auditory-linguistic deficits, visual-spatial deficits, and mixed deficits. Children with auditory-linguistic problems primarily have difficulty in integrating symbols with sounds and they have minimal understanding of letter-sound relationships. Children with a primary deficit in visual-processing skills have difficulty reading words as a whole. They cannot recognize and remember how letter and whole word configurations look and they seem to attend to only partial cues in words. The most severely disabled readers are weak in both visual- and auditory-processing abilities.

An important contribution to the clinical identification of reading subtypes was made by Boder (1970) who classified children (N=107) on the basis of reading and spelling scores from a personally developed screening instrument. Five distinct reading patterns emerged and three were classified as dyslexic. *Dysphonetic* readers used a global, gestalt approach because of deficient phonetic decoding skills and they made frequent misspellings. A *dyseidetic* subtype displayed poor visual perceptual and visual memory skills and employed phonetic decoding strategies. *Alexia*, a combined subtype, was the most severely impaired with a combination of deficits. Even though this research lacked internal and external validation and was not fully supported by further research, it provided the foundation for our present understanding of reading disability.

Two other studies classified children based on reading and spelling errors. Ingram, Mason, and Blackburn (1970) found three reading subtypes in a sample of 62 children with developmental dyslexia: *audio-phonic* with primary deficits in sound discrimination, sound blending, phonic analysis, and speech to sound abilities; *visuo-spatial* with primary deficits in recognizing simple words and demonstrating letter reversals and letter/syllable transpositions; and a third subtype who exhibited a combination of these problems. Thomson (1982) classified children as auditory-linguistic, visual-spatial, and a mixed subtype.

Mitterer (1982) used reading comprehension and recognition to describe two reading disabled subtypes that were characterized by the quality of their reading errors. *Recoding* readers seemed to use continual phonetic strategies and *whole word* readers exclusively employed whole-word strategies in their reading. These two subtypes are similar to Boder's dyseidetic and dysphonetic subtypes.

Memory for verbal and nonverbal stimuli in four learning disability subgroups and a group of normally achieving children was investigated by Fletcher (1985). Subjects (N=87) had FSIQs between 80 and 115 and were placed according to their pattern of WRAT scores. Relative to the control sample, reading-spelling (R-S) disabled children were associated with poorer verbal skills and retrieval difficulties on verbal tasks while the reading-spelling-arithmetic (R-S-A) disabled subjects displayed poorer verbal and nonverbal abilities with retrieval problems on verbal tasks along with storage and retrieval problems on nonverbal tasks. The spelling and arithmetic groups are discussed later in their respective sections. Results were limited by small group sizes and the lack of control on age. Siegel and Ryan (1988) revealed that reading-disabled children had significantly lower scores on working-memory tasks involving both verbal and numerical material.

Extensive subtyping research in two age groups of children, 7-8 and 9-14, using a clinical-inferential achievement model was carried out by Rourke and associates (Rourke & Finlayson, 1978; Rourke and Strang, 1978, 1983; Ozols & Rourke, 1988, 1991). Based on patterns of reading and spelling tasks relative to arithmetic performance on the WRAT and a FSIQ range of 86 to 114, three learning disability subtype groups were formed (reading-arithmetic-spelling, reading-spelling, and arithmetic). These groups were then compared on measures of auditory-perceptual, verbal, verbal-perceptual-organizational, complex psychomotor, and tactile-perceptual abilities.

Rourke (1993) concluded that children with learning disabilities who were chosen solely on the basis of academic achievement patterns with adequate controls on age and IQ exhibited very different patterns of neuropsychological assets and deficits. His conclusions on reading disabilities are summarized below. Math learning disability findings are detailed later. The reading-spelling (R-S) group in comparison to the math group showed deficiencies in the more rote aspects of psycholinguistic skills such as recall of information and word definitions. They demonstrated outstanding deficiencies in the complex semantic-acoustic aspects of psycholinguistic skills (auditory perception) like sentence memory and auditory analysis of common words. The rote aspects of verbal skills were a greater deficit at ages 7-8. Academic weaknesses appeared in graphomotor skills, word decoding, reading comprehension (ages 7-8), spelling, verbatim memory, and mechanical arithmetic. Assets were shown in visual-spatial-organizational, psychomotor, and tactile-perceptual tasks as well as non-verbal problem solving tasks. Verbal neuropsychological strengths were evident in prosody, semantics, phonology, content, pragmatics, and verbal associations. Academic assets were in reading comprehension, mathematics, and science (Rourke, 1993).

Several researchers have replicated Rourke's findings increasing the validity of this type of academic achievement classification system (Breen, 1986; Loveland, Fletcher, & Bailey, 1990; Share, Moffitt, & Salvia, 1988; White, Moffitt, & Salvia, 1992). Breen (1986) replicated Rourke's clinical LD subtypes using the Woodcock-Johnson Psycho-Educational Battery rather than the WRAT-R in three groups of 30 children each. In the High Reading/Low Math group, verbal reasoning and general linguistic skills contributed most to the Full Scale Index.

Related to the findings from reading disability classification research is the strong support for the importance of phonological processing abilities in the acquisition of early reading skills (Mann, 1994; Swanson, 1989; Torgensen, Wagner, & Rashotte, 1994). Measures of phonological processing reliably distinguished among grade one children with and without reading disabilities (Hurford, Schauf, Brunce, Blaich, & Moore, 1994). The types of skills most frequently studied were phonological awareness, phonological memory, and rate of access for phonological information. Phonological awareness is a sensitivity to the phonological structure of words and is assessed by tasks requiring children to identify, isolate, or blend the individual phonemes in words. Young children with stronger phonological awareness typically learn to read more easily and children with poor phonemic awareness had poor decoding skills which led to fewer opportunities for vocabulary growth and exposure to new ideas and concepts (Blachman, 1994b).

Phonological awareness enables youngsters to determine individual words not seen before (Cornwall, 1992).

Phonological memory involves mentally representing the phonological features of language through codes such as digits, letters, words, or pronounceable nonwords. The child is required to simultaneously store and process individual sounds in words; difficulty with this process is usually associated with severe reading disabilities (Torgensen et al., 1994).

The efficiency with which a child can access phonological information stored in long-term memory influences the extent to which phonological information is useful in decoding (Torgensen et al., 1994). Rapid retrieval of information may make it easier for youngsters to develop automaticity in word recognition (Cornwall, 1992).

Math Learning Disability Subtypes. Badian's (1983) study was the only one that focused solely on math subtypes. Four subtypes were proposed from an analysis of 50 childrens' arithmetic errors. Twenty-four percent manifested *spatial dyscalculia* by showing horizontal and vertical confusion. Another 14% manifested *anarithmetria* by confusing the operations of addition, subtraction, multiplication, and division. A third subtype (42%) called *attentional-sequential dyscalculia* was unable to recall number facts along with attention deficits. The remaining 20% had mixed spatial, operational, and attentional difficulties. Little data has been generated with respect to these subtypes.

The studies from the preceding section concerning reading subtypes also included math groups and these findings are presented next. Fletcher (1985) found that arithmetic disabled children showed both storage and retrieval problems on nonverbal tasks. In general, this subtype had poorer nonverbal skills. In Breen's (1986) High Math/Low Reading group, subtests requiring short-term auditory/visual sequential memory, expressive language, and numerical reasoning contributed the most to the Full Scale Index. In working memory tasks, children with a writing/arithmetic disability had significantly lower scores on numerical tasks (Siegel & Ryan, 1988).

Considerable research was conducted by Rourke and associates in math subtypes (Rourke & Finlayson, 1978; Rourke and Strang, 1978, 1983; Ozols & Rourke, 1991). Compared to reading-spelling children, Rourke concluded that arithmetic disabled children had superior skills in the rote aspects of psycholinguistic skills such as the recall of information and word definitions (Rourke, 1993). This group also demonstrated stronger abilities in the complex semantic-acoustic aspects of psycholinguistic skills (auditory perception) like sentence memory and auditory analysis of common words. Weaker performances were shown in the processing of novel, complex, or meaningful material. The more novel the psychomotor, visual-spatial, or tactile-perceptual task, the more impairment that was shown. Profound problems were demonstrated on non-verbal problem solving tasks. Academic assets were evident in graphomotor skills (ages 9-14), word decoding, spelling, and verbatim memory. Academic deficits appeared in graphomotor skills (ages 7-8), reading comprehension, mechanical arithmetic, mathematics, and science. From research on learning disability subtypes, Rourke, Del Dotto, Rourke and Casey (1990) developed the nonverbal learning disabilities syndrome (NLD) which is related to specific patterns of impairment in mechanical arithmetic and psychosocial functioning. The model is based on clinical and psychometric variables including the WISC subtests Information, Similarities, Vocabulary, Comprehension, Arithmetic, Digit Span, Coding, Picture Completion, Picture Arrangement, Block Design, and Object Assembly.

Strang and Rourke (1985) classified mechanical math errors of arithmetic disabled students into several categories: (1) spatial organization; (2) alertness to visual detail; (3) procedural errors; (4) failure to shift psychological set; (5) graphomotor; (6) memory; and (7) mathematical judgment and reasoning. These findings were limited to math calculation skills and did not include problem solving ability

Spelling Learning Disability Subtypes. Limited research was available in the area of spelling. Frith (1983) described two subtypes of spelling disabilities. One of the subtypes involved phonological spelling deficits and the other involved lexical spelling deficits.

Phonological skills involve accurate phoneme-to-grapheme translations and deficits in these skills lead to spelling errors characterized by numerous dysphonetic spellings that may omit consonant clusters. According to Frith, these deficits also seem related to reading deficits. Lexical skills involve the ability to store letter strings in sequence and to access these strings effectively. Poor lexical spellers can be good readers because they use a lexical strategy based on partial cues. Meanwhile, good spellers can access a full-cue strategy if necessary.

Lennox and Siegel (1988) investigated spelling errors made by children with reading disabilities (RD), arithmetic disabilities (AD), and no disabilities by analyzing the first consecutive ten errors from the WRAT Spelling subtest. The subjects ranged in age from 6 to 18 and had an IQ of at least 80. Children with RD made more nonphonetic spelling errors than the other two groups. The group with AD made more phonological matches than visual matches and the group displaying RD showed the reverse pattern. Normal children made the closest visual matches.

In a cross-sectional study, Sweeney and Rourke (1978) analyzed the WRAT Spelling subtest in a younger (ages 8 to 10) and an older (ages 12 to 14) age group. A spelling deficit was operationalized by a percentile score of 20 or lower. In each group, the children were subdivided into phonetically accurate (PA) spellers and phonetically inaccurate (PI) spellers. Older PI problem spellers exhibited significantly weak receptive linguistic operations. Older PA problem spellers had difficulty in associating the spoken word with visual-spatial information and encoding relatively complex word strings in response to verbally presented information. PI poor spellers responded weakly to the linguistic demands of phonic segmentation or synthesis while poor PA spellers had difficulty extrapolating beyond verbal information. Phonetic spellers seemed to have a better academic prognosis than their dysphonetic counterparts.

Combined Reading, Math, Spelling Learning Disability Subtypes. Data on a combined learning disability subtype was virtually non-existent. Even though a reading-math-spelling disability group was included in two studies (Rourke & Finlayson, 1978; Strang & Rourke, 1985), the focus was on differences between the reading-spelling and arithmetic groups resulting in the exclusion of the combined group in the discussion section of the studies. From the limited information available, it seemed the combined group demonstrated abilities similar to the reading-spelling group with a lower VIQ than PIQ and stronger psychomotor and tactile-perceptual skills.

Empirical Classification Subtype Learning Disability Models

Empirical classification models have the advantage of being used to generate classification schemes and therefore contribute to the validity of the classification model. There are two methods commonly used, cluster analysis and Q-type factor analysis. Cluster analysis does not limit the number of clusters that can be generated nor does it adhere to a rigid linear model. Consequently, it is a useful method for snooping data. The primary use of Q-type factor analysis lies in its ability to calculate the degree of similarity in the profile patterns of a target population (Hooper & Willis, 1989). The next four studies represent achievement classification models utilizing cluster analysis.

Using 256 males, Satz and Morris (1981) isolated two subtypes of children with overall deficient achievement. The two groups were combined and reanalyzed using four neuropsychological measures with five subtypes located: global and specific language impaired; visual-perceptual deficit; mixed deficit; verbal fluency and naming disorder; and neuropsychologically intact with low achievement. The study was limited in theory formulation as no prior learning disability academic theories were specified. Van der Vlugt and Satz (1985) replicated these findings in a Dutch sample of 500 younger and older males. Johnson, Fennell, & Satz (1987) replicated Satz and Morris' subtypes in a sample of 150 males showing some variation in the number of subtypes identified. Two of the six subtypes reflected distinct achievement deficits. One showed generalized deficiencies across all achievement areas and the other was weak in arithmetic. The findings of Johnson et al. were similar to Satz and Morris' results except for a specific reading rather than math deficit.

Finally, DeLuca, Rourke & DelDotto (1991) used clustering techniques to group 156 children, ages 9 to 14, with arithmetic deficiencies into four subtypes. The subjects had FSIQs in the range of 85 to 115. The first subtype displayed mild deficits in tactile-perception, conceptual flexibility, and some aspects of expressive language. The second subtype had significant discrepancies in higher order tactile-perception, visual-motor speed and coordination, verbal fluency, verbal memory, and conceptual flexibility. The third subtype showed deficits in nonverbal problem solving and processing. The fourth subtype was characterized by mild difficulties in verbal expression, conceptual flexibility, tactile-perceptual skills, and manipulation of visual-symbolic material.

Summary of Achievement Classification Models

Clinical-inferential and empirical classification systems using achievement tests revealed specific areas of cognitive strengths and weaknesses in reading-spelling and arithmetic learning disability subtypes. Spelling as a separate entity received little attention and a combined disability in reading-math-spelling was virtually ignored. There appear to be some direct connections between clinical-inferential and empirical based achievement models. Children with arithmetic difficulties consistently experienced problems with visual-spatial-motor skills or non-verbal abilities. Reading and spelling disabled children experienced phonetic, psycholinguistic, and auditory processing problems. Phonological processing research revealed promising methods for intervention with young readers to overcome early phonemic awareness problems. To date, little research has provided insight into children with generalized disabilities in reading, math, and spelling.

WISC-R Empirical Classification

Some researchers used the WISC-R exclusively in a classification procedure for learning disabilities developed from a Q-type factor analysis. Vance, Wallbrown, & Blaha (1978) reported the first study of this nature and identified five subtypes in 128 children diagnosed with a specific reading disability. One subtype had a high degree of distractibility, another subtype showed problems in visual-perceptual abilities, and three subtypes displayed deficits in some aspect of language functioning.

Hale and Saxe (1983) used a sample of 77 children, aged 6 to 16, to develop a classification for a heterogeneous group of disabled learners. Four subtypes were identified. One subtype had intact visual-spatial abilities but impaired sequential processing abilities along with reading deficits. Another subtype showed higher verbal than non verbal abilities. The third subtype showed attentional difficulties and the fourth group had visual-spatial weaknesses.

Snow, Cohen, & Holliman (1985) identified six subtypes in a population of 106 students with learning disabilities. Three of these subtypes were consistent with specific learning disabilities. Two of the subtypes exhibited specific language disturbances with Verbal Comprehension abilities lower than Perceptual Organization and attention abilities. The other subtype showed attentional deficits as the primary contributor to the learning problems.

Holcomb, Hardesty, Adams, & Ponder (1987) also found six subtypes in a sample of 119 children from five separate learning disability programs but only two were characteristic of learning disability profiles. One subtype represented probable language disorders while the other exhibited the ACID profile of sequencing and attention deficits. All of the above four studies identified specific WISC-R LD subtypes characterized by deficits in visual-perceptual, verbal, and attentional skills. The external validity of these subtypes is questionable since the factor structure of the test was reflected in the subtypes. Nevertheless, the heterogeneous nature of LD samples with respect to the WISC-R was evident.

Summary of Learning Disability Subtype Classification Research

Learning disability classification research is still at a preliminary developmental stage. This review focused solely on learning disability subtypes derived from achievement test models but numerous other approaches have been used. For example, Morris, Blashfield, & Satzs' (1986) methodological improvements provided a basis for understanding subtypes of learning disabilities from a longitudinal perspective. They showed that children presenting reading disabilities had retarded verbal development in comparison to visual-perceptual-motor development from kindergarten to grade five based on their performances on a neuropsychological test battery.

Even though homogeneous subtypes were identified by various clustering techniques, a universally accepted clinical classification model has not yet been adopted. There remains much to be learned as evidenced by a meta-analysis of 1077 studies investigating achievement, neurocognitive, neurolinguistic, and socio-emotional features of learning disabilities. Kavale and Nye (1985/86) accounted for only about 40% of the variances between subjects with learning disabilities and normal samples of subjects. Of particular interest was that the linguistic domain, specifically the phonological category, provided the greatest differentiation. Learning disabilities are a complex and multivariate problem not easily defined by any one particular area of functioning.

Intelligence testing still maintains an active role in learning disability research. IQ is commonly used to determine an ability/aptitude discrepancy for learning disability group membership and to attain a global estimate of intellectual functioning within learning disability groups. Eight of the WISC or WISC-R subtests were commonly used in a neuropsychological test battery. The Vocabulary, Information, Similarities, and Comprehension subtests from the Verbal Scale were included to measure verbal and concept formation ability. The nonverbal subtests Picture Completion, Picture Arrangement, Block Design, and Object Assembly evaluated visual-spatial and tactile-perceptual skills. Given the consensus that children with learning disabilities are characterized by varying verbal and nonverbal abilities, validation of the WISC-III Verbal and Performance Scales with learning disability samples is needed.

Information-Processing Theory

The information-processing model of intelligence applied to learning disabilities was briefly reviewed to consider the criticisms it aimed at the psychometric assessment approach. An alternate view of assessment contends that children exhibiting learning disabilities experience a lack of classroom success in academic tasks or in social interactions because of an inability to shift from one strategy to another, to abandon inappropriate strategies, to process information with one strategy and then select another, or to use several processing approaches in rapid succession to solve a problem (Naglieri & Das, 1990; Swanson, 1987; 1988). The information-processing approach to assessment focuses on evaluation of cognitive strategies that reflect a child's ability to construct or to choose a way of solving a task. Children are viewed as active learners with inefficient thought patterns who have difficulty in selecting a relevant plan of action from a repertoire of strategies.

From an information-processing perspective, traditional psychometric tests are criticized for not providing insight into the ways students with learning disabilities use their skills and abilities (Swanson, 1988). Psychometric tests reflect a child's generalized performance strengths and deficits but provide an incomplete representation of a child's knowledge base and may obscure understanding of the processes a child with a learning disability uses to acquire knowledge.

The theory of information-processing was applied to children with a learning disability in mathematics, spelling, and reading. Pellegrino and Goldman (1987) presented a framework for understanding math disabilities in terms of the structures and processes inherent in children's *procedural* and *declarative knowledge*. Procedural knowledge was knowledge of rules while declarative knowledge was lexical or factual knowledge. Children with a math disability reflected incomplete or inadequate information at both levels. Gerber and Hall (1987) found students showing a spelling disability could not hold words in short-term memory, could not identify the phonemic representations of words, and had difficulty with spelling rules. Samuels (1987) suggested children's skills or processes with reading problems were not automaticized when tasks demanded too much attention. Reading problems were not so much a function of attending as they were of accessing lexical information.

The information-processing approach does not advocate that psychometric assessment be abandoned, only that it is put in perspective. Learning disabilities are the result of a unique coordination of processes rather than a specific type of processing deficiency (Spear & Sternberg, 1987). Focusing on isolated deficiencies, such as behaviors derived from factor analysis, fails to capture the integrative nature of children's intellectual and academic functioning.

Summary

Revisions to the WISC-R and initial research findings for the WISC-III were examined. The addition of the Symbol Search subtest created a new fourth factor, Processing Speed, which also diminished the Freedom From Distractibility factor from three to two subtests. Questions were raised about the validity of the FD and PS factors (Kaufman, 1993; Sattler, 1992). Wechsler (1991) maintained that children exhibiting learning disabilities could be discriminated with the WISC-III on the basis of higher Performance IQs than Verbal IQs, lower PS and FD factor index scores, and the ACID profile. Significant correlations were found between the WISC-III IQ/index scores and achievement test scores (Smith & Smith, 1988; Smith et al., 1991).

A review of learning disability research using the WISC-R outlined the limitations of the discrepancy definition of learning disabilities and the limitations of the WRAT-R. The VIQ and PIQ were the most robust factor analytic findings (Kaufman et al., 1990; Sattler, 1992) lending support for their interpretation. The existence of the WISC-R FD factor was supported but consensus lacked over the cognitive processes that affected this score (Kaufman et al., 1990; Silver & Clampit, 1988; Stewart & Moely, 1983). A characteristic LD subtest profile was not evident but LD children frequently scored higher in Picture

Completion, Picture Arrangement, and Object Assembly while the ACID subtests were more difficult (Kaufman et al., 1990; Kavale & Forness, 1984; Sattler, 1992). Although Bannatyne's recategorization of WISC-R subtests was not effective for differential diagnosis, LD children frequently had a pattern of Spatial > Conceptual > Sequential (Kaufman et al., 1990).

Characteristics of reading, math, and spelling learning disability subtypes were presented from clinical-inferential classification models using achievement tests. Reading disorders were characterized by three primary subtypes: auditory-linguistic deficits; visual-spatial deficits; or a combination of both (Fletcher, 1985; Thomson, 1982; Rourke, 1993; Share et al., 1988). Phonological processing abilities were found to be highly significant in distinguishing readers with problems from effective readers (Mann, 1994; Swanson, 1989; Torgensen et al., 1994). Math learning disability subtypes were characterized by the Nonverbal Learning Disabilities syndrome developed by Rourke (1993). Phonological skills were also related to spelling learning disabilities (Lennox & Siegel, 1988; Sweeney & Rourke, 1978). Research on combined reading, math, and spelling learning disability subtypes was virtually non-existent.

Empirical classification models produced learning disability achievement subtypes including language impairments, visual-perceptual deficits, and mixed deficits (Satz & Morris, 1985; DeLuca et al., 1987). WISC-R subtyping research produced similar results (Hale & Saxe, 1983; Snow et al., 1985). Multivariate statistical techniques have improved subtyping research but learning disabilities remain a complex problem not easily defined by specific areas of functioning.

Previous WISC-R studies indicated that children with a learning disability exhibit characteristic patterns of performance that may aid in the differential diagnosis of learning disabilities. Initial WISC-III research indicated convergent and discriminative validity was evident for identification of learning disabilities. The purpose of the study was to confirm or deny these findings and to provide further information on the validity of the WISC-III. The following specific research questions were developed from the literature review.

Research Questions

The revision of a major assessment tool typically elicits considerable interest among practicing educators, psychologists, and psychometric theoreticians. The present study addresses the issues of the WISC-III's convergent and discriminative validity for identifying learning disabilities. Research questions under two major headings were formulated after an analysis of the literature and the WISC-III manual.

i. What evidence exists for the convergent validity of the WISC-III with the Wide Range Achievement Test-Revised (WRAT-R), Wechsler Individual Achievement Test (WIAT), and the Canada QUick Individual Educational Test (QUIET)?

   1. What is the degree of relationship between the WISC-III IQ and the subtest scores?
   2. What is the degree of relationship between the WISC-III FSIQ, VIQ, and PIQs and the WRAT-R, WIAT, and QUIET subtest scores?
   3. What is the degree of relationship between the WISC-III four Index scores (Verbal Comprehension, Perceptual Organization, Freedom from Distractibility, Processing Speed) and the WRAT-R, WAIT, and QUIET subtest scores?

ii. What evidence exists for the discriminative validity of the WISC-III and the WRAT-R, WIAT, and QUIET for identifying children with reading learning disabilities (LD), math LD, spelling LD, or a combination of all three reading, math, and spelling LD?

   4. Are there significant differences in the mean achievement test scores when each of the LD groups are compared to the control group?
   5. Are there significant differences in the WISC-III IQ scores (Full Scale, Verbal, Performance) Index scores (Verbal Comprehension, Perceptual Organization, Freedom from Distractibility, and Processing Speed) and subtest mean scores?
   6. Do patterns of subtest scores with distinct high and low scores emerge for each of the LD groups that are different from the control group profile?

CHAPTER 3

RESEARCH DESIGN AND PROCEDURES

Procedures

Thesis data were collected by graduate students enrolled in graduate psychological assessment courses at the University of Alberta between September, 1992 and April, 1994. The students were competently trained in the administration, scoring, and interpretation of all the tests with Faculty Staff or other trained supervisors checking all test protocols for administration and scoring accuracy. Tests were administered in the Education Clinic, a well established service operated under the auspices of the Department of Educational Psychology, Faculty of Education, University of Alberta whose primary function is to train graduate students in Special Education, School Psychology, or Counselling programs. Clients were referred to the Clinic by schools, parents, individuals, and various agencies for the purpose of administering a battery of tests. As part of a routine test battery used in the Clinic, clients were administered an intelligence test, a visual-motor integration test, an achievement test, and in some cases a self-esteem measure and/or behavior checklist(s).

The data for this study was collected by reviewing the subjects' test reports held within confidential files in the Clinic. Prior to assessment, all client parents or guardians signed a consent form allowing test data to be used for research purposes at the university. Confidentiality in the study was maintained because no personal information that identified subjects was included and only the age, gender, referral reason, and WISC-III, WRAT-R, WIAT, and QUIET test scores were extracted from each client's file. Test report information was entered in a Microsoft Excel computer database and then analyzed using SPSS/PC for Windows, a statistical package for the IBM microcomputer.

Sample

The initial non-random sample consisted of 338 subjects ranging in age from 6 to 16 years. There were 239 male (71%) and 99 female (29%) subjects and the grade levels of the subjects ranged from one to eleven. See Appendix A for the WISC-III and achievement test mean scores of the initial sample. Each individual was seen by a student clinician who administered the WISC-III, a visual-motor integration test, and an achievement test. Although several different achievement tests were used, only the WRAT-R, WIAT, and QUIET scores were collected for this study.

The Control and four LD groups were formed from a pool of 234 cases, non-randomly selected out of the initial sample of 338, based on a WISC-III Full Scale IQ score in the range of 85 to 115. Forty of the 234 cases who lacked WRAT-R, WIAT, or QUIET achievement test scores were removed, leaving 194 subjects to form the control and LD groups. Subjects were non-randomly placed in four LD groups based on a discrepancy of 15 or more standard score points between the WISC-III FSIQ and respective achievement scores from the WRAT-R, WIAT, or QUIET. The four LD groups created were; (1) reading learning disabled (RLD); (2) math learning disabled (MLD); (3) spelling learning disabled (SLD); and (4) learning disabled in reading, math, and spelling or learning disabled in combined subjects (CSLD). The RLD group had a discrepancy of 15 or more standard score points between the FSIQ and reading or both reading/spelling scores, the MLD group was discrepant in math or math/spelling scores, the SLD group was discrepant in spelling scores only, and the CSLD group was discrepant in all three reading, spelling, and math scores. Table 4.2 outlines the distribution of the groups in this study by size, gender, and age. The Levene Test for Homogeneity of Variances revealed no significant differences between control and LD groups in age, gender, or grade.

TABLE 3.1

Size, Sex, Grade, and Age Characteristics of Control and LD Groups

Sample	n	Gender Female	Gender Male	Grade Range	Mean Grade	SD	Age Range	Mean Age	SD
Control	87	26	61	1-11	4.8	2.4	5.8-16.0	10.4	2.5
RLD	27	7	20	1-11	4.3	2.5	6.7-16.7	10.2	2.6
MLD	23	5	8	2-11	5.0	2.7	7.6-16.3	10.6	2.6
SLD	26	5	21	1-11	5.3	2.6	6.9-16.7	11.1	2.7
CSLD	25	6	19	1-10	3.8	2.7	6.7-16.2	9.8	2.6
Total	n = 188	49	139						

Due to the limited number of subjects with discrepancy scores in reading only and in math only, 20 subjects with discrepant scores in both reading and spelling were included in the RLD group and 12 subjects with discrepant scores in both math and spelling were included in the MLD group. Because there were only three subjects with discrepant scores in both math and reading, they were excluded from the LD groups leaving a total of 191 subjects in the Control and LD groups. The Control group, a non-random selection of individuals not included in the LD groups from the sample of 191 children, was composed of subjects with a discrepancy of 14 or less points between the WISC-III FSIQ and all three reading, spelling, and math achievement scores. Due to extreme achievement test scores, one subject from the MLD group and two cases from the control group were removed leaving a total of 188 subjects.

Operational Definition for Learning Disability

For the purpose of this study, the following operational definition of learning disabilities was adapted from Alberta Education (1986).

1. The child demonstrated average intellectual abilities as measured by the WISC-III Full Scale IQ score which fell in the range of 85-115.
2. There was an ability-achievement discrepancy of at least one standard deviation as indicated by comparing the Full Scale IQ and achievement test scores.

3. There was evidence of a deficit in one of the following areas: attention, memory, reasoning, coordination, communicating, reading, writing, spelling, calculation, social competence, or emotional maturation.
4. The learning disability was not due primarily to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or environmental disadvantage, although it may occur concurrently with any of these.

The first three criteria were used in the forming of the LD groups as described in the preceding two paragraphs. Number four of the definition was applied by excluding any children suspected of having other debilitating handicaps and psychological reports in each of the clients' files revealed this information.

Control and LD subjects were usually administered one achievement test, but in the few cases where two achievement scores were available, the mean achievement score was calculated. The following achievement tests were used for determining the aptitude/achievement discrepancy: WRAT-R Reading, Spelling, and Arithmetic subtests; WIAT Basic Reading, Mathematics Reasoning, and Spelling subtests; and the QUIET Word Identification, Arithmetic, and Spelling subtests.

Instrumentation

The Wechsler Intelligence Scale for Children-III (WISC-III), and an achievement test, either the Canada QUIET, WRAT-R, or WIAT, were administered to the subjects in the Control and LD groups. Standard scores (M = 100 and SD = 15) were used from all of the tests included in the study.

Wechsler Intelligence Scale for Children-Third Edition (WISC-III)

The WISC-III, for children aged 6 through 16 years, contains 13 subtests, 6 in the Verbal Scale and 7 in the Performance Scale. There are 5 subtests in each scale designated as standard subtests. In the Verbal Scale, they are Information, Similarities, Arithmetic, Vocabulary, and Comprehension while in the Performance Scale they are Picture Completion, Coding, Picture Arrangement, Block Design, and Object Assembly. Used as supplementary tests, the remaining three subtests are Digit Span in the Verbal Scale and Symbol Search and Mazes in the Performance Scale. The standardization of the test was excellent using a total sample of 2200 children with 100 boys and 100 girls in each of the 11 age groups from 6 through 16 years.

Reliability. The WISC-III has adequate reliability with reliability coefficients for ages 6 to 16 ranging from .94 to .97 for the Full Scale IQ, .92 to .96 for the Verbal Scale IQ, and .89 to .94 for the Performance Scale IQ (Sattler, 1992). The subtests' internal consistency reliabilities are lower than those for the three main scales. The average verbal subtest reliability coefficients for all 11 age groups range from a low of .77 for Comprehension to a high of .87 for Vocabulary while the Performance coefficients ranged from a low of .69 for Object Assembly to a high of .79 for Coding. Test-retest reliability coefficients for three age groups (6-7, 10-11, 14-15) were reported in the manual. The stability coefficients were, respectively, .92, .95, and .94 for the Full Scale IQ; .90, .94 and .94 for the Verbal Scale IQ ; and .86, .88, and .87 for the Performance Scale IQ.

Validity. Because of the WISC-III's newer publication, the extent of validity studies is limited to what is published in the manual. Wechsler (1991) cited numerous factor analysis studies on the WISC-R that provided evidence of the global intelligence construct "g" and the Verbal-Performance dichotomy. In addition, Wechsler (1991) maintained the Freedom From Distractibility (FD) factor composed of the Arithmetic and Coding subtests is present in many types of samples for the WISC-R. Sattler (1992) performed his own factor analysis of the WISC-III standardization sample and found strong empirical support for the measure of "g" and the Verbal-Performance dichotomy. However, Sattler (1992) questioned the four-factor model citing the fourth factor did not emerge in 4 of the 11 age groups during a maximum-likelihood and a principals component analysis. Because of the weakness of the FD factor, Sattler cautioned against interpreting it until further research confirms or refutes his findings.

Criterion validity studies cited in the manual reported correlations between the WISC-III Full Scale and WRAT-R subtests as follows; Reading .53, Spelling .28, and Arithmetic .58. With group administered achievement tests, the correlations were in the high .50s and .60s.

Intercorrelations between the WISC-III subtests revealed that Verbal subtests correlated more highly with each other (Mdn r=.55) than did the Performance Scale subtests (Mdn r=.33) possibly indicating the Verbal subtests have more in common with each other than do the Performance subtests. Average correlations between the 13 subtests and the Full Scale ranged from .31 to .74 (Mdn r=.58). The five standard Verbal subtests and Block Design correlated more highly with the Full Scale IQ than the others did. Vocabulary had the highest correlation with Verbal Scale (.78) Block Design had the highest correlation with the Performance Scale.

The Canada QUick Individual Educational Test (Canada QUIET)

The Canada QUick Individual Educational Test (Canada QUIET) was developed at the University of British Columbia and released in 1991 as a individually administered screening instrument for assessing, comparing, and classifying the academic skills of English speaking pupils in grades 1 to 12. The four subtests are Spelling (ability to spell dictated words from Canadian curriculum material); Arithmetic (ability to understand concept and math calculation skills taught from Kindergarten to grade 12); Word Identification (ability to recognize and name letters and words out of context); and Passage Comprehension (ability to read a cloze passage and insert an appropriate missing word). Only two subtests, Word Identification and Arithmetic, are administered at the grade one level.

Reliability and Validity. The test was normed in 1989 on a random sample of 1600 pupils with approximately 100 students in each of the grades 1 to 12 stratified by province, excluding Quebec, then by school site, district size, and gender. The manual (1991) reported the following mean internal consistent reliabilities for the four subtests from grades two to twelve: Spelling r=.89, Arithmetic r=.84, Word Identification r=.94, and Passage Comprehension r=.84. Content validity was based on test item selection from relevant Canadian teaching materials and empirical item analysis. There was a noticeable lack of construct and concurrent validity studies in the Technical Report. Raw scores are converted to percentiles and then to standard scores. Wormeli and Carter (1991, p. 156) provided the following classification index for standard scores.

Standard Score		Classification
- 75	=	well below average
76 - 85	=	below average
86 - 95	=	low average
96 - 105	=	average
106 - 115	=	above average
116 - 125 -	=	well above average
126 -	=	superior

Wide Range Achievement Test-Revised

The WRAT-R is a revision of the WRAT completed in 1984. Covering an age range from 5-0 to 74-11, the WRAT-R is a brief, individually administered screening instrument used to evaluate children's' achievement levels with the following three subtests: Reading (naming letters and naming words out of context); Spelling (copying marks, writing one's name, write single words);and Arithmetic (counting, reading numbers, solving oral problems, and written computation). Level I is for ages 5-0 to 11-11 and Level II covers the ages 12-0 to 74-11.

Reliability and Validity. The test manual (Jastak & Wilkinson, 1984) reported test-retest coefficients for the Level I Reading, Spelling, and Arithmetic subtests to be .96, .97, and .94 respectively while Level II coefficients were lower, .90, .89, and .79, respectively. Concurrent validity cited in the manual for the WRAT indicate correlations in the .60s to .80s when compared to the Peabody Individual Achievement Test, California Achievement Test, and Stanford Achievement Test. Validity studies for the WRAT-R were not provided in the revised manual. Raw scores are converted into percentiles, standard scores, and grade equivalents. According to the manual (Jastak & Wilkinson, 1984, p. 29.), standard score ratings included the following classifi.ations:

Classification	Score Range
Very Superior	130 and up
Superior	120 to 139
High Average	110 to 119
Average	90 to 110
Low Average	80 to 89
Borderline	70 to 79
Deficient	69 and below

Wechsler Individual Achievement Test

The WIAT, released in 1992, is an individually administered battery of eight subtests for assessing the achievement of children in grades K through 12 and aged 5-0 to 19-11. Three of the subtests - Basic Reading, Mathematics Reasoning, and Spelling - can be used as a brief screening instrument. A Total Composite score can be calculated from all eight subtests, plus, Reading, Mathematics, Language, and Writing Composite scores are available depending on which of the eight subtests are administered. In addition, scores are available for individual subtests. The Basic Screening tests were used for the study and measure the following skills: Basic Reading (assesses decoding and single word reading ability); Mathematics Reasoning (assesses problem-solving ability); and Spelling (assesses encoding and spelling of letters and words).

Reliability and Validity. Wechsler (1991) reported test-retest coefficients ranging from .81 to .92 for individual subtests and .90 to .97 for Composite scores. Adequate validity studies were reported in the manual. Content-related evidence was established through expert judgment and empirical item analysis. Construct-related evidence was demonstrated by comparing the WIAT to a number of individually and group administered achievement tests. Correlations between the WIAT and Basic Achievement Skills Individual Screener, Kaufman Test of Educational Achievement, Wide Range Achievement Test-Revised, Woodcock-Johnson Tests of Achievement, and Differential Ability Scales ranged from .42 to .88. The Basic Reading subtest scores correlated from .79 to .87

(median = .82) across the corresponding subtests in the five individual achievement just listed. Using a predicted achievement method (Wechsler, 1991), a sample of 48 learning disabled children demonstrated two or more significant composite score discrepancies in 58.3% of the cases. The manual claims that predicted-actual score discrepancies are effective in identifying children with learning problems.

Subtest raw scores are converted into percentiles, standard scores, age equivalents, and grade equivalents. According to the manual (Wechsler , 1991), standard score ratings included the following classifications:

Classification	Score Range
Very Superior	130 and up
Superior	120 to 139
High Average	110 to 119
Average	90 to 110
Low Average	80 to 89
Borderline	70 to 79
Deficient	69 and below

Rationale for Achievement Test Selection

Because data was extracted from pre-existing protocols in the Clinic files, test selection was controlled by the student clinicians' choice of instruments at the time of assessment. Even though at least seven different achievement tests are administered in the Clinic, only the WRAT-R, Canada QUIET, and WIAT were given a sufficient number of times to warrant data collection. For comparison across achievement tests, only the reading, arithmetic, and spelling subtest standard scores from the WRAT-R, Canada QUIET, and WIAT were recorded. The reading comprehension test from the Canada QUIET and WIAT were excluded because the WRAT-R does not measure this reading skill. The WIAT Listening Comprehension, Oral Expression, and Written Expression subtests were not used because the WRAT-R and Canada QUIET lack similar subtests.

The WIAT Numerical Operations subtest rather than the Mathematics Reasoning subtest more closely resembles the Arithmetic subtests from the WRAT-R and Canada QUIET because it measures mathematics computation in isolation from problems. Even though the Mathematics Reasoning subtest measures computational skills in the context of problem-solving, it was used as the WIAT math score because of far more frequent administrations as part of the WIAT Basic Screener. See Chapter Five for a more detailed discussion of the differences between the two WIAT math subtests and possible implications for the data analysis.

Analysis of the Data

Frequencies and summary statistics were generated for the entire clinic sample of 338 subjects in terms of age, grade, gender, WISC-III scores, and achievement test scores to determine if the clinic sample resembled a general population. This information is included in Appendix A, Tables 1 and 2.

Frequencies and summary statistics for the Control and four LD groups are shown in chapter four. Table 4.8 includes the means and standard deviations of the reading, math, and spelling scores for each of the groups. Appendix C, Tables 7 to 11 display the means and standard deviations of the WRAT-R, WIAT, and Canada QUIET scores of all the groups. WISC-III means and standard deviations for the scores of the Control and four LD groups are shown in Tables 4.12 to 4.13. IQ, Index, and subtest mean scores for each group were evaluated individually to obtain group profiles of high and low scores and are represented by line graphs in Figures 4.1 to 4.10.

Because no information existed about the Canada QUIET's relationship to measures of intelligence, a sample of 104 cases was non-randomly selected from the entire clinic population (n = 338). Pearson Product Moment correlations were calculated to determine the relationship between the QUIET subtests and WISC-III IQ and Index scores. Appendix B, Tables 3 to 6 report the summary statistics and correlations. It was expected the correlation coefficients would approximate the correlations reported for the WRAT-R, WIAT, and WISC-III.

Pearson Product Moment correlations were calculated to determine the relationship between the WISC-III IQ, Index scores, and individual subtests for the Control group.

Tables 4.2 to 4.3 include this information. A comparison of the control group subtest intercorrelations was made to the results reported in the manual to establish internal validity for the control. Correlations were calculated to determine the WISC-III's relationship with the reading, math, and spelling achievement scores in each of the LD groups and the control. Tables 4.4 to 4.7 contain the correlation results.

Oneway analysis of variance (ANOVA) was used to determine if differences existed between the Control and LD groups on the mean WISC-III, WRAT-R, WIAT, and QUIET scores. Appendix D, Tables 12 to 34 report these results and Tables 35 to 57 report Scheffé significant differences. One way ANOVAs on WISC-III scores in each group were also conducted to search for significant differences within groups. Appendix E, Tables 58 to 64 report these results. The Scheffé test, a post hoc comparison test, was chosen over the Tukey because group sizes were not equal in this study. Although the Scheffé test is probably one of the most conservative of the multiple comparison tests it is the least likely to make a Type 1 error (Moore, 1983). It also requires larger differences between means for significance than most of the other post hoc tests.

CHAPTER 4

RESULTS

Introduction

The chapter begins with the descriptive statistics of the clinic population from which the research groups were created and the representativeness of the control group used in the study. The results of the study are then presented in two main sections that correspond to the research questions formulated at the end of Chapter Two. The intent of the questions was to focus on the convergent validity of the WISC-III, WRAT-R, WIAT, and QUIET for non LD and LD populations, and to explore the discriminative validity of the WISC-III among four types of LD populations.

Clinic Population Characteristics

The LD and control groups were created from a clinic referral population of 338 subjects. The distribution of this clinic population by age, gender, and grade is shown in Appendix A, Table I. The summary statistics of mean, standard deviation, range, kurtosis, and skewness for the WISC-III, WRAT-R, WIAT, and Canada QUIET scores are listed in Appendix A, Table II. The FSIQ, VIQ, and PIQ (99.3, 98.3, and 100.4 respectively) of the clinic population were similar to the mean of 100 reported in the WISC-III Manual. Although the VC and PO Index scores were similar to the WISC-III standardization sample, the FD and PS Index scores were lower (96.1 and 96.5). The achievement test mean scores deviated considerably more from the mean of 100 with differences ranging from two to fourteen standard score points. Lower achievement scores were expected because a majority of the University of Alberta Education Clinic referrals were for learning problems.

Comparison of Control Group and WISC-III Sample

The representativeness of the control sample used in the study was established by comparing it to a similar aged sample (age 10-11) of 119 children reported in the WISC-III Manual. Table 4.1 displays the mean and standard deviations of the IQ and Index scores for the two groups. The mean age of the control was 10.4 years with 30% females and 70% males while the Manual sample consisted of 48% females and 52% males. The control group subtest scores were one to two points lower but demonstrated minimal variability like the standardization sample. Even though the control represented a clinic sample, it appeared appropriate for comparison with the LD groups in this study.

TABLE 4.1

Comparison of WISC-III Scores Between Standardization and Control Samples

	WISC-III (n = 119)		Control (n = 87)	
Scale	Mean	SD	Mean	SD
Full Scale IQ	99.6	13.1	97.5	7.3
Verbal IQ	100.3	13.7	98.8	9.6
Performance IQ	99.0	13.1	97.0	8.8
Verbal Comp. Index	101.0	14.2	99.3	10.1
Perceptual Org. Index	100.1	12.9	98.4	9.7
Freedom-Distract. Index	100.3	12.5	98.4	10.4
Processing Speed Index	98.8	13.9	96.8	13.4

The Convergent Validity of the WISC-III with the WRAT-R, WIAT, and Canada QUIET

Research Question 1

What are the correlations between the WISC-III FSIQ, VIQ, PIQ, and subtest scores in the control group?

The subtest intercorrelations in the control group were examined to determine if the verbal subtests generally correlated more highly with each other than with Performance subtests, and if the Performance subtests generally correlated more highly with each other than Verbal subtests as reported in the WISC-III internal validity studies (Wechsler, 1991). The LD groups were omitted because of small sample sizes. Table 4.2 contains the Pearson Product Moment correlations between the Control group subtest scores. Table 4.3 displays the uncorrected Pearson Product Moment correlations for the subtests and scales. Some of these correlations were inflated because the two correlated scales have subtests in common (e.g., Performance with Full Scale).

TABLE 4.2

WISC-III Subtest Intercorrelations for Control Group (n = 87)

Subtest	I	S	A	V	C	DS	PC	Cd	PA	BD	OA	SS
S	.36c											
A	.29b	.29b										
V	.46c	.36c	.17									
C	.14	.39c	.04	.39c								
DS	.18	.16	.17	.04	.11							
PC	.25a	.18	-.00	.25a	.02	.13						
Cd	.01	.04	-.03	-.17	.01	.14	-.15					
PA	.02	.01	.06	.12	-.04	.06	.22a	-.05				
BD	.15	.09	.14	-.30	-.07	.36b	.25a	.16	.03			
OA	-.03	-.01	.02	-.07	-.23	.10	.22a	-.20	.24a	.22a		
SS	.09	.09	.16	-.06	-.07	-.05	.07	.48c	.11	.23a	.03	
Mz	.09	-.04	.17	-.01	-.04	.29b	.07	.12	.07	.26a	.15	.22a

[a] Significant at .05 level [b] Significant at .01 [c] Significant at .001
I-Information, S-Similarities, A-Arithmetic, V-Vocabulary, C-Comprehension, DS-Digit Span, PC-Picture Completion, Cd-Coding, PA-Picture Arrangement, BD-Block Design, OA-Object Assembly, SS-Symbol Search, MZ-Mazes

TABLE 4.3

WISC-III Scales and Subtest Intercorrelations for Control Group (n = 87)

Subtest	I	S	A	V	C	DS	PC	Cd	PA	BD	OA	SS	Mz
FSIQ	.59c	.62c	.42c	.57c	.40c	.33b	.49c	.17	.38c	.45c	.26a	.28b	.20
VIQ	.67c	.73c	.51c	.73c	.63c	.19	.20	-.05	.05	.08	-.09	.05	.04
PIQ	.13	.11	.07	.03	-.13	.31b	.52c	.33b	.56c	.64c	.54c	.39c	.28b

[a] Significant at .05 level [b] Significant at .01 [c] Significant at .001
I-Information, S-Similarities, A-Arithmetic, V-Vocabulary, C-Comprehension, DS-Digit Span, PC-Picture Completion, Cd-Coding, PA-Picture Arrangement, BD-Block Design, OA-Object Assembly, SS-Symbol Search, MZ-Mazes

Higher correlations which were present in the verbal subtests ranged from .04 to .47, Mdn r = .17. Information, Comprehension, and Vocabulary were moderately correlated with coefficients in the 30s and 40s. Coefficients in Performance subtests ranged from -.20 to .48, Mdn r = .07. Weak correlations, .21 to .24, existed between Picture Completion Picture Arrangement, and Object Assembly while the strongest correlation was between Symbol Search and Coding, r = .48.

The intercorrelations between subtests and scales corresponded closely with the correlations cited in the Manual. Similarities had the highest correlation with the FSIQ (.62), followed by Vocabulary (.57), Information (.59), Picture Completion (.49), Block Design (.45), Arithmetic (.42), Comprehension (.40), Picture Arrangement (.38), Digit Span (.33), Symbol Search (.28), Object Assembly (.26), Mazes (.20), and Coding (.17). Vocabulary had the highest correlation with the Verbal Scale and Block Design had the highest correlation with the Performance Scale which corresponded to the reported Manual correlations.

Research Question 2

What are the correlations between the WISC-III FSIQ, VIQ, PIQs and the WRAT-R, WIAT, and QUIET subtest scores?

Because the QUIET technical manual did not provide evidence of criterion-related validity with measures of intelligence, Pearson Product Moment Correlations were calculated for all of the QUIET scores in the clinic population (n = 104) to compare with the WISC-III, WRAT-R, and WIAT correlations reported in the literature and test manuals. The distribution of the sample by age, gender, and grade; the mean WISC-III IQ and Index scores; mean QUIET subtest scores; and correlation coefficients are listed in Appendix B, Tables 3 to 6. The QUIET had similar correlations with the WISC-III scores when compared to the WRAT-R and WIAT and therefore was included in the study.

Table 4.4 reports the Pearson Product Moment Correlations between WISC-III and achievement scores for the control group. The FSIQ had moderate to strong correlations,

.49 to .62, with all three achievement subtests except the QUIET reading test and it also had higher correlations with reading and spelling scores compared to the math scores. The VIQ also demonstrated moderate to strong correlations, .39 to .42, with all subtests except the QUIET math test and was more consistently correlated with the reading and spelling scores. The PIQ did not significantly correlate with either the reading or spelling scores but had moderate correlations with the WRAT-R and QUIET math scores, .35 and .42 respectively. These results are very consistent with the WRAT-R and WISC-III correlations for a learning disability sample (n = 23) reported in the WISC-III manual. Correlation coefficients were not calculated for the LD groups' WISC-III IQs, WRAT-R, WIAT, and QUIET scores because of an inadequate number of cases, sample sizes ranged from six to twelve.

TABLE 4.4

Control Group Correlations of WISC-III IQs, WRAT-R, WIAT, and QUIET Scores

	WRAT-R	WIAT	QUIET
Reading Scores			
IQ Scores			
Full Scale IQ	.59**	.62**	.33
Verbal IQ	.43*	.66**	.41*
Performance IQ	.32	.13	.15
Math Scores			
IQ Scores			
Full Scale IQ	.61**	.61**	.46*
Verbal IQ	.41*	.61**	.35
Performance IQ	.35*	.17	.42*
Spelling Scores			
IQ Scores			
Full Scale IQ	.49**	.50**	.40*
Verbal IQ	.39*	.61**	.51*
Performance IQ	.24	-.00	.18
* Significant at .05 ** Significant at .01	n = 33	n = 30	n = 24

To examine the relationship between the LD groups' achievement and WISC-III IQ scores, the WRAT-R, WIAT, and QUIET scores were combined to create three new variables-Reading, Spelling, and Math scores for each LD group because insufficient cases were available for calculating correlations for each of the three individual achievement tests, e.g. Reading Scores represent scores from either the WRAT-R, WIAT, or QUIET depending what test was administered to the subject. The Pearson Product Moment correlations of the achievement and IQ scores are recorded in Table 4.5. The FSIQ scores demonstrated stronger correlations with the reading, math, and spelling scores than the VIQ and PIQs. Across the LD groups, the VIQ showed a larger number of correlations with achievement scores than the PIQ scores, possibly indicating the verbal scale has more in common with the achievement measures. The PIQ displayed moderate to strong correlations with achievement scores in three of the four LD groups which differed from the control group PIQ coefficients. It would appear that the non-verbal Performance scale is a more significant factor in the LD samples than the control.

TABLE 4.5

WISC-III IQ and Achievement Test Score Correlations for LD Groups

Achievement Scores[a]	Reading	Math	Spelling
Reading LD			
IQ Scores			
Full Scale IQ	.71**	.64**	.41*
Verbal IQ	.65**	.53**	.34
Performance IQ	.36	.42*	.26
	n = 26	n = 27	n = 26
Math LD			
Full Scale IQ	.70**	.83**	.33
Verbal IQ	.65**	.74**	.43*
Performance IQ	.46*	.61**	.09
	n = 23	n = 23	n = 23
Spelling LD			
Full Scale IQ	.77**	.43*	.75**
Verbal IQ	.47*	.53**	.54**
Performance IQ	.52**	.02	.46*
	n = 25	n = 25	n = 26
Combined LD			
Full Scale IQ	.70**	.76**	.63**
Verbal IQ	.50*	.49*	.39
Performance IQ	.48*	.56**	.49*
	n = 25	n = 25	n = 25

* Significant at .05
** Significant at .01
[a] Achievement scores are from either the WRAT-R, WIAT, or Canada QUIET

Research Question 3

What are the correlations between the WISC-III four index scores (Verbal Comprehension, Perceptual Organization, Freedom from Distractibility, Processing Speed) and the WRAT-R, WIAT, and QUIET subtest scores?

Table 4.6 displays the Pearson Product Moment Correlations for the control group's WISC-III and WRAT-R, WIAT, and QUIET scores. The LD groups' correlations for their WISC-III and achievement scores are arranged in Table 4.7. In the control group, the Verbal Comprehension (VC) Index had the highest and largest number of correlations with achievement scores while the Perceptual Organization (PO) Index showed no significant correlations. Higher VC correlations were expected since both VC and PO Indexes are derived from the Verbal and Performance Scales and the Verbal Scale was more closely correlated to the achievement tests than the Performance Scale. The Freedom From Distractibility (FD) Index correlated only with the WRAT-R reading, math and the WIAT math scores. The Processing Speed (PS) Index did not significantly correlate with any of the achievement tests.

The correlations in each LD group are discussed individually since there was considerable variability in the correlations between groups. The RLD group demonstrated the least number of significant correlations with only the VC Index correlated with the Reading and Spelling scores and the PS Index with the math scores. The VC, PO, and FD Indexes in the MLD group had strong correlations with the math scores and in the SLD group the same three indexes correlated with the spelling scores. In the CSLD group, the PO and FD Indexes had moderate correlations with all three reading, math, and spelling achievement scores. This revealed a common trend in the MLD, SLD, and CSLD groups where the PO and FD Indexes significantly correlated with the groups' respective below average achievement scores.

TABLE 4.6

Control Group Correlations Between WISC-III Index, WRAT-R, WIAT, and QUIET Scores

	Reading Scores		
	WRAT-R	WIAT	QUIET
Index Scores			
Verbal Comprehension	.40*	.66**	.40*
Perceptual Organization	.30	.09	.15
Freedom From Distractibility	.55**	.25	.33
Processing Speed	.00	.18	.39
	Math Scores		
Index Scores			
Verbal Comprehension	.27	.56**	.25
Perceptual Organization	.21	.20	.38
Freedom From Distractibility	.56**	.47**	.38
Processing Speed	.30	-.02	.39
	Spelling Scores		
Index Scores			
Verbal Comprehension	.38*	.61**	.52*
Perceptual Organization	.06	-.03	.14
Freedom From Distractibility	.33	.20	.31
Processing Speed	.32	.32	.20
	n = 33	n = 30	n = 24

* Significant at .05
** Significant at .01

TABLE 4.7

LD Group Correlations Between WISC-III Index and Achievement Test Scores

Reading LD			
Achievement Scores[a]	Reading	Math	Spelling
Index Scores			
Verbal Comprehension	.66**	.37	.39*
Perceptual Organization	.37	.26	.18
Freedom From Distractibility	.34	.43	.19
Processing Speed	.27	.55**	.29
	n = 26	n = 27	n = 26

Math LD			
Verbal Comprehension	.68**	.69**	.48*
Perceptual Organization	.47*	.57**	.04
Freedom From Distractibility	.37	.60**	.23
Processing Speed	.20	.22	.27
	n = 23	n = 23	n = 23

Spelling LD			
Verbal Comprehension	.37	.47*	.39*
Perceptual Organization	.57**	.05	.49*
Freedom From Distractibility	.57**	.34	.59*
Processing Speed	.04	-.01	.11
	n = 25	n = 25	n = 26

Combined LD			
Achievement Scores[a]	Reading	Math	Spelling
Index Scores			
Verbal Comprehension	.33	.24	.16
Perceptual Organization	.44*	.58**	.45*
Freedom From Distractibility	.58**	.43*	.45*
Processing Speed	.31	.24	.27
	n = 25	n = 25	n = 25

* Significant at .05
** Significant at .01
[a] Achievement scores are from either the WRAT-R, WIAT, or QUIET

Conclusions about Convergent Validity

The convergent validity of the WISC-III was confirmed through examination of the test's intercorrelations in a control sample that approximated a standardization sample reported in the WISC-III Manual. Verbal and Performance subtests correlated more strongly with their respective scales lending support to the verbal/non-verbal factors of the test. Convergent validity with the WRAT-R, WIAT, and QUIET was evident in correlations with the WISC-III IQ and index scores in the control and LD groups. In the control group, the FSIQ and VIQ showed stronger correlations with reading, spelling ,and math scores while the PIQ correlated only with math scores. In the LD groups, however, the FSIQ, VIQ, and PIQ all displayed significant correlations with achievement scores. Moderate correlations of the FD Index were evident in the MLD, SLD, and CSLD groups whereas the FD factor showed fewer significant correlations with achievement scores in the control group. Therefore, FD correlations in the LD groups' may suggest some cognitive processing differences from the control group.

The Discriminative Ability of the WISC-III, WRAT-R, WIAT, and Canada QUIET for Identifying Learning Disabilities

Research Question 4

Are there significant differences in the mean achievement test scores when each of the LD groups are compared to the control group?

As discussed earlier in the chapter, three different achievement tests were used in the study for each group. It was not possible to statistically compare each group on each individual achievement test because of inadequate cases, therefore, the three tests were treated as one to form three new test variables - reading; math; and spelling achievement scores.

Means and standard deviations for the reading, math, and spelling scores in the control and LD groups are reported in Tables 4.8. The means and standard deviations of the specific WRAT-R, WIAT, and QUIET scores by group are provided in Appendix C, Tables 7 to 11. In order to determine whether scores were significantly different for the five groups, a oneway analysis of variance (ANOVA) was performed on each of the achievement score variables. When significant Fs were obtained in the ANOVAs, Scheffé post hoc comparisons were conducted with the .05 level of significance as the criterion for all tests. Oneway ANOVA results are found in Appendix D, Tables 32 to 34, and the Scheffé post hoc significant differences between the five groups for the achievement scores are recorded in Appendix D, Tables 55 to 57. ANOVA results must be interpreted with caution because the distribution of scores in the LD groups and control were slightly negatively or positively skewed.

TABLE 4.8

Mean Achievement Scores for Control and LD Groups

	Achievement Scores*								
	Reading			Math			Spelling		
Group	Mean	SD	n	Mean	SD	n	Mean	SD	n
Control	100.2	11.2	87	96.7	10.2	87	98.0	11.6	87
RLD	79.2	8.0	27	98.5	12.2	26a	79.8	9.7	26b
MLD	99.8	10.9	23	80.7	7.4	23	92.0	13.6	23
SLD	94.1	11.0	25c	95.2	8.8	25c	80.0	7.5	26
CSLD	75.1	13.4	25	81.9	9.3	25	74.9	9.7	25

* Includes scores from the WRAT-R, WIAT, or QUIET
[a] One subject not administered WRAT-R Arithmetic subtest [b] One subject not administered Canada QUIET Spelling subtest [c] One subject not administered WRAT-R Reading & Arithmetic subtests

The results indicated the achievement scores differentiated the reading, math, spelling, and combined subjects learning disabled groups. The SLD group had significantly lower spelling scores and the MLD group had lower scores in math and spelling. The RLD group had lower scores in both reading and spelling because children with discrepancies between FSIQ and reading/spelling scores were included. The CSLD group demonstrated lower scores in all three achievement scores. In comparison, the control group showed little variation between scores. These differences were expected because of a discrepancy between aptitude and achievement formed the basis of the groups, however, the difference between the LD and control groups is as large as 20 to 25 points in some cases. This would indicate that something more than the 15 point discrepancy formula is causing the differences.

Research Question 5

Are there significant differences in the WISC-III IQ (FSIQ, VIQ, PIQ), Index (Verbal Comprehension, Perceptual Organization, Freedom from Distractibility, and Processing Speed) and subtest mean scores when the LD groups are compared to the control?

The WISC-III IQ, Index, and subtest means and standard deviations by group are listed in Tables 4.12 and 4.13 and Figures 4.1 to 4.5 display the mean IQ scores by group in line graphs . Oneway ANOVAs were performed on each of the WISC-III score variables and Scheffé post hoc comparisons were conducted when significant Fs were obtained. Oneway ANOVA results and Scheffé post hoc significant differences between the five groups for the WISC-III scores are recorded in Appendix D, Tables 12 to 32 and Tables 35 to 54. ANOVA results must be interpreted with caution because the distribution of scores in the LD groups and control was slightly negatively or positively skewed.

IQ and Index Scores. Two of the three WISC-III IQ scores were significantly different between groups, the FSIQ ($F = 4.2056$, $p<.01$) and the PIQ ($F = 9.215$, $p<.001$). The RLD and the CSLD groups' FSIQ score was higher than the control and the SLD, RLD, and CSLD all had significantly higher PIQs than the control. The same three LD groups also exhibited higher PO Index scores than the control group ($F = 11.987$, $p<.001$) which would be anticipated because the PO Index is comprised of four subtests from the Performance Scale.

Subtests Scores. Of the 13 subtests, only four were significantly different between groups. In Comprehension, the CSLD group's score was significantly higher than the SLD group ($F = 3.240$, $p<.05$) but was not significantly different from the control group. With Picture Completion, the RLD, SLD, and CSLD groups had significantly higher scores than the control ($F = 7.950$, $p<.001$). In Picture Arrangement, the RLD and CSLD groups scored higher than the control ($F = 5.934$, $p<.001$). Finally, the RLD group score was significantly higher than the control group in Object Assembly ($F = 4.956$, $p<.001$).

The LD groups did not demonstrate any significantly lower WISC-III scores compared to the control group. By using a more liberal post hoc comparison, the Tukey-HSD test, only one additional score became significant and that was the Digit Span subtest, F = 27.125, p<.05. The CSLD group score was significantly lower than the control group.

TABLE 4.9

WISC-III Mean IQ and Index Scores for Control and LD Groups

	Reading LD		Math LD		Spelling LD		Combined LD		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
IQ Scores										
FSIQ	102.2	7.5	100.6	8.3	100.5	5.7	103.0	8.0	97.5	7.3
VIQ	97.8	9.5	100.2	8.3	97.8	7.4	100.7	9.0	98.8	9.6
PIQ	107.4	9.5	101.7	9.9	104.1	7.8	105.5	12.2	97.0	8.7
Index Scores										
VC	97.4	10.2	102.1	8.9	98.3	7.1	102.4	10.0	99.3	10.1
PO	109.8	9.0	103.8	10.6	108.6	9.7	109.3	12.2	98.4	9.7
FD	96.1	9.9	98.0	9.1	96.0	10.1	92.6	9.8	98.4	10.4
PS	97.7	10.7	94.6	12.8	93.5	12.4	93.4	12.4	96.8	13.4*
Total	n = 27		n = 23		n = 26		n = 25		n = 87	

* One subject Missing Processing Speed Index mean score

TABLE 4.15

WISC-III Mean Subtest Scores for Control and LD Groups

	Reading LD		Math LD		Spelling LD		CombinedLD		Control	
Subtest	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Information	9.3	2.3	9.3	2.7	9.0	2.1	8.9	2.6	9.7	2.4
Similarities	9.3	3.0	11.1	2.2	10.2	2.5	10.3	2.7	10.0	2.7
Arithmetic	10.1	2.7	8.6	2.0	9.1	2.4	9.2	2.6	9.5	2.3
Vocubulary	8.8	2.3	10.1	2.6	10.2	1.7	10.1	2.2	9.5	2.5
Comprehension	10.4	2.4	10.8	2.6	9.3	2.0	11.8	3.0	10.1	2.8
Digit Span	8.1	2.5	10.3	2.4	8.8	2.5	8.0	1.8	9.6	2.7
Picture Completion	12.3	2.3	10.9	2.5	12.6	2.3	12.7	2.8	10.5	2.2
Coding	9.3	3.4	8.8	3.0	7.5	2.5	8.1	3.6	8.8	3.2
Picture Arrangement	11.6	3.0	10.7	3.3	11.6	3.4	12.1	3.2	9.4	2.9
Block Design	11.2	2.8	9.7	3.5	10.5	2.6	10.2	3.4	9.5	2.7
Object Assembly	11.0	2.0	10.3	2.4	10.6	2.3	10.8	3.4	9.1	2.4
Symbol Search	9.0	2.9	8.7	2.6	9.5	2.7	9.0	1.9	9.7	3.0
Mazes	9.7	2.9	10.4	4.0	10.4	2.9	11.0	2.9	10.4	3.6
Total	n = 27		n = 23		n = 26		n = 25		n = 87	

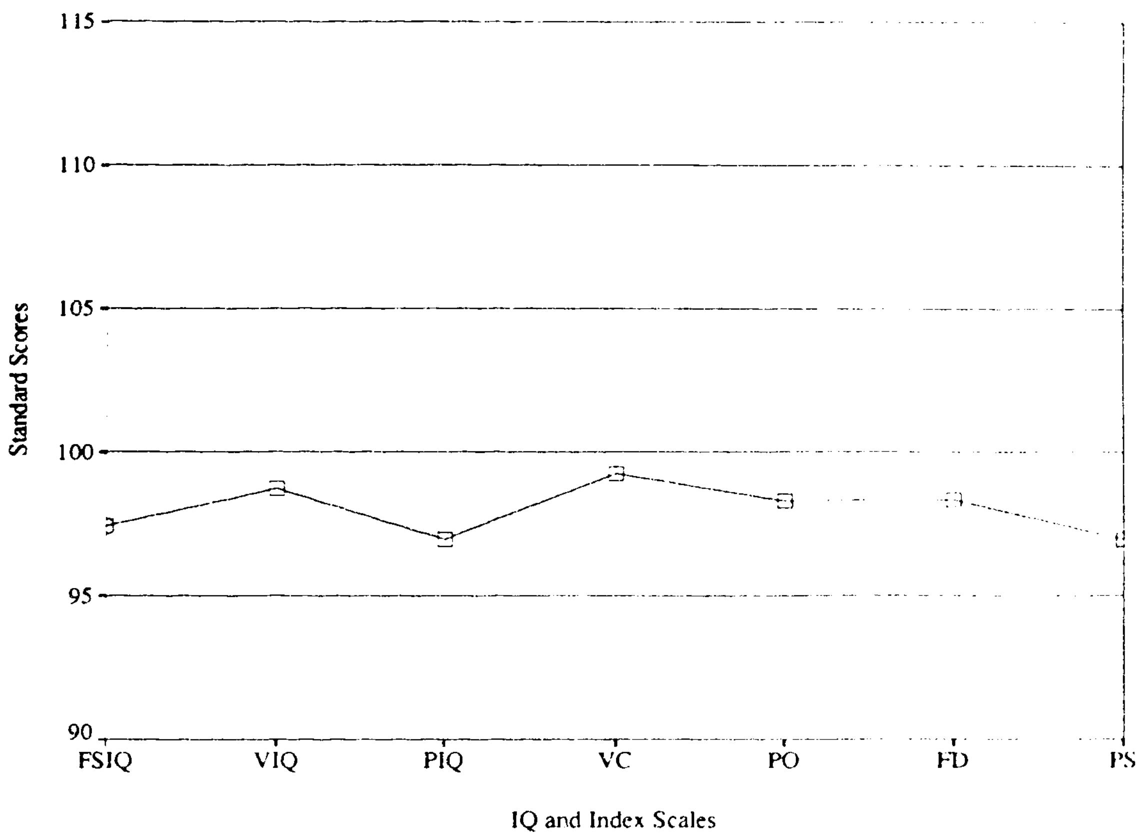

FIGURE 4.1

Control Group WISC-III Profile

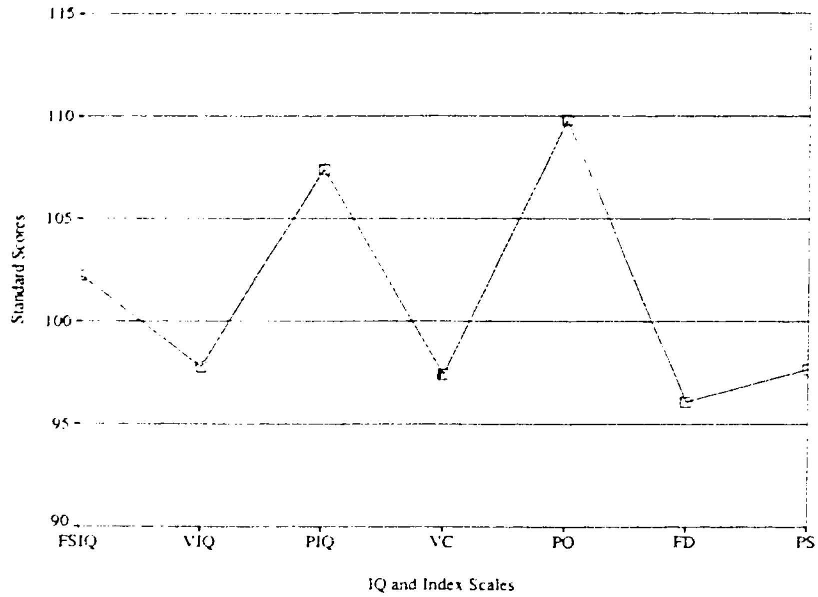

FIGURE 4.2

Reading LD Group WISC-III Profile

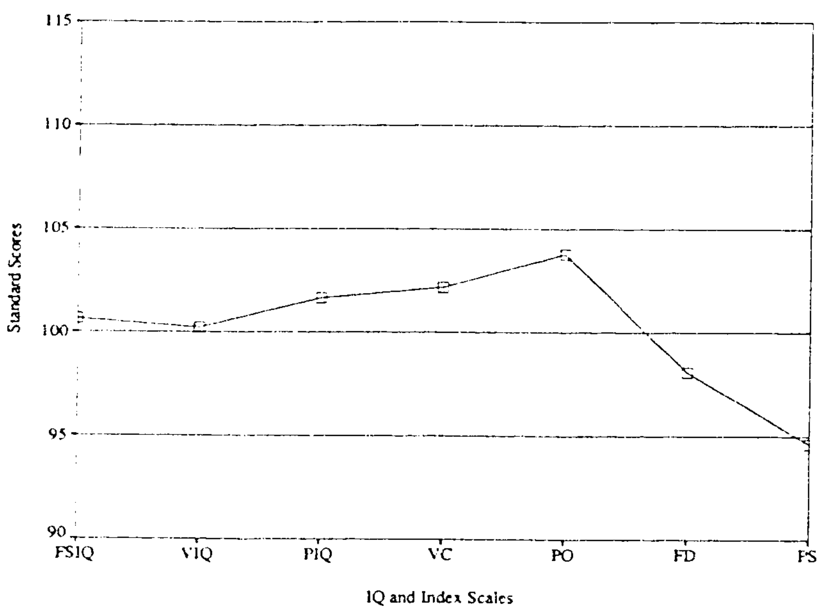

FIGURE 4.3

Math LD Group WISC-III Profile

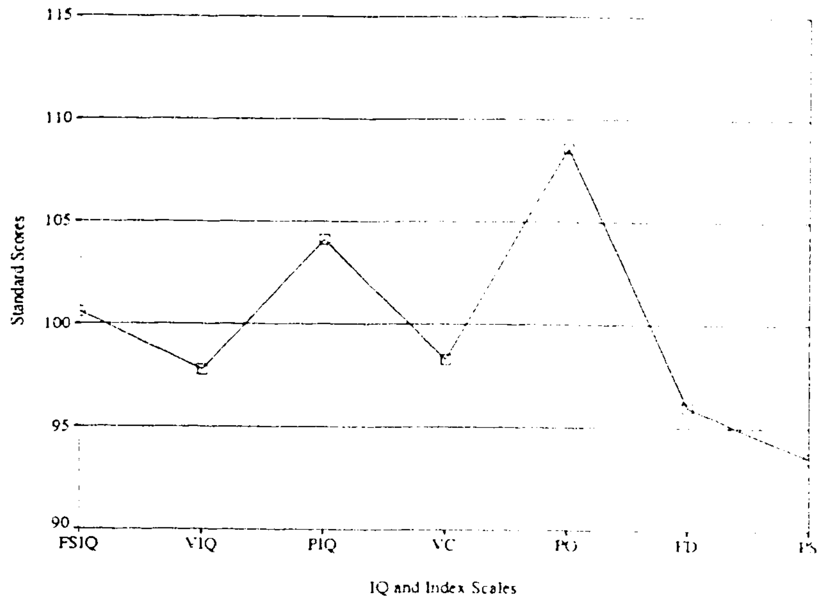

FIGURE 4.4

Spelling LD Group WISC-III Profile

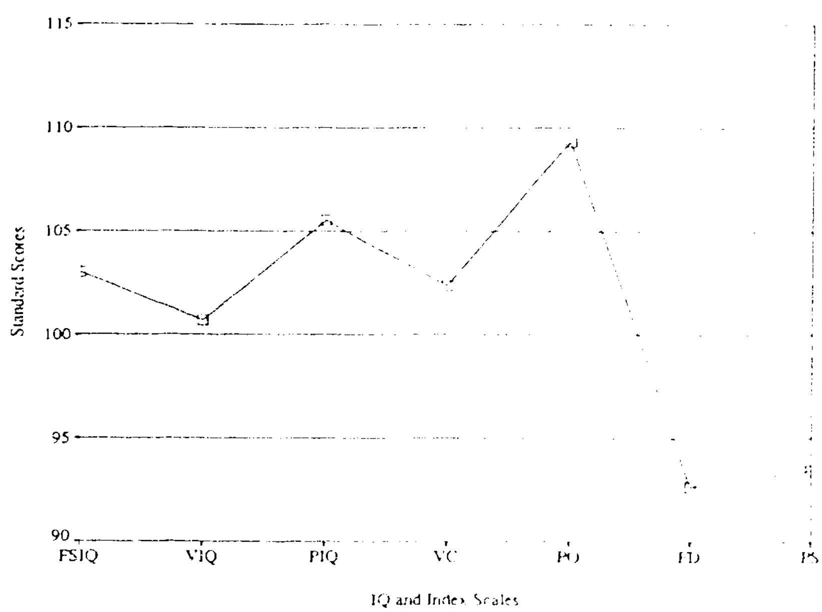

FIGURE 4.5

Combined LD Group WISC-III Profile

Research Question 6

Do patterns of IQ, Index, and subtest scores with distinct high and low scores emerge for each of the LD groups that are different from the control group profile?

The answer to this question was first explored quantitatively followed by a more qualitative approach to examine within group differences. First, oneway ANOVAs were conducted to compare specific high and low IQ, index, and subtest scores in each of the LD and the control groups. Significant F ratios and probabilities are provided in this section and Appendix E, Tables 58 to 64 report the detailed significant one way ANOVA results. The Levene Test of Homogeneity of Variances was conducted with each ANOVA analysis to rule out the effect of varying standard deviations contributing to significant results. Figures 4.6 to 4.10 display the mean subtest scores of the control and LD groups.

Control Group. Oneway ANOVAs were calculated for index and subtest scores. No significant differences existed between index scores. Picture Completion was higher than Coding, $F = 2.001$, $p < .01$, and Picture Completion was higher than Symbol Search, $F = 2.418$, $p < .01$.

RLD Group. Oneway ANOVAs were calculated for VIQ and PIQ, index, and subtest scores. No significant differences were found between the IQ scores and between the index scores. The subtest Digit Span was higher than Symbol Search and Picture Arrangement was higher than Block Design, but significant Levene Test results ($p < .05$) rendered these differences insignificant.

MLD Group. Oneway ANOVAs were calculated for index and subtest scores. No significant differences were found.

SLD Group. Oneway ANOVAs were calculated for VIQ and PIQ, index, and subtest scores. The only significant difference was a higher score on the Perceptual Organization (PO) Index compared to the Verbal Comprehension (VC) Index, $F = 1.1851$, $p < 05$.

CSLD Group. Oneway ANOVAs were also calculated in this group for VIQ and PIQ, index, and subtest scores. Significant differences were noted in subtest scores. Coding was higher than SS, $F = 3.812$, $p < .05$, and Vocabulary , $F = 2.912$, $p < .05$. Picture Arrangement was higher than Digit Span, $F = 3.058$, $p < .05$. Block Design was higher than Coding, $F = 4.113$, $p < .01$.

Qualitative Profile Analysis

A qualitative approach was also used by employing a profile analysis of each group using the seven primary approaches to profile analysis of the WISC-III recommended by Sattler (1992). The steps are:

1. Comparing Verbal and Performance Scale IQs.
2. Comparing each Verbal subtest scaled score to the mean Verbal scaled score.
3. Comparing each Performance subtest scaled score to the mean Performance scaled score.
4. Comparing pairs of individual subtest scores.
5. Comparing the Verbal Comprehension (VC), Perceptual Organization (PO), Freedom From Distractibility (FD), and Processing Speed (PS) factor scores.

Significant differences between IQs, indexes, and scaled scores were determined using Sattler's Table L-3 for the average age level (1992, p.1152). For this profile analysis, a difference of 4 or more points between subtest scores was considered significant at the .05 level. Figures 4.5 to 4.10 display the mean individual subtest scores of each group in a line graph. The mean IQ, index, and subtest scores are found in Tables 4.12 and 4.13. The mean Verbal and Performance Scales were calculated for each group and there was no significant differences with all means between 9.3 and 10.6. Using a qualitative approach, the VIQs, PIQs, and Index scores in each of the groups were not significantly different and all the individual subtest scores were within three points of their respective Verbal or Performance Scale. Profile analysis results are reported by group. Scaled subtest scores are shown in parentheses during the discussion in this section.

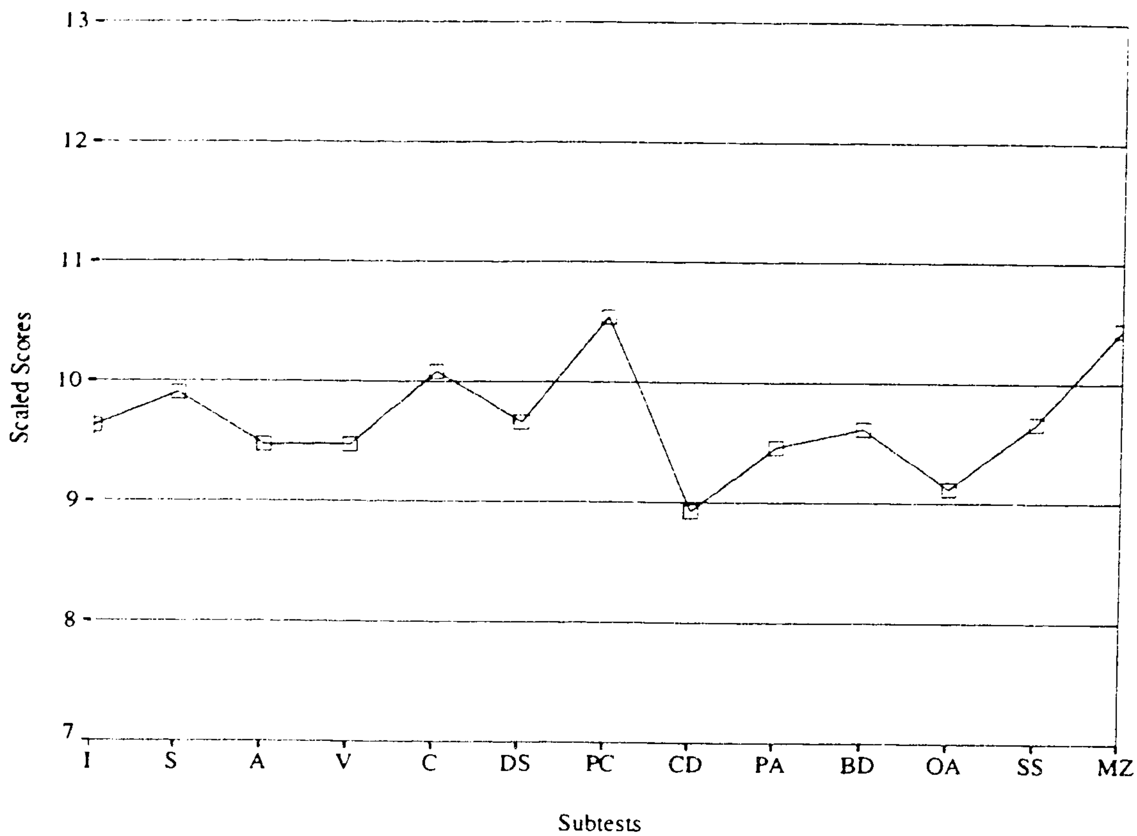

FIGURE 4.6

Control Group WISC-III Subtest Profile

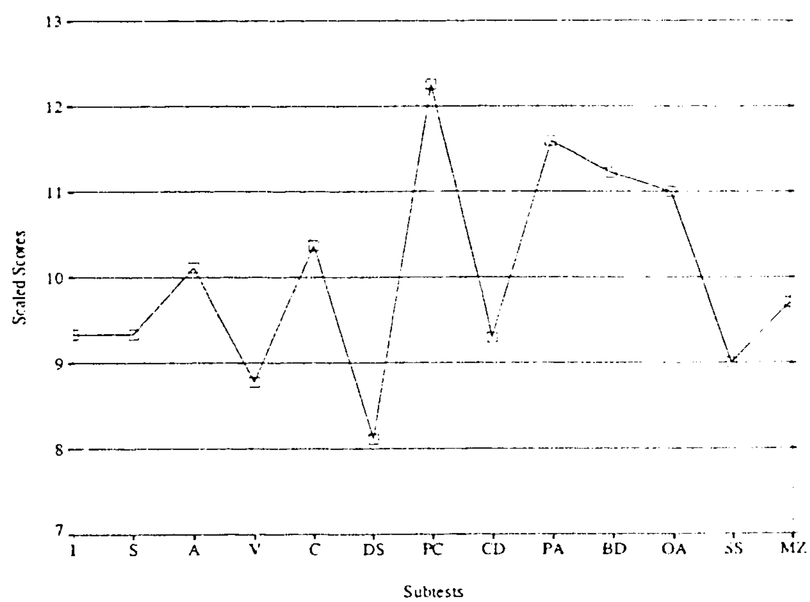

FIGURE 4.7

Reading LD Group WISC-III Subtest Profile

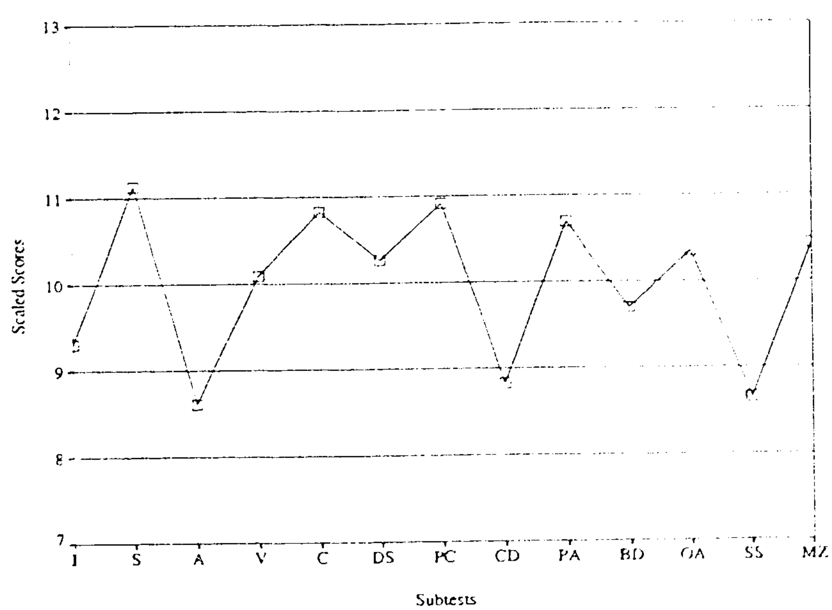

FIGURE 4.8

Math LD Group WISC-III Subtest Profile

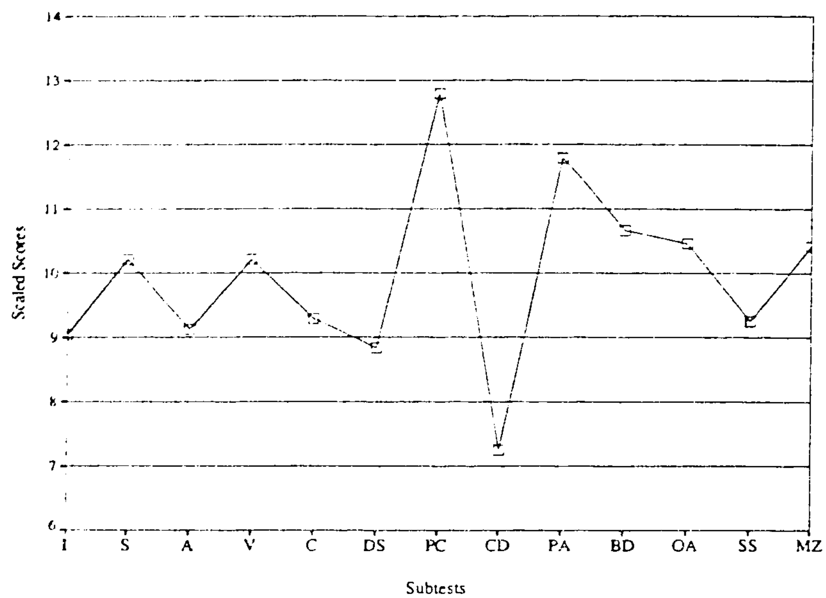

FIGURE 4.9

Spelling LD Group WISC-III Subtest Profile

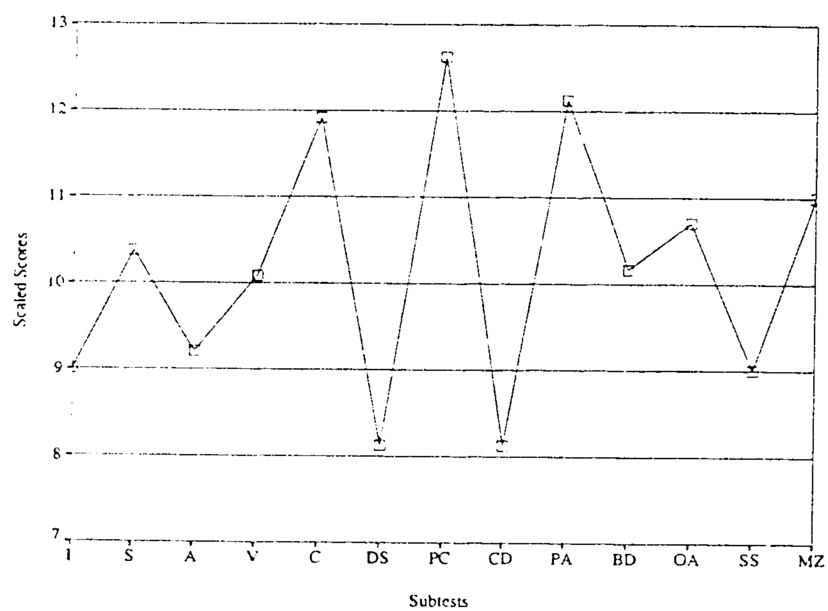

FIGURE 4.10

Combined LD Group WISC-III Subtest Profile

Control Group. The control group demonstrated minimal variation between VIQ and PIQs and also between index scores. All these scores were between 96 and 97 standard score points. Subtest scores ranged from 8.8 to 12.5 with no significant differences. There was little variation in the Verbal Scale subtest scores but the Performance subtests varied with PC the highest subtest score and Coding and Object Assembly the lowest scores.

RLD Group. Although not significant, the PIQ was nine standard score points higher than the VIQ. The PO index score was higher than the similar VC, FD, and PS scores. Subtests scores ranged from 8.1 in Digit Span to 12.3 in Picture Completion. Digit Span was significantly lower than Picture Completion and Picture Arrangement. In the Verbal Scale, Vocabulary (8.8) and Digit Span (8.1) were the lowest while Coding (9.3) and Symbol Search (9.0) were lowest in the Performance Scale. Picture Completion, Picture Arrangement, Block Design, and Object Assembly were the highest subtest scores (12.3, 11.6, 11.2, and 11.0 respectively).

MLD Group. The VIQ and PIQs were very similar meaning the VC and PO indexes were almost identical. However, the FD and PS indexes were lower (98.0 and 94.6) with the PS score the lowest of the four. Subtest scores ranged from 8.6 to 11.1 with no significant differences between them. Information (I), Arithmetic (A),Coding (Cd), and Digit Span (DS) were the lowest verbal subtests (9.3, 8.6, 10.8, 10.3) which corresponds to the ACID profile reported for the LD samples in the WISC-III manual (Wechsler, 1991). Coding (8.8) and Symbol Search (8.7) were the lowest Performance subtests.

SLD Group. The PIQ was about six standard score points higher than the VIQ. PO was the highest index score, followed by VC, FD, and PS in descending order. Subtest scores ranged form 7.5 to 12.6 with little variability between Verbal subtests but considerable variance in the Performance Scale. Picture Completion and Picture Arrangement (12.6 and 11.6) were the highest Performance Scale subtests. Coding (7.5) was significantly lower than Picture Completion and Picture Arrangement. The ACID subtests including Information, Coding, Arithmetic, and Digit Span (7.5, 9.3, 9.1, and 8.8) were about one standard score point less than the other two verbal subtests.

CSLD Group. The VIQ was about five standard score points lower than the PIQ. This group showed the greatest spread between the VC/PO and FD/PS index scores. Even though the VC index was approximately seven points lower than the PO index, there was still a nine point difference between the VC and PS indexes. Subtest scores ranged from 8.1 to 12.7 and the four ACID profile subtests were lower. Comprehension was the highest Verbal subtest. Picture Completion and Picture Arrangement (12.7 and 12.1) were the highest Performance subtests.

Conclusions about Discriminative Validity

The discriminative ability of the WRAT-R, WIAT, and QUIET for identifying learning problems was confirmed. Based on analysis and post hoc comparisons of achievement scores, the LD groups displayed significantly lower scores in their respective tests.

Based on IQ, index, and subtest scores, the WISC-III did not effectively differentiate the LD groups from the control group with evidence of statistically significant lower scores between groups. Only one lower WISC-III subtest score, Digit Span, approached significance. The LD groups, however, gained significantly higher scores in the Picture Completion, Picture Arrangement, and Object Assembly subtests of the Performance (non-verbal) scale which raises questions about specific cognitive strengths and weaknesses within each group that may relate to learning problems in reading, math, or spelling. There was a consistent pattern in the LD groups of stronger non-verbal reasoning skills compared to verbal reasoning abilities.

Oneway ANOVAs revealed statistically significant differences on WISC-III index, and subtest scores in only two of the four LD groups. No significant differences were found within the RLD and MLD groups. In the SLD group, the PO Index score was higher than the VC Index. In the control group, the Picture Completion subtest score was higher than Coding and Symbol Search. In the CSLD group the following differences were found: Coding was significantly higher than Symbol Search and Vocabulary; Picture Arrangement was higher than Digit Span; and Block Design was higher than Coding.

A qualitative profile analysis of the LD groups revealed patterns of scores that were different from the control group whose profile was similar to that of the WISC-III standardization sample. The control's IQ, Index, Verbal, and Performance subtest scores showed minimal variation. Trends in scores emerged from the LD groups. The RLD, SLD, and CSLD groups' VIQ score was lower than the PIQ although no differences were significant at the .05 level. The lowest PIQ score was from the control group, indicating that the LD groups demonstrated stronger non-verbal reasoning skills compared to verbal reasoning abilities because of higher PIQs and a slight split in the VIQ-PIQ scores. The RLD group had the lowest VIQ, the CSLD had the lowest FD Index score, and the SLD had the lowest PS Index score. The FD and PS scores were the lowest of the four index scores in the MLD, SLD, and CSLD groups. The Digit Span subtest was generally the lowest Verbal subtest in the LD groups and the Coding/Symbol Search subtests were the lowest Performance scores. The prevalence across the LD groups of the suppressed subtest scores that comprise the FD and PS index scores indicate that children identified as learning disabled in this study were less proficient with processing speed and sustaining attention. The ACID profile was also evident in the LD groups but not in the control.

Summary

The results provided evidence of convergent and discriminative validity for the WISC-III with the WRAT-R, WIAT, and QUIET in identifying learning problems. Support was provided for the use of factor based index scores and subtest scores in developing a profile of an individual's cognitive strengths and weaknesses. Although there were seemingly large differences in WISC-III scores between and within groups, oneway ANOVAs revealed few significant score differences.

Chapter Five

DISCUSSION

Introduction

The purpose of the study was to consider the validity of the WISC-III for identifying specific types of learning disabilities in reading, math, and spelling. To demonstrate construct validity, a test must correlate highly with other variables with which it should theoretically correlate and it must not correlate significantly with other variables from which it should differ (Anastasi, 1982). This study focused on the convergent validity of the WISC-III with the WRAT-R, WIAT, and Canada QUIET because an ability-achievement discrepancy definition of learning disabilities is still prevalent in school systems. The WISC-III was found to demonstrate convergent validity with the achievement tests.

The ability of the WISC-III to discriminate among four types of learning disabilities was also explored to confirm the discriminative validity of the test. This information has important implications for educational psychologists. In general, the results of the study supported the discriminative validity of the WISC-III. Specific results are discussed within each relevant section.

Convergent Validity

The results of this study are consistent with previous research and demonstrated a significant relationship between the WRAT-R, WIAT, QUIET, and WISC-III. The results also affirmed the convergent validity of the WISC-III with these individually administered achievement tests.

The Verbal and Performance dichotomy of the WISC-III was supported in the subtest intercorrelations of the control sample consisting of normally achieving children. The highest correlations were between the achievement scores and FSIQ score from the WISC-III for both LD and normally achieving subjects.

In subjects without learning disabilities, reading and math scores correlated more highly with the VIQ and FSIQ scores than spelling. The PIQ score showed the lowest correlations with achievement scores. These findings are similar to other research (Smith et al., 1986; Smith & Smith, 1986; Wechsler, 1991; 1992).

With subjects exhibiting learning disabilities, a significant relationship was found between the achievement scores and the PIQ score which differs from the normally achieving children. This stronger relationship corresponds to the subjects with learning disabilities significantly higher PIQ scores compared to the control group which may indicate stronger non-verbal reasoning abilities for the subjects with learning disabilities.

Of particular interest was the lack of significant correlations between the Processing Speed Index and achievement scores for all children in the study. It appears that the PS Index may measure a trait quite distinct from the skills related to reading, math, and spelling. Wechsler (1991) merely mentioned that the Symbol Search subtest was added to increase the power of the third Freedom From Distractibility factor but a new fourth factor emerged. No information was provided in the manual about the PS factor's structure or its possible applications. Clearly, research is needed to clarify the new factor's structure and its relevance to learning disability assessment.

Correlational results for the groups with learning disabilities must be viewed as tentative due to the composition of the study groups. Although there was no significant difference between groups, the subjects were not matched on age, grade, or gender. Further research with closely matched subjects may confirm the findings of this study.

Discriminative Validity

Analysis of Variance Findings

In the current study, the discriminative validity of the WISC-III was investigated by comparing the mean scores of the WRAT-R, WIAT, QUIET, and WISC-III scores to determine if significant differences existed between the control and learning disability groups. The significant oneway ANOVA findings of the achievement tests are discussed first followed by the significant WISC-III scores.

WRAT-R, WIAT, QUIET. The WRAT-R is often used as an estimate of academic ability. The WIAT is a more comprehensive instrument and includes listening skills and written expression. The QUIET, although not as comprehensive as the WIAT, was standardized on Canadian children from several provinces. The WIAT and QUIET are new tests and require research to establish their use in assessment of school aged children. The results of the study show that all three achievement tests discriminated between normally achieving and children with learning disabilities even though a discrepancy between ability-achievement formed the basis of the learning disability groups. These results were consistent with findings in the literature (Hale & Saxe, 1983; Janzen et al., 1983).

Even though the learning disability groups were formed by a discrepancy of 15 or more standard score points between ability and achievement, the LD groups' achievement scores in comparison to the control group were 18 to 25 points lower. The CSLD group demonstrated the lowest scores in comparison to the other LD groups indicating children with below average reading, spelling, and math scores in this study seemed to have more severe learning problems. A comparison of below average scores across all four learning disability groups revealed that reading and spelling scores were lower than math which corresponds to weaker language abilities found in children with learning disabilities (Kaufman et al., 1990; Kavale & Nye, 1985-86; Sattler, 1992).

Because one of three different achievement measures were used to generate a single reading, math, and spelling score for each subject, content sampling or theoretical orientation of the instruments might have contributed to varying scores other than the children's ability (Bracken, 1988). For example, each achievement measure contained a subtest assessing sight word vocabulary but there may have been differences in the number of non-phonetic words included. Content differences may exist between math tests because of a varying emphasis on knowledge of concepts, ability to rote count and place count, or proficiency in addition, subtraction, multiplication, and division.

A visual inspection of the items revealed that the reading and spelling subtests appeared the most similar in content across the three achievement tests. The WRAT-R Arithmetic subtest was oriented towards pure calculation skills while the WIAT and QUIET math subtests were tied more closely to the curriculum with a greater variety of questions including temperature and geometry. Nevertheless, the similarities between high and low achievement scores in all the groups indicated the tests' contents may have been similar.

WISC-III. In summary, the research results failed to produce a statistically significant learning disability profile different from normally achieving children which was consistent with previous research on the WISC-R (Kaufman et al., 1990). However, the results indicated that the PIQ and PO Index scores, reflective of non-verbal reasoning abilities, were significantly higher in the RLD, SLD, and CSLD groups compared to the control group. The well documented weaker auditory-linguistic abilities of students with learning disabilities (Kaufman et al., 1990; Kavale & Nye, 1985-86; Sattler, 1992; Swanson, 1989; Torgensen et al., 1994) were clearly supported by the findings. Although a lower VIQ, higher PIQ score discrepancy is common in LD profiles, it has not proved to be a reliable indicator of LD which was confirmed by this study (Kaufman et al., 1990; Kavale and Forness, 1984). This finding was confirmed by the present study.

Given the heterogeneous nature of learning disabilities (Smith, 1991), the absence of numerous significant differences was expected. Another possible contributing factor may have been the small LD sample sizes in the study which produced significantly different WISC-III subtest standard deviations making comparisons within each group difficult. Research with larger sample sizes may produce more definitive results.

Despite the lack of significant ANOVA results, a qualitative analysis of each LD group utilizing a clinical approach revealed several characteristics common in the WISC-R profiles of children with learning disabilities. The clinical analysis yielded important information relevant to individuals using the WISC-III as part of an assessment battery for LD. The results are discussed in the next section.

Comparison of WISC-R and WISC-III Learning Disabled Profiles

The ability of the WISC-III to differentiate children with and without learning disabilities was supported by the research results. As a whole, the four LD groups exhibited differences from the control group in Verbal-Performance Scale discrepancies, lower FD and PS factor index scores, subtest scatter, ACID profiles, easiest and most difficult subtests, and subtest categorizations.

Verbal-Performance Differences. As mentioned earlier, the RLD, SLD, and CSLD groups demonstrated lower VIQ than PIQ scores which corresponded with results reported in the manual (Wechsler, 1991). Similar patterns were noted on the WISC-R by Kaufman et al. (1990) and Sattler (1992). The difference for the above three LD groups ranged from 5 to 9 while the control demonstrated only a 2 point difference. The clinical relevance of this difference was already noted and cognitive processes of the individual LD groups are discussed later.

Subtest Scatter. Characteristic high and low subtest scores reported in the literature (Kaufman et al., 1990; Kavale and Forness, 1984; Sattler, 1992; Wechsler, 1991) were clearly replicated in this study. Table 5.1 displays the rankings of the WISC-III subtests from easiest to most difficult for each of the groups in the study.

TABLE 5.1

Subtest Ranking - Easiest to Most Difficult

Control	RLD	MLD	SLD	CSLD
PC	PC	S	PC	PC
Mz	PA	PC	PA	PA
C	BD	C	OA	C
S	OA	PA	BD	Mz
I	C	Mz	Mz	OA
SS	A	OA	S	S
BD	Mz	DS	V	BD
A	I	V	SS	V
V	S	BD	C	A
DS	Cd	I	A	SS
PA	SS	Cd	I	I
OA	V	A	DS	Cd
Cd	DS	SS	Cd	DS

I-Information, S-Similarities, A-Arithmetic, V-Vocabulary, C-Comprehension, DS Digit Span, PC-Picture Completion, Cd-Coding, PA-Picture Arrangement, BD-Block Design, OA-Object Assembly, SS Symbol Search, Mz-Mazes

The four easiest subtests common to the LD groups were Picture Completi[illegible], Picture Arrangement, Object Assembly, and Mazes. These non-verbal subtests require children to think in terms of visual images and manipulate them with fluency, flexibility, and relative speed. Forming concepts and relationships without the use of words is also required (Sattler, 1992). Because students with learning disabilities typically have phonologic deficits (Kavale & Nye, 1985-86), the decreased level of language demands in the nonverbal Picture Completion, Picture Arrangement, Object Assembly, and Mazes subtests is an advantage for LD students. Naglieri and Das (1990) proposed the u[illegible]deriying process in Picture Arrangement and Object Assembly was simultaneous pro[illegible] the requirement that the parts of each item need to be interrelated to complete the task successfully. Simultaneous processing is associated with the visual and kinesthetic neurological systems which corresponds with Wechsler's Performance Scale.

The most difficult subtests common to the LD groups were Coding, Symbol Search, Digit Span, Arithmetic, and Information. Coding and Symbol Search form the Processing Speed Index while Digit Span and Arithmetic make up the Freedom From Distractibility Index. The FD Index relates to an ability to sustain attention, short-term memory, numerical ability, rehearsal strategies, mental flexibility, and ability to self-monitor. The PS Index is associated with visual-motor coordination, psychomotor speed, short-term memory, visual recall, attentional skills, perceptual discrimination, and cognitive flexibility (Sattler, 1992). These neuropsychological capacities were shown to be weaker in LD students (Kavale & Nye, 1985-86) which corresponds to more recent information-processing theories of cognitive processing. Wielkiewicz (1990) proposed that the FD index tasks were difficult for some children because they require coordination of problem-solving strategies in working or short-term memory. Difficulties would be experienced in selectively attending to the key stimuli, holding the information in working memory, and manipulating it appropriately. Digit Span required the individual to reproduce the correct order of numbers. Naglieri and Das (1990) concluded that the WISC-R subtest Digit Span and to some degree Arithmetic, corresponded with successive processing or the ability to handle the linearity of relationships among stimuli.

Of the five most difficult WISC-III subtests for the LD groups in this study, three of them formed the ACID subtest profile, Digit Span, Arithmetic, and Information (Sattler, 1992; Wechsler, 1991). The most difficult tests for the spelling and combined disabled children were the ACID group while the math group's most difficult subtests included three of the four ACID subtests. The abilities measured by these subtests were discussed above except for the Information subtest that taps general fund of knowledge and long-term memory and is a common weakness for children with learning disabilities (Sattler, 1992). The presence of an ACID profile certainly does not indicate a learning disability but should alert the examiner to that possibility and the need to integrate test and background information.

The characteristic groups of high and low subtest scores are similar to the LD subtypes derived from WISC-R empirical research. Numerous studies revealed LD subtypes with visual-perceptual problems, verbal difficulties, or sequencing and attention deficits (Hale & Saxe, 1983; Holcomb et al., 1987; Snow et al., 1985). The suppressed FD and PS index scores in all the LD groups corresponded to the WISC-III manual results (Wechsler, 1991) but more research on these two indexes is needed to clarify what cognitive processes are measured.

Bannatyne Categorizations. Recategorization of subtests aids in generating hypotheses about an individual's cognitive and behavioral functioning. Hypotheses are not facts but only ideas that require external validation from background information, test-taking behavior, reports from others, and scores from other pertinent tests (Kaufman, 1990). Bannatyne's (1974) categories of learning disability patterns found in WISC-R research (Kaufman et al., 1990) were present in this study, Spatial > Conceptualization > Sequencing. Table 5.2 displays the category scores for each group based on the sums of relevant subtests comprising each category.

TABLE 5.2

Bannatyne Subtest Categorizations

	Verbal Conceptualization (S + V + C)	Spatial Ability (PC + BD + OA)	Sequencing Ability (A + DS + Cd)	Acquired Knowledge (I + A + V)
Reading LD	29	35	28	28
Math LD	32	31	28	28
Spelling LD	29	34	25	28
Combined LD	32	34	25	28
Control	30	30	28	29

S-Similarities, V-Vocabulary, C-Comprehension, PC-Picture Completion, BD-Block Design, OA-Object Assembly, A-Arithmetic, DS-Digit Span, Cd-Coding, I-Information

Although the score differences in each group were not significant, a consistent pattern was apparent. In three of the four LD groups Spatial Ability was highest and in all four groups Sequencing Ability was the lowest. The three subtests comprising the Spatial Ability category compose the PO index and they measure simultaneous processing, a gestalt-holistic problem solving approach related to Naglieri and Das' (1990) model. Sequencing Ability, related to the FD and PS indexes, corresponds to the skills of attention, memory, and cognitive flexibility discussed in the previous section. The greatest difference between spatial and sequencing abilities was noted in the reading, spelling, and combined LD groups. The math disabled children had slightly higher verbal conceptualization skills compared to Spatial ability which corresponded to Rourke's (1993) findings of non-verbal learning problems with math LD students. The CSLD group experienced the largest score difference between conceptualization and sequencing abilities pointing to the higher degree of impairment for these children.

In summary, the value in regrouping subtests lies not in diagnosis but in remedial intervention (Kaufman et al., 1990). Even though Bannatyne's categories do not reliably distinguish LD children in assessment, regrouping subtests may provide insights into a child's cognitive processing that lead to more effective intervention methods.

Characteristics of Learning Disabled Subtypes

The performance of each of the LD groups on the WISC-III was compared to LD subtyping research findings to determine if the test provided any information on diagnosing specific academic LD areas. Subtest score differences of four or more within each LD group were deemed significant (Sattler, 1992). In general, several relationships were noted between WISC-III scores in this study and LD subtyping research but these commonalties are only tentative and represent areas for discussion and further research. Each of the LD groups is discussed separately.

Children With a Reading Learning Disability. The RLD group in this study consisted of 26% with below average reading scores and 74% with below average reading and spelling scores. The high number of combined reading-spelling problems was probably reflective of the referrals received at the University of Alberta Education Clinic but it was also representative of the greater number of school children with this combined academic weakness (Smith, 1991). There were inadequate subjects to form a reading deficit only group but the inclusion of a separate LD group with below average spelling scores helped determine if differences in the WISC-III profiles were present.

The group with reading disabilities in this study appeared to most closely resemble readers with auditory-linguistic processing problems. The RLD group demonstrated the largest discrepancy between VIQ and PIQ scores (nine points). Stronger nonverbal abilities appear characteristic of readers with auditory-linguistic deficits (Ingram et al., 1970; Rourke, 1993; Sattler, 1992; Smith, 1991; Thomson, 1982). Children with reading-spelling problems were also found to obtain lower scores on tasks involving working memory (Fletcher, 1985; Lennox & Siegel, 1988). Difficulties these children may have related to WISC-III subtests are as follows: processing rapid auditory inputs, remembering individual sounds of words or sequences of words, inability to retrieve letter sounds while analyzing words, limited sight word vocabulary, and poor spelling because of over reliance on sight rather than the ear (Smith, 1991). Short-term memory problems were indicated in the low Digit Span score that was at least three scaled score points below four of the nonverbal subtests (Picture Completion, Picture Arrangement, Block Design, and Object Assembly). The Vocabulary subtest measuring verbal comprehension and word knowledge was also significantly lower than the Picture Completion, Picture Arrangement, Block Design, and Object Assembly subtests.

The Coding and Symbol Search subtests which comprise the Processing Speed Index score were two to three points lower than the other nonverbal subtests. This finding may indicate a relative weakness in visual-processing skills related to perceptual discrimination and psychomotor speed.

The WISC-III scores of the reading disabled group closely resembled Rourke's (1993) profile of reading-spelling disabled children between the ages of 9 and 14. These children scored lower on the auditory-perceptual measures from the WISC-III Information, Similarities, Vocabulary, and Digit Span subtests while demonstrating relative strengths in the visual-perceptual-organizational Picture Completion, Picture Arrangement, Block Design, and Object Assembly subtests. According to Rourke's model (1993), primary neuropsychological deficits in auditory perception lead to secondary visual and auditory attention difficulties which in turn cause tertiary auditory and verbal memory problems leading to verbal deficits in phonology, verbal reception, verbal repetition, verbal storage, verbal association, and verbal output. Academic problems occur in graphomotor, word decoding, reading comprehension, spelling, verbatim memory, and mechanical arithmetic.

The WISC-III by no means provides an assessment of these many facets of cognitive functions related to reading, but it does tap attention (Digit Span, Arithmetic), memory (Digit Span, Symbol Search, Information, Vocabulary), and graphomotor skills (Coding, Symbol Search). In the WISC-III, there is a noticeable lack of subtests that measure phonological processes directly related to reading skills. Given the growing evidence of the importance of phonological skills to reading (Mann, 1994; Swanson, 1989; Torgensen et al., 1994), tests measuring these skills should be included in an LD assessment.

Children With a Spelling Learning Disability. The SLD group showed the second largest VIQ - PIQ score discrepancy. Consequently, the relative auditory-linguistic weaknesses of the reading disabled children were also evident with spelling disabled children. The high degree of verbal ability and verbal comprehension of the WISC-III Verbal Scale and its relationship to both reading and spelling probably accounts for some of the similarities between the RLD and SLD subtest profiles. The SLD subtest profile closely resembled the RLD profile especially in the nonverbal subtests where scores were almost identical except for a lower score on the Coding subtest.

Spelling research presumes a two channel processing model, auditory-processing and visual-processing (Frith, 1983; Smith, 1991). Analyzing phonetic sequences in words is difficult for weak auditory-processors and visual-processing problems make it hard to revisualize correct letter sequences for words. The child is inattentive to which letter sequences are conventional. More recent research proposed a more complex interaction of the two processes and identified three characteristics of LD spellers with learning disabilities: short-term memory problems in holding dictated words long enough to encode a complete phonemic string, problems identifying conventional phonemic boundaries, and inventing simple, economic spellings (Gerber & Hall, 1987). The first characteristic pertains to the SLD group's low scores on the WISC-III.

Two attributes stand out from the profile of the spelling group: the four lowest subtest scores were the ACID subtests and the Coding subtest score was the lowest of all the LD groups. As mentioned earlier, the ACID subtests comprise the FD and PS Index scores which measure ability to sustain attention and processing speed. The low FD score seems to relate to Gerber and Hall's contention that short-term memory hinders accurate spelling. The low Coding subtest score corresponds to their theory that LD students do not develop spontaneously sufficient speed in basic processes such as phonemic analysis.

In summary, the SLD and RLD groups demonstrated similar patterns of high and low scores on the WISC-III. The presence of lower FD and PS index scores in the SLD group pointed to processing weaknesses that may have contributed to spelling problems. These findings indicate the necessity for a close analysis of a child's spelling errors and probing to discover what strategies are used for spelling unfamiliar words.

<u>Children With a Math Learning Disability.</u> The MLD group profile is compared to math LD subtypes investigated by Rourke and his associates (DeLuca et al., 1991; Rourke, 1993) because of similarities in research design. Canadian children with a FSIQ range of 85 to 115 were used in all these studies.

The MLD group in this study exhibited the least degree of variability in IQ and subtest scores compared to the other LD groups. The VIQ and PIQ scores were 100 and 102, respectively, which is at odds with Rourkes' et al., (1990) Nonverbal Learning Disabilities (NLD) syndrome related specifically to arithmetic problems. Children with a math disability typically had a higher PIQ than VIQ score. The main characteristics of the NLD syndrome are as follows: (1) Bilateral tactile-perceptual deficits; (2) bilateral psychomotor coordination deficiencies; (3) marked deficits in visual-spatial-organizational abilities; (4) problems in nonverbal problem solving, concept formation, hypothesis testing, and difficulties in cause-effect relationships; (5) well developed rote verbal capacities; (6) extreme difficulty in adjusting to novel and complex situations; (7) deficits in mechanical arithmetic compared to reading (word recognition) and spelling; (8) poor psycholinguistic pragmatics and phonetically accurate spelling errors; and (9) significant deficits in social perception, social judgment, and social interaction skills (Casey & Rourke, 1991). The MLD group displayed some of the above characteristics based on their WISC-III scores. Tactile-perceptual, psychomotor coordination, adjusting to novel situations, and mental math computation appeared more difficult based on lower scores in Coding, Symbol Search, Block Design, and Arithmetic. Most striking were the two lowest nonverbal scores in Coding and Symbol Search that form the Processing Speed Index score. The PS index for the MLD group may be related to conceptual flexibility and symbolic shifting. This group also showed stronger rote verbal capacities.

Comparisons to the NLD syndrome were limited by a difference between the MLD group in this study and the Arithmetic disabled group from DeLuca et al., (1991). While the subtype being discussed from DeLuca et al. had average to above average WRAT Reading/Spelling scores and below average Arithmetic scores, the MLD group consisted of 52% with below average reading and spelling scores while the remaining 48% demonstrated deficient scores only in math. Another consideration stems from the current lack of internal and external validation of the NLD syndrome. The model's success at correctly identifying individuals remains speculative.

In summary, although the MLD group demonstrated a different profile from the other LD groups, it lacked a strong resemblance to math LD subtypes associated with Nonverbal Learning Disabilities syndrome. Like the reading and spelling disabled children in this study, the PS and FD Index scores were lower indicating possible attentional, memory, and cognitive flexibility weaknesses.

Children With a Combined Learning Disability. A consistent comparable subtype in the literature was not found for comparison purposes. This group is largely ignored by researchers probably due to the confounding variables in studying children with reading, math, and spelling LD.

The CSLD group resembled the reading and spelling disabled groups with a lower VIQ - higher PIQ score difference and lower scores in the FD and PS indexes. This group demonstrated the greatest degree of subtest score variability possibly indicating more pronounced cognitive strengths and weaknesses. Some of these differences may be accounted for by the composition of the group. It had the lowest mean age of the LD groups and 86% of the subjects were between the ages of 6 to 12. Considering the severity of the academic problems, it was not surprising to find a majority of these children in the elementary grades because the learning problems would be more apparent at a younger age causing parents to seek assessment services soon

The findings in this study bear implications for any individual utilizing the WISC-III and achievement tests in LD assessment. The prolific use of the Wechsler scales has led to inappropriate and unsubstantiated diagnosis of LD. The WISC-III plays an important role in identifying LD providing certain interpretation procedures are adhered to. Careful selection of achievement measures and related tests can provide valuable information on specific academic areas affected by learning problems.

Practical Implications

The distinct emergence of the factors that resemble the Verbal and Performance scales of the WISC-R suggests to practitioners that the VIQ and PIQ scores need to be given much credence instead of over focusing on individual subtest interpretation. Interpretation must begin with comparing the child's subtest scores to his/her respective mean Verbal and Performance scale scores. Only when scaled scores significantly deviate from the Verbal and/or Performance means is there grounds for speculating about strengths and weaknesses in abilities less global than verbal comprehension and perceptual organization (Kaufman et al., 1990; Sattler, 1992). If the verbal comprehension-perceptual organization dichotomy does not apply then prudent subtest analysis is required to understand the child's profile.

Caution is advised on how the Processing Speed and Freedom From Distractibility Index scores are interpreted. From this study, it was apparent the four subtests comprising the two indexes were difficult tasks for the LD subjects but current factor analysis research does not support the FD factor that was prevalent in the WISC-R. In the WISC-III, Coding moved from the FD to the new PS factor perhaps diminishing the validity of the FD factor. If possible, examiners should include other tests that measure similar abilities to provide valid evidence of attentional or processing speed cognitive processes.

A practice frequently overlooked by examiners is the readministration of subtests without the standardized administration constraints to explore how children approach tasks. Removing time limits or allowing the child to verbalize aloud while performing the task may provide invaluable insights about the executive functions of planning and strategy selection that many children with learning disabilities are deficient in. This approach is also useful with achievement tests where children are later permitted to elaborate on math problem solving strategies, reading unfamiliar word approaches, or how words were spelled. The extra time taken in the testing session may yield invaluable information for planning remediation.

An abundance of research now supports a causal role for phonological awareness in early literacy acquisition. An awareness of the internal structure of words facilitates success in learning how to read and spell (Blachman, 1994a). It would be beneficial to include in an LD test battery measures of phonological knowledge and processing to evaluate whether these areas are contributing to learning difficulties. Some examples of these instruments are: (1) the Word Attack subtest from the Woodcock Reading Mastery Tests - Revised which requires the child to decode phonetically regular nonwords; (2) the Memory For Sentences subtest from the Stanford-Binet Intelligence Scale: Fourth Edition; and (3) auditory analysis tasks requiring phonemic deletion and blending.

The WIAT and QUIET should be used rather than the WRAT-R because of the inclusion of a reading comprehension subtest. One drawback of the QUIET is the restricted standard score range of 68 to 135 limiting its use with children possessing severe learning problems or exceptionally strong academic skills. Examiners should note the Mathematics Reasoning subtest for the WIAT short form, the Screener, is a measure of problem solving ability requiring reading skills. The Numerical Operations subtest should also be administered so calculation skills and reading comprehension/problem solving abilities can be contrasted. If only the Mathematics Reasoning subtest is administered, the child's true calculation skills may not be accurately evaluated. This discrepancy was evident in the entire WISC-III clinic sample of 338 subjects where the mean Mathematics Reasoning subtest score was approximately nine points higher than Numerical Operations. It appeared performing math calculations in the context of word problems seemed to improve math performance. The choice of subtests has implications if the scores are used in placement decisions. At this point however, the score difference in the two WIAT math subtests is only a hypothesis that needs confirmation through research.

The WRAT-R appears to differ from the WIAT and QUIET in item gradient or how quickly test items become increasingly difficult. A test with a less comprehensive series of items like the WRAT-R is less sensitive to small or moderate differences in children's abilities and will produce major differences in standard scores as a result of minor fluctuations (Bracken, 1988). The WRAT-R, especially Level 2 covers a broad age range (12 to 75) and therefore contains a steeper item gradient, whereas the WIAT and QUIET are restricted to grades 1 to 12.

Further Research

Research on the Freedom From Distractibility and Processing Speed Indexes is needed to establish the validity of these two factors for test interpretation. In light of the poor performances on the FD and PS Indexes by all of the LD groups in this study, it is important to clarify what cognitive processes are measured so meaningful interpretation data can be translated into advantageous intervention practises.

Studies utilizing matched samples of children with learning disabilities from the general school population are essential to verify the presence of characteristic learning disability profiles on the WISC-III that surfaced in this study. The clinic sample may not have been representative of the general population with learning disabilities and replication studies may substantiate the role of these profiles in learning disability assessment for developing remediation programs.

Children with a combination of reading, math, and spelling deficits are a neglected group in the literature on LD subtyping research. With the increased emphasis on validation methods to justify specific LD subtypes and the focus on linking assessment to direct intervention, research addressing the cognitive and learning styles of this group could lead to more efficient means of addressing their higher level of academic impairment.

The case study approach in LD research is experiencing a resurgence (Hooper & Willis, 1989). This model would be extremely effectual for addressing the dynamic variability in learning disabilities shifting the focus from probing for commonalties among groups to exploring the unique characteristics of a individual with a learning disability and how to address those special needs. It allows for a more creative and flexible research method that links assessment practises and intervention.

Summary

Convergent validity of the WISC-III with the WRAT-R, WIAT, and QUIET achievement tests was substantiated. In view of the criticisms of the WRAT-R concerning its limited content and lack of a reading comprehension measure, the WIAT or QUIET offer a valid alternative.

The main research question concerning the discriminative validity of the WISC-III for identifying learning disabilities in a clinic sample based on a discrepancy between ability and achievement was only partially substantiated. The test discriminated children with learning disabilities from normally achieving children with differences in VIQ and PIQ scores, lower scores in the Freedom From Distractibility and Processing Speed Indexes, and the presence of lower scores in the subtests composing the ACID acronym (Arithmetic, Coding, Information, Digit Span). However, the test failed to distinguish between reading, math, spelling, and combined LD subtypes based on WISC-III scores. Since research on differential diagnosis has been largely unsuccessful, psychologists need to avoid the pitfall of relying on characteristic WISC-III profiles of children exhibiting a learning disability for making a diagnosis. Meta-analytic research has indicated only slightly significant but not necessarily distinctive performance on recategorized groupings for children with learning disabilities. Subtest scatter and Verbal-Performance differences overlap between normal and populations with learning disabilities rendering them ineffective for diagnosis.

The results underscore the heterogeneous nature of learning disabilities and the failure of any single test to effectively distinguish various types of LD. An effective test battery for LD assessment should evaluate developmental-cognitive processes, achievement skills, environmental demands, reactions of others to the individual, and interaction effects of the preceding factors that affect the child's performance (Sattler, 1992). In addition to utilizing standardized tests, the examiner should include informal measures such as oral reading miscue analysis to aid in the development of remedial programs beneficial for the child.

A WISC-III cognitive profile is only one piece of a complex puzzle that needs assembling to create an accurate picture of an individual's abilities. Kaufman (1990) aptly described the flexible expertise demanded in this process:

> Examiners must be detectives, actively attacking subtest profiles in systematic fashion. They need to regroup the subtests in new ways to best explain each individual's subtest-to-subtest fluctuations. Different theories of intelligence as well as practical and clinical approaches to assessment must be integrated to find the one best synthesis for each person tested. (p. 481)

As a detective and scientist, the practitioner must be fully cognizant of theories of intelligence and cognitive functioning and interpret test functioning in light of these theories. The WISC-III like any other intelligence test can potentially wreak havoc or ultimately improve the quality of education for a child with a learning disability. Psychologists have an ethical obligation to use intelligence tests in a manner that benefits the child and ensures their social, emotional, and psychological well being.

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APPENDIX A

Summary Statistics for WISC-III Clinic Population

TABLES 1 - 2

TABLE 1

Distribution of Entire WISC-III Clinic Sample By Age, Gender, and Grade

	Mean	SD	Range	N = 338 Male	Female
Age	10.4	2.5	6.8-16.7		
Grade	4.6	2.4	1-11		
Gender				239 (71%)	99 (29%)

TABLE 2

WISC-III Clinic Population Summary Statistics (n=338)

Test	Mean	SD	Min	Max	Kurt	Skew	
WISC-III							
FSIQ	99.3	15.4	46.0	143.0	.434	-.041	
VIQ	98.3	16.0	50.0	145.0	.166	.017	
PIQ	100.4	16.2	49.0	148.0	.402	.059	
VC Index	99.3	15.6	54.0	144.0	.188	-.006	
PO Index	102.5	16.2	50.0	145.0	.179	-.153	
FD Index	96.1	13.8	58.0	137.0	.235	.109	
PS Index	96.5	16.3	50.0	146.0	.119	.167	
Information	9.4	3.2	1.0	18.0	.055	.044	
Similarities	10.1	3.5	1.0	19.0	.118	-.163	
Arithmetic	9.3	3.2	1.0	19.0	.627	.476	
Vocabulary	9.6	3.3	1.0	19.0	.386	.165	
Comprehension	10.1	3.6	1.0	19.0	-.022	-.102	
Digit Span	9.0	2.8	2.0	16.0	-.478	.179	
Picture Completion	11.0	3.2	1.0	19.0	-.158	-.196	
Coding	8.7	3.7	1.0	18.0	.002	.432	
Picture Arrangement	10.3	3.4	1.0	19.0	-.120	.028	
Block Design	10.0	3.7	1.0	19.0	.267	.014	
Object Assembly	9.7	3.2	1.0	19.0	.314	-.230	
Symbol Search	9.6	3.5	1.0	19.0	.063	.093	
Mazes	10.4	3.6	1.0	19.0	-.212	.258	
WRAT-R							
Reading	91.9	20.0	70.0	141.0	-.229	-.029	n=118
Arithmetic	87.4	16.9	21.0	126.0	-.052	-.029	n=111
Spelling	85.6	16.0	40.0	128.0	-.174	-.159	n=119
WIAT							
Basic Reading	97.5	16.4	70.0	141.0	-.050	.689	n=70
Mathematical Reasoning	97.8	15.4	68.0	138.0	.144	.773	n=70
Spelling	93.1	14.5	67.0	139.0	.777	.773	n=69
Canada QUIET							
Word Identification	93.8	17.5	60.0	135.0	-.551	.234	n=107
Arithmetic	92.4	15.8	67.0	138.0	-.264	.302	n=111
Spelling	92.4	18.8	60.0	136.0	-.486	.525	n=106

APPENDIX B

Summary Statistics for Canada Quiet Sample

TABLES 3 - 6

TABLE 3

Distribution of Canada QUIET Sample By Age, Gender, and Grade

	Mean	SD	Range	N = 104 Male	Female
Age	10.8	2.4	6.8-16.7		
Grade	5.1	2.	1-11		
Gender				69 (66%)	35 (34%)

TABLE 4

Mean WISC-III IQ Scores For Canada QUIET Sample (n=104)

	Mean	SD
IQ Scores		
Full Scale	100.2	17.9
Verbal	99.4	16.7
Performance	101.2	18.9
Index Scores		
Verbal Comprehension	100.2	16.4
Perceptual Organization	103.1	18.8
Freedom From Distractibility	96.1	15.6
Processing Speed	97.1	18.4

TABLE 5

Mean Achievement Scores For Canada QUIET Sample (n=104)

Subtest	Mean	SD	n
Word Identification	93.7	17.5	104
Arithmetic	91.7	15.7	104
Spelling	92.0	18.7	103*

* One subject not administered Spelling subtest

TABLE 6

Correlations For WISC-III IQ/Index Scores and Canada QUIET Subtests (n=104)

	QUIET Subtests		
WISC-III Scores	Word Identification	Arithmetic	Spelling
IQ Scores			
Full Scale IQ	.57	.68	.47
Verbal IQ	.63	.65	.54
Performance IQ	.43	.62	.33
Index Scores			
Verbal Comprehension	.61	.59	.51
Perceptual Organization	.42	.61	.29
Freedom From Distractibility	.65	.67	.61
Processing Speed	.40	.46	.39

Note: All coefficients were significant at the .001 level

APPENDIX C

Achievement Scores for Control and LD Groups

TABLES 7 - 11

TABLE 7

Reading LD Group Mean Reading Achievement Test Scores

Achievement Test	Mean	SD	n
WRAT-R	74.2	9.1	10[a]
WIAT	83.9	7.4	9
Canada QUIET	78.4	6.4	9[a]
Total			28

[a] One subject administered both WRAT-R and Canada QUIET

TABLE 8

Math LD Group Mean Arithmetic Achievement Test Scores

Achievement Test	Mean	SD	n
WRAT-R	82.8	7.7	12
WIAT	79.0	2.8	2
Canada QUIET	78.3	7.3	9
Total			23

TABLE 9

Spelling LD Group Mean Spelling Achievement Test Scores

Achievement Test	Mean	SD	n
WRAT-R	81.3	8.8	11
WIAT	81.8	7.4	6
Canada QUIET	78.5	6.8	10
Total			27

TABLE 10

Combined LD Group Mean Reading, Math, and Spelling Achievement Test Scores

Achievement Test	Mean	SD	n
Reading Tests			
WRAT-R	72.0	15.3	13
WIAT	82.5	6.4	2
Canada QUIET	77.7	11.4	10
Total			25
Arithmetic Tests			
WRAT-R	78.4	10.0	13[a]
WIAT	87.0	4.2	2
Canada QUIET	85.0	9.4	11[a]
Total			26
Spelling Tests			
WRAT-R	71.8	9.8	13
WIAT	82.5	3.5	2
Canada QUIET	72.4	9.3	10
Total			25

[a] One subject administered both WRAT-R and Canada QUIET

TABLE 11

Control Group Mean Reading, Math, and Spelling Achievement Test Scores

Achievement Test	Mean	SD	n
<u>Reading Tests</u>			
WRAT-R	99.5	11.9	33
WIAT	98.7	12.3	30
Canada QUIET	103.2	11.1	24
Total			87
<u>Arithmetic Tests</u>			
WRAT-R	96.1	10.0	33
WIAT	96.1	9.8	30
Canada QUIET	98.3	11.1	24
Total			87
<u>Spelling Tests</u>			
WRAT-R	95.1	8.9	33
WIAT	96.5	11.8	30
Canada QUIET	104.1	13.1	24
Total			87

APPENDIX D

Oneway Analysis of Variance for WISC-III Scores

TABLES 12 - 57

TABLES 12 - 31

Oneway Analysis of Variance on WISC-III IQ Scores, Index Scores, and Individual Subtests

TABLE 12

Oneway Analysis of Variance - WISC-III Full Scale IQ

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	899.2105	224.8026	4.2056	.0028
Within Groups	183	9781.9543	53.4533		
Total	187	10681.1649			

TABLE 13

Oneway Analysis of Variance - WISC-III Verbal IQ

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	186.6638	46.6660	.5672	.6867
Within Groups	183	15055.6926	82.2715		
Total	187	15242.3564			

TABLE 14

Oneway Analysis of Variance - WISC-III Performance IQ

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	3258.8658	814.7164	9.2149	.0000
Within Groups	183	16179.6183	88.4132		
Total	187	19438.4840			

TABLE 15

Oneway Analysis of Variance - WISC-III Verbal Comprehension Index

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	525.5108	131.3777	1.4178	.2298
Within Groups	183	16957.3189	92.6629		
Total	187	17482.8298			

TABLE 16

Oneway Analysis of Variance - WISC-III Perceptual Organization Index

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	4845.3873	1211.3393	11.9871	.0000
Within Groups	183	18492.8767	101.0540		
Total	187	23338.2340			

TABLE 17

Oneway Analysis of Variance - WISC-III Freedom from Distractibility Index

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	713.7749	178.4437	1.7612	.1386
Within Groups	183	18440.4925	101.3214		
Total	187	19154.2674			

TABLE 18

Oneway Analysis of Variance - WISC-III Processing Speed Index

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	487.3083	121.8271	.7513	.5583
Within Groups	183	29510.3708	162.1449		
Total	187	29997.6791			

TABLE 19

Oneway Analysis of Variance - WISC-III Information Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	16.2127	4.0532	.7020	.5915
Within Groups	183	1056.6596	5.7741		
Total	187	1072.8723			

TABLE 20

Oneway Analysis of Variance - WISC-III Similarities Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	43.3826	10.8456	1.5751	.1828
Within Groups	183	1260.0802	6.8857		
Total	187	1303.4628			

TABLE 21

Oneway Analysis of Variance - WISC-III Arithmetic Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	31.8386	7.9596	1.4089	.2327
Within Groups	183	1033.8369	5.6494		
Total	187	1065.6755			

TABLE 22

Oneway Analysis of Variance - WISC-III Vocabulary Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	38.4772	9.6193	1.7428	.1424
Within Groups	183	1010.0494	5.5194		
Total	187	1048.5266			

TABLE 23

Oneway Analysis of Variance - WISC-III Comprehension Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	90.7461	22.6865	3.2405	.0135
Within Groups	183	1281.1901	7.0010		
Total	187	1371.9362			

TABLE 24

Oneway Analysis of Variance - WISC-III Digit Span Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	108.4985	27.1264	4.4077	.0020
Within Groups	183	1120.0042	6.1539		
Total	187	1228.5057			

TABLE 25

Oneway Analysis of Variance - WISC-III Picture Completion Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	175.1505	43.7876	7.7501	.0000
Within Groups	183	1007.9293	5.5078		
Total	187	1183.0798			

TABLE 26

Oneway Analysis of Variance - WISC-III Coding Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	55.2035	13.8009	1.3528	.2522
Within Groups	183	1866.9826	10.2021		
Total	187	1922.1862			

TABLE 27

Oneway Analysis of Variance - WISC-III Picture Arrangement Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	223.1850	55.7963	5.9338	.0002
Within Groups	183	1720.7724	9.4031		
Total	187	1943.9574			

TABLE 28

Oneway Analysis of Variance - WISC-III Block Design Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	72.8951	18.2238	2.3108	.0787
Within Groups	183	1565.1049	8.5525		
Total	187	1638.0000			

TABLE 29

Oneway Analysis of Variance - WISC-III Object Assembly Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	124.0802	31.0200	4.9561	.0008
Within Groups	183	1145.3879	6.2590		
Total	187	1269.4861			

TABLE 30

Oneway Analysis of Variance - WISC-III Symbol Search Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	28.5302	7.1325	.9151	.4563
Within Groups	183	1426.2996	7.7940		
Total	187	1454.8298			

TABLE 31

Oneway Analysis of Variance - WISC-III Mazes Subtest

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	21.6687	5.4172	.4735	.7551
Within Groups	183	2024.9247	11.4403		
Total	187	2046.5934			

TABLES 32 - 34

Oneway Analysis of Variance on WISC-III IQ Scores, Index Scores, and Individual Subtests

TABLE 32

Oneway Analysis of Variance - Reading Achievement Scores

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	18745.9224	4686.4806	36.2163	.0000
Within Groups	182	23551.2620	129.4025		
Total	186	42297.1845			

Note. Achievement scores included the WRAT-R, WIAT, and Canada QUIET

TABLE 33

Oneway Analysis of Variance - Math Achievement Scores

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	8608.9354	2152.2338	21.9778	.0000
Within Groups	182	17724.9262	97.9278		
Total	186	26333.8616			

Note. Achievement scores included the WRAT-R, WIAT, and Canada QUIET

TABLE 34

Oneway Analysis of Variance - Spelling Achievement Scores

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	4	16571.2379	4142.8099	34.7274	.0000
Within Groups	182	21711.7042	119.2951		
Total	186	38282.9439			

Note: Achievement scores included the WRAT-R, WIAT, and Canada QUIET

TABLES 35 - 54

Scheffé Tests of Comparison on WISC-III IQ Scores, Index Scores, and Individual Subtests

TABLE 35

Scheffé Test for Full Scale IQ

Mean	Group	Control	SLD	MLD	RLD	CSLD
97.52	Control					
100.58	SLD					
100.65	MLD					
102.22	RLD					
103.00	CSLD	*				

TABLE 36

Scheffé Test for Verbal IQ

Mean	Group	SLD	RLD	Control	MLD	CSLD
97.77	SLD					
97.78	RLD					
98.82	Control					
100.22	MLD					
100.68	CSLD					

TABLE 37

Scheffé Test for Performance IQ

Mean	Group	Control	MLD	SLD	CSLD	RLD
97.01	Control					
101.65	MLD					
104.11	SLD	*				
105.52	CSLD	*				
107.40	RLD	*				

TABLE 38

Scheffé Test for Verbal Comprehension Index

Mean	Group	RLD	SLD	Control	MLD	CSLD
97.41	RLD					
98.27	SLD					
99.31	Control					
102.17	MLD					
102.36	CSLD					

TABLE 39

Scheffé Test for Perceptual Organization Index

Mean	Group	Control	MLD	SLD	CSLD	RLD
98.41	Control					
103.78	MLD					
108.58	SLD	*				
109.32	CSLD	*				
109.81	RLD	*				

TABLE 40

Scheffé Test for Freedom From Distractibility Index

Mean	Group	CSLD	SLD	RLD	MLD	Control
92.64	CSLD					
95.96	SLD					
96.07	RLD					
98.09	MLD					
98.37	Control					

TABLE 41

Scheffé Test for Processing Speed Index

Mean	Group	CSLD	SLD	MLD	Control	RLD
93.44	CSLD					
93.50	SLD					
94.61	MLD					
96.79	Control					
97.67	RLD					

TABLE 42

Scheffé Test for Information Subtest

Mean	Group	CSLD	SLD	MLD	RLD	Control
8.92	CSLD					
9.04	SLD					
9.30	MLD					
9.33	RLD					
9.68	Control					

TABLE 43

Scheffé Test for Similarities Subtest

Mean	Group	RLD	Control	SLD	CSLD	MLD
9.33	RLD					
9.95	Control					
10.23	SLD					
10.28	CSLD					
11.13	MLD					

TABLE 44

Scheffé Test for Arithmetic Subtest

Mean	Group	MLD	SLD	CSLD	Control	RLD
8.61	MLD					
9.12	SLD					
9.16	CSLD					
9.47	Control					
10.11	RLD					

TABLE 45

Scheffé Test for Vocabulary Subtest

Mean	Group	RLD	Control	SLD	MLD	SLD
8.78	RLD					
9.53	Control					
10.08	CSLD					
10.09	MLD					
10.19	SLD					

TABLE 46

Scheffé Test for Comprehension Subtest

Mean	Group	SLD	Control	RLD	MLD	CSLD
9.35	SLD					
10.14	Control					
10.37	RLD					
10.83	MLD					
11.84	CSLD	*				

TABLE 47

Scheffé Test for Digit Span Subtest

Mean	Group	CSLD	RLD	SLD	Control	MLD
8.04	CSLD					
8.11	RLD					
8.85	SLD					
9.60	Control					
10.26	MLD					

TABLE 48

Scheffé Test for Picture Completion Subtest

Mean	Group	Control	MLD	RLD	SLD	CSLD
10.52	Control					
10.91	MLD					
12.26	RLD	*				
12.62	SLD	*				
12.72	CSLD	*				

TABLE 49

Scheffé Test for Coding Subtest

Mean	Group	SLD	CSLD	MLD	Control	RLD
7.54	SLD					
8.08	CSLD					
8.83	MLD					
8.84	Control					
9.30	RLD					

TABLE 50

Scheffé Test for Picture Arrangement Subtest

Mean	Group	Control	MLD	SLD	RLD	CSLD
9.47	Control					
10.70	MLD					
11.58	SLD					
11.59	RLD	*				
12.16	CSLD	*				

TABLE 51

Scheffé Test for Block Design

Mean	Group	Control	MLD	CSLD	SLD	RLD
9.49	Control					
9.70	MLD					
10.16	CSLD					
10.54	SLD					
11.22	RLD					

TABLE 52

Scheffé Test for Object Assembly Subtest

Mean	Group	Control	MLD	SLD	CSLD	RLD
9.09	Control					
10.35	MLD					
10.58	SLD					
10.76	CSLD					
11.00	RLD	*				

TABLE 53

Scheffé Test for Symbol Search Subtest

Mean	Group	MLD	CSLD	RLD	SLD	Control
8.65	MLD					
9.00	CSLD					
9.00	RLD					
9.54	SLD					
9.69	Control					

TABLE 54

Scheffé Test for Mazes Subtest

Mean	Group	RLD	Control	SLD	MLD	CSLD
9.70	RLD					
10.38	Control					
10.42	SLD					
10.43	MLD					
11.00	CSLD					

TABLES 55 - 57

Scheffé Tests of Comparison on WISC-III IQ Scores, Index Scores, and Individual Subtests

TABLE 55

Scheffé Test for Math Achievement Scores

Mean	Group	MLD	CSLD	SLD	Control	RLD
80.73	MLD					
81.94	CSLD					
95.12	SLD	*	*			
96.70	Control	*	*			
98.54	RLD	*	*			

Note: Significant at .05 level. Includes scores from the WRAT-R, WIAT, and Canada QUIET

TABLE 56

Scheffé Test for Reading Achievement Scores

Mean	Group	CSLD	RLD	SLD	MLD	Control
75.16	CSLD					
79.22	RLD					
94.10	SLD	*	*			
99.82	MLD	*	*			
100.24	Control	*	*			

Note: Includes scores from the WRAT-R, WIAT, and Canada QUIET

TABLE 57

Scheffé Test for Spelling Scores

Mean	Group	CSLD	RLD	SLD	MLD	Control
74.92	CSLD					
79.78	RLD					
80.04	SLD					
92.00	MLD	*	*	*		
98.05	Control	*	*	*		

APPENDIX E

Oneway Analysis of Variance for WISC-III Scores Within Groups

TABLES 58 - 64

TABLE 58

Oneway Analysis of Variance - SLD VC and PO Index Scores

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	15	978.3205	65.2214	1.1851	.0422
Within Groups	10	550.3333	55.0333		
Total	25	1528.6538			

TABLE 59

Oneway Analysis of Variance - Control PC and CD Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	10	181.2937	18.1294	2.0013	.0047
Within Groups	76	688.4534	9.0586		
Total	86	869.7471			

TABLE 60

Oneway Analysis of Variance - Control PC and SS Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	14	252.846	18.0605	2.4180	.0078
Within Groups	72	537.7738	7.4691		
Total	86	790.6207			

TABLE 61

Oneway Analysis of Variance - CSLD CD and SS Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	11	68.7000	6.2455	3.8118	.0125
Within Groups	13	21.3000	1.6385		
Total	24	90.0000			

TABLE 62

Oneway Analysis of Variance - CSLD CD and V Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	11	82.3900	7.4900	2.9109	.0353
Within Groups	13	33.4500	2.5731		
Total	24	115.8400			

TABLE 63

Oneway Analysis of Variance - CSLD PA and DS Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	10	52.7933	5.2793	3.0584	.0279
Within Groups	14	24.1667	1.7262		
Total	24				

TABLE 64

Oneway Analysis of Variance - CSLD BD and CD Subtests

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	F RATIO	F Prob.
Between Groups	9	216.2233	24.0248	4.1131	.0078
Within Groups	15	87.6167	5.8411		
Total	24				