AN INVESTIGATION OF
THE WISC-R CODING SUBTEST AS
A MEASURE OF LEARNING POTENTIAL

By
REINER KUPPERS
B.A., Walla Walla College, 1974

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in
THE FACULTY OF GRADUATE STUDIES
Department of
EDUCATIONAL PSYCHOLOGY
AND SPECIAL EDUCATION

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
March 1985
© Reiner Kuppers, 1985
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Educational Psychology and Special Education

The University of British Columbia
1956 Main Mall
Vancouver, Canada
V6T 1Y3

Date April 10, 1985
ABSTRACT

The purpose of this study was to compare the practice effects of "normal" students on the WISC-R Coding subtest to those of "learning disabled" students, to see if Coding can be used as a measure of "learning potential." In addition, data from the WISC-R Coding subtest were compared to subjects' scores from the four subtests of the British Columbia Quick Individual Educational Test (B.C.Q.U.I.E.T.). The WISC-R Coding subtest was administered to 38 students from two school districts, one urban and one rural; it was readministered approximately 24 hours later. Seventeen of the students were classified as "learning disabled" and came from regional learning centers in each district. Twenty one students selected from elementary schools in the two districts were classified as "normal."

Analysis of the data showed that the students could be pooled into two groups, one labeled "normal" and one "learning disabled." Further analysis found significant differences between the pre-and posttest Coding scores for the normal group but not for the learning disabled group. There was also a significant difference between the two groups on both their pre-and posttest Coding scores. Significant correlations were found between all four of the B.C.Q.U.I.E.T. subtest and posttest Coding scores for normal subjects. The learning disabled group's scores correlated significantly with the Coding subtest.
For the normal group no significant correlations were found between pre-and posttest Coding scores; however these scores were correlated significantly for the learning disabled group. A multivariate discriminant analysis found the two groups could be clearly separated by using a combination of all four B.C.Q.U.I.E.T. subtests and the pre-and posttest Coding scores.

Results indicated that students classified as "normal" showed significantly greater practice effects on the WISC-R Coding subtest than students classified as "learning disabled". Furthermore these two groups could be identified clearly using a discriminant analysis with a combination of all four subtests of the B.C.Q.U.I.E.T. and pre-and posttest Coding scores.

It would seem that there is merit in pursuing the use of the WISC-R Coding test-retest scores to screen for learning disabilities, especially in combination with B.C.Q.U.I.E.T. subtest scores. Implications were discussed.
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>viii</td>
</tr>
<tr>
<td>CHAPTER I: The Problem</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Coding and learning disabilities</td>
<td>2</td>
</tr>
<tr>
<td>Test-retest method with Coding scores</td>
<td>3</td>
</tr>
<tr>
<td>Summary</td>
<td>4</td>
</tr>
<tr>
<td>Purpose of the study</td>
<td>4</td>
</tr>
<tr>
<td>Research questions</td>
<td>6</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>7</td>
</tr>
<tr>
<td>Definition of terms</td>
<td>8</td>
</tr>
<tr>
<td>Summary</td>
<td>8</td>
</tr>
<tr>
<td>CHAPTER II: Review of the Literature</td>
<td>10</td>
</tr>
<tr>
<td>Problems of assessment</td>
<td>10</td>
</tr>
<tr>
<td>Wechsler Intelligence Scale and learning disabled populations</td>
<td>12</td>
</tr>
<tr>
<td>Performance of disabled readers on WISC subtests</td>
<td>12</td>
</tr>
<tr>
<td>Performance of subjects with learning problems on the WISC-R</td>
<td>13</td>
</tr>
<tr>
<td>Factor structure and test scatter of Wechsler scales</td>
<td>15</td>
</tr>
<tr>
<td>Coding</td>
<td>17</td>
</tr>
<tr>
<td>Validity of using Coding as a measure of learning ability</td>
<td>20</td>
</tr>
<tr>
<td>Test-retest as a measure of learning disability</td>
<td>22</td>
</tr>
<tr>
<td>Test-retest studies of the Wechsler scales</td>
<td>28</td>
</tr>
<tr>
<td>Summary</td>
<td>32</td>
</tr>
<tr>
<td>CHAPTER III: Method</td>
<td>35</td>
</tr>
<tr>
<td>Selection of subjects</td>
<td>35</td>
</tr>
<tr>
<td>Normal groups</td>
<td>36</td>
</tr>
<tr>
<td>Disabled groups</td>
<td>36</td>
</tr>
<tr>
<td>Instruments</td>
<td>36</td>
</tr>
<tr>
<td>Coding</td>
<td>37</td>
</tr>
<tr>
<td>B.C.Q.U.I.E.T.</td>
<td>38</td>
</tr>
<tr>
<td>Procedure</td>
<td>39</td>
</tr>
<tr>
<td>Normal group</td>
<td>39</td>
</tr>
<tr>
<td>Learning disabled group</td>
<td>39</td>
</tr>
<tr>
<td>Analysis of the data</td>
<td>40</td>
</tr>
<tr>
<td>Hypotheses 1-3</td>
<td>40</td>
</tr>
<tr>
<td>Hypothesis 4</td>
<td>40</td>
</tr>
<tr>
<td>Hypothesis 5</td>
<td>41</td>
</tr>
<tr>
<td>Summary</td>
<td>42</td>
</tr>
</tbody>
</table>
Table 1  
Means, standard deviations and t-test values for four B.C.Q.U.I.E.T subtests (normal groups: C-Chilliwack; K-Kamloops) ................. 45

Table 2  
Means, standard deviations and t-test values for four B.C.Q.U.I.E.T. subtests (learning disabled groups: C-Chilliwack; K-Kamloops) ............ 45

Table 3  
Means, standard deviations and t-test values for normal subjects (test-retest: WISC-R Coding subtest) ................................. 47

Table 4  
Means, standard deviations and t-test values for learning disabled subjects (test-retest: WISC-R Coding subtest) ................................. 49

Table 5  
Means, standard deviations and t-test values between normal and learning disabled subjects (WISC-R Coding subtest) ................................. 51

Table 6  
Means, standard deviations and t-test values between normal and learning disabled subjects (Retest: WISC-R Coding subtest) ................................. 51

Table 7  
Pearson r correlation coefficients between WISC-R Coding and B.C.Q.U.I.E.T. subtest scores (Normals-upper half, Learning disabled-lower) ................................................. 54

Table 8  
Pearson r correlation coefficients between WISC-R Coding and B.C.Q.U.I.E.T. subtest scores (Normals and learning disabled scores pooled) ................................................. 54

Table 9  
Discriminant analysis ................................................. 56
LIST OF FIGURES

Figure 1
Phases of Learning ................................................. 21

Figure 2
Some Selected Common Learning Difficulties of Learning Disabled Students Affecting Math Performance ........................................ 21
ACKNOWLEDGEMENTS

I would like to thank the members of my Thesis committee, Dr. E. Goetz, and Dr. H. Ratzlaff for having guided me through the research with so much patience, kindness and understanding. It has been a privilege for me to work with them.

I would also like to thank the students and teachers of the regional learning centers and elementary schools in the Chilliwack and Kamloops School Districts who took part in the study. Their willingness to participate at a busy time of year was greatly appreciated.

Finally I would like to thank my family for their encouragement and help, especially my wife Elizabeth for her patience and constant support and the many hours spent in typing drafts for me.
CHAPTER I

The Problem

Introduction

One of the challenges facing educators is that of discovering a child's learning potential or ability. This may be of special importance in the diagnosis and remediation of the learning disabled child where there can be conflicting ideas about the etiology of the disability. For example, a child may have a learning disability which manifests itself in an inability to perform at grade level in arithmetic. Educators and parents may disagree over whether this is because the child lacks motivation in that subject, has learned to dislike it and so does not perform, or, perhaps, has an organic problem. If there were a way to estimate the child's potential for academic learning, quickly and reliably, then perhaps an effective instructional method could be developed.

Presently, a child's learning potential is measured by two kinds of tests, achievement and IQ tests. According to Ross (1977) however, both of these measure what the child has learned in the past, not what he could perhaps learn in the future. One test, which may have the ability to measure a child's potential or learning ability is the Coding subtest of the WISC-R (Derner et al., 1950; Ross, 1977; Royer, 1971). This is a timed test which requires a subject to match each of a group of numbers with its appropriate symbol. It is similar to paired-associate learning tasks which according to some researchers, measure learning potential (Kratochwill, 1977).
Two kinds of research on the Coding test indicate its possible effectiveness as a measure of learning ability or potential. First, some researchers have established that Coding scores for learning disabled and reading disabled children differ significantly from the same scores for children of normal learning ability. Secondly test-retest studies of the WISC-R including the Coding subtest indicate a large practice effect for normal children and a very small one for the learning disabled.

Coding and Learning Disabilities. Some studies on the WISC-R have led researchers to suggest that the Coding subtest may be of singular diagnostic import for children with learning problems, as their Coding scores deviate substantially from all other subtests (Tabachnick, 1979). This finding has been supported by Rugel's (1974) review of 25 studies which showed that disabled readers' lowest scores were in the "sequential" category of a WISC-R factor analysis, a category which includes Coding. Lyle & Goyen (1969) have claimed that Coding differentiated between normal and retarded readers. Burks and Bruce (1955) have reported that the Coding subtest was the most difficult for poor readers. Raskin et al. (1978) found a good correlation between the WISC-R Arithmetic and Coding subtests and the Binet IQ for developmentally disabled children. Vance et al. (1980) found that learning disabled children had the lowest scores on the Arithmetic, Digit Span and Coding subtests of the WISC-R. No research has been reported, however, where Coding has been investigated as a single measure of learning ability or potential.
This research seems to suggest that the Coding test has the ability to differentiate between children of normal learning ability and children with a learning problem. One way to investigate further if Coding measures the ability to learn would be by using it in a test-retest situation.

**Test-Retest Method with Coding Scores.** Some researchers, notably Feuerstein (1979) and Budoff (1972) claim that learning potential or ability can be measured by testing a child once and then readministering the same test or tests. If there is a gain on the second administration they claim that this indicates something has been learned in the interval between the tests to cause the gain (greater gain means more has been learned).

Test-retest studies on normal populations using the WISC-R show a mean gain on the second administration of the Coding subtest, probably indicating a significant practice effect (Matarazzo et al., 1973; Quereshi, 1968; Tuma & Appelbaum, 1980). Other test-retest studies with this test show non-significant practice effects among students with learning problems (Lombard & Reidel, 1978). Catron & Catron (1977) found the same results for educably retarded students. One study (Solly, 1977) in which gifted students were compared with retarded students found a significantly greater gain for the gifted on a Coding subtest readministration.

The time interval between test administrations for these studies was between one day and a year. It is significant to note that the length of time between administrations was not important as in all cases there was a significant practice
effect for normal and no significant practice effect for students with learning problems. The relative size of the gain for normal students was greater, however, with a shorter time interval between administrations.

Except perhaps for Solly's (1977) study which compared gifted to learning disabled students, no research is reported in which test-retest data on the WISC-R Coding subtest for normal students is compared to students with learning problems. Such a comparison could be important to investigate whether there are significant differences in practice effects of a normal population as compared to a population with learning difficulties.

Summary

Since research seems to suggest that Coding scores on the WISC-R subtest can differentiate between normal students and those with learning problems, and since it seems that this difference can be measured by the test-retest method, this may suggest using Coding scores as a possible measure of learning potential. It also indicates the importance of exploring the use of a test-retest difference in Coding scores with a learning disabled population.

Purpose of the Study

Research suggests that normal students will have a higher mean gain on the second administration of the Coding subtest than learning disabled students. It also suggests that this subtest can differentiate between the two groups of students.
The present study proposes to compare the practice effects of normal students versus learning disabled students on the Coding subtest. It asks, will there be a difference between the two groups and if so will the difference be significant, indicating the need for further study in this area.

The classification of subjects into two groups, either learning disabled or normal was according to whether they had been referred to a Provincial regional center for learning disabilities as well as their scores on a current achievement test. An achievement test was employed because the main areas of learning as measured by achievement tests, such as reading, arithmetic and spelling have all been correlated with the Coding subtest (Derner et al., 1950; Hale, 1978; Lyle & Goyen, 1969; Raskin et al., 1978). The subjects' achievement test scores would also be compared to their Coding scores in order to further investigate the diagnostic qualities of the Coding subtest.

The achievement test selected for this study was the British Columbia Quick Individual Educational Test (B.C. Q.U.I.E.T.) (Wormeli, 1982). This test was selected because it was normed in British Columbia and thus more valid for the population sample of the study than other achievement tests. As well it consists of Spelling, Arithmetic, Word Identification and Passage Comprehension, all areas of academic learning which have been correlated in previous studies with Coding. The author also claims it has the ability to identify a learning disabled population (Wormeli, 1982).
In summary then, this study will compare the test-retest scores of learning disabled and normal students on the WISC-R Coding subtest. It will further examine relationships between subjects Coding scores and their current achievement test scores as measured by the B.C.Q.U.I.E.T.

Research Questions

This study was designed to answer the following research questions:

1. Will there be a significant mean gain in test-retest scores on the WISC-R Coding subtest for "normal" students over a 1-2 day period?

2. Will there be a statistically non-significant mean gain in test-retest scores on the WISC-R Coding subtest for "learning disabled" students over a 1-2 day period?

3. Will the "normal" students have a significantly higher score on the initial administration and retest of the WISC-R Coding subtest than the "learning disabled" students?

4. Is there a correlation between the initial and retest WISC-R Coding scores and scores from the B.C.Q.U.I.E.T. for "learning disabled" and "normal" students, first separately and then combined?

5. Will a combination of the test-retest scores of the WISC-R Coding subtest plus the four subtests of the B.C.Q.U.I.E.T. differentiate between the "normal" students and the "learning disabled" students?
Hypotheses

1. There will be no statistically significant test-retest mean score difference on the Coding subtest for "normal" students at the .05 confidence level.

2. There will be no statistically significant test-retest mean score difference on the Coding subtest for "learning disabled" students at the .05 confidence level.

3. There will be no statistically significant mean score difference between "normal" and "learning disabled" students on the initial and retest Coding score at the .05 confidence level.

4. There will be no statistically significant correlation between the Coding subtest scores and each of the four subtest scores of the B.C.Q.U.I.E.T. for both "normal" and "learning disabled" students, first separately and then combined, at the .05 confidence level.

5. There will be no statistically significant difference between the "normal" and "learning disabled" students on the combined mean score of the WISC-R Coding test and the four subtests of the B.C.Q.U.I.E.T.
Definition of Terms

1. **Academic Learning** - Is defined as the type of learning that takes place in schools during students' regular courses of study, such as language arts and arithmetic as measured by the B.C.Q.U.I.E.T.

2. **Academic Material** - Is defined as the type of material a student is asked to master in school.

3. **Learning Abilities** - Is defined as the ability of a student to master academic material. This may be what he has learned in the past as measured by achievement tests such as the B.C.Q.U.I.E.T., or what he can be expected to learn in the future, then called learning potential.

4. **Learning Potential** - Is used here to measure the future capacity of a student to learn academic material.

5. **Normal Students** - Refers to students in public schools who have no known learning disabilities and an average to above average IQ as measured by their scores on the B.C.Q.U.I.E.T.

6. **Learning Disabled Students** - Are defined as those who are more than one year behind in two or more school subjects, or who are in an inappropriate age/grade level, but have average to above IQ's as measured by the WISC-R.

Summary

The significance of this study will be to investigate whether or not the Coding subtest of the WISC-R is a measure of learning ability as indicated by Ross (1977). It will further attempt to see if this test correlates to areas of academic learning as measured by an achievement test, the test selected.
for this study being the B.C.Q.U.I.E.T. in view of its validity. This will be done by testing the five hypotheses listed earlier. As this is a preliminary study and involves relatively small populations the results of this study may not be widely generalized. However it is hoped that this study may indicate a need for further research in the area of measuring learning potential and the use of the WISC-R Coding subtest as a tool for achieving this.

In the next chapter the literature dealing with the performance of subjects on the WISC-R and especially the Coding subtest will be reviewed along with how this subtest relates to the rest of the WISC-R and other tests. Also reviewed will be the literature dealing with test-retest studies on the WISC-R. In Chapter Three the method and procedures of this study as well as selection of the subjects and analysis of the data will be described. Chapter Four will describe the results and analysis of the data. Chapter Five will discuss the implications and limitations of this study and present a view for further research.
CHAPTER II
A Review of the Literature

The review of the literature is organized around six main areas of interest. It reviews literature relevant to this study in:

- problems of assessment in learning potential;
- use of Wechsler's Coding Subtest and other measures of learning ability, to assess retarded readers, and to test Educably Mentally Retarded subjects;
- factor structure and test scatter of the Wechsler Scales;
- validity of Coding and its use as a measure of learning potential;
- test-retest procedures as a measure of learning ability; and
- practice effects on WISC-R Coding and other subtests, and its use as a measure of learning potential.

Problems of Assessment

The problem of measuring an individual's learning potential has existed from the earliest development of intellectual assessment. Thorndike (1926) complained about existing intelligence tests in that they did not directly measure an individual's ability to learn more things, more quickly than another individual. Sattler (1982) and Ross (1977) claimed that what intelligence tests do measure is acquired knowledge and that they yield an estimate of a child's current level of performance. In fact, Sattler (1982) claimed that "it is dangerous to make inferences from the current level
of performance to another level (called innate potential) because we cannot observe potential" (p. 50).

Hardy et al. (1976) conducted a study of 200 inner city children (77% black, 23% white), who were each given all subtests of the WISC. The mean Full Scale I.Q. was 96. Then the Information, Comprehension, Vocabulary, Digits Backward and Picture Arrangement subtests were readministered using a structured set of probing questions to ascertain the reason for the child's response. These responses were scored for correctness if the response was not according to the manual but was acceptable to the researchers in view of the child's background. The results yielded a significant mean increase in all the readministered tests at the .001 level. The conclusions drawn from this study were that for I.Q.'s obtained on a standardized test, the WISC may not be a valid estimate of the intellectual capabilities of inner city children.

This view, that intellectual potential cannot be measured has been challenged by other researchers. Kaufman claims that "Intelligence quotients are used to predict ability to learn in school, and the close theoretical relationship between intelligence and learning ability is indisputable" (Kaufman, 1979, pg.5). He goes further to state that the Animal House/Coding/Digit Symbol subtest of the Wechsler scales can be thought of as actual learning tasks. This is supported by Ross who states that "Coding, in fact, is best viewed as a test of ability to acquire new learning" (Ross, 1977, pg. 79).

To further support the concept that the Coding subtest of the WISC-R may be a measure of learning potential, the next
section will examine studies on the Wechsler Intelligence scales. It will be divided into two parts. The first will deal with the use of the Wechsler Scales with learning disabled populations. The second part will examine factor analytic studies of the Wechsler Scales and more specifically the uniqueness of the Coding subtest.

Wechsler Intelligence Scales and Learning Disabled Populations

The first subsection will review the performance of disabled readers on the WISC. The second subsection will review studies analyzing the performance of subjects with various learning problems.

Performance of Disabled Readers on WISC Subtests. Burks & Bruce (1955) found that poor readers who were one or more years below grade level on the reading part of the WRAT ranked lowest in Information, Arithmetic, Coding and Digit Span. They concluded that the Coding subtest is the most outstandingly difficult subtest for poor readers.

McLeod (1965) found a similar result when he reported a study of 177 successful and 116 unsuccessful readers. In this study a comparison was made between the subjects' scores on eleven of the subtests of the WISC. When adjustments were made for differences in Verbal IQ (VIQ) or Full Scale IQ (FSIQ), the retarded reading group scored significantly lower than the successful readers on Information, Vocabulary, Arithmetic, Digit Span and Coding. However, while Information, Vocabulary and Arithmetic correlated significantly with both FSIQ and VIQ for both groups, neither Digit Span nor Coding had a
significant correlation with IQ for either group. McLeod also listed eight other studies which found Coding to be weak in reading disabled students.

In a carefully controlled study of 54 retarded and 54 adequate readers, Lyle & Goyen (1969) found that IQ differences between the two groups were due principally to differences in Information, Arithmetic and Coding subtests. They speculated that a disability in the area of Coding may also be responsible for the poor performance in Information and Arithmetic. This suggests an underlying common thread linking these three subtests.

Rugel (1974) reviewed 25 studies which reported WISC subtest scores for disabled readers. The subtests were reclassified into categories labelled: Spatial, Conceptual and Sequential and disabled readers were ranked as to their relative strength in these categories. He found that disabled readers scored lowest in the sequential category which included the Coding and Digit Span Subtests.

Performance of Subjects with Learning Problems on the WISC-R. Hale (1978) administered both the WRAT and WISC-R to 155 referred children in Nebraska. A multiple regression analysis was conducted where VIQ and PIQ scores were jointly regressed on Reading, Spelling and Arithmetic standard scores from the WRAT. The results indicated that PIQ did not significantly predict academic achievement and that VIQ significantly predicted Reading and Arithmetic scores. No individual subtest scores were reported in this study although it would have been interesting to see the results of this with
Coding, especially since other researchers have suggested that Coding might possibly be part of the VIQ scale of the WISC (Lyle & Goyen, 1969; McLeod, 1965).

Raskin et al. (1978) reported a study in which 50 children, aged 6-1 to 10-11, who were referred for possible mental retardation or learning disabilities, were administered a battery of tests. The battery included the WISC-R, Stanford Binet, Bender VMG, Beery Developmental test of VMI, and the Reading, Spelling, Math subtests of the WRAT. A significant correlation was found between the WISC-R Arithmetic, Digit Span and Coding subtests and the Binet IQ. In view of the fact that the Binet is language oriented and correlates significantly with the Verbal IQ of the WISC-R (r = .84), this finding lends credence to the idea that the Arithmetic, Digit Span and Coding subtest of the WISC-R may be important in the assessment of language related learning disabilities.

Vance, Singer and Engin (1980) conducted a study to answer two questions: first, to determine whether any subtest differences existed between learning disabled males and females; and secondly, if the discrepancy between the WISC-R VIQ and PIQ was significant for this sample, and if it was of diagnostic importance. The WISC-R was administered to the subjects for this study who were 98 children (6-3 to 13-6 years; 69 males, 29 females) who had been labelled learning disabled. Results of this study indicated that both males and females obtained significantly higher scores on Picture Arrangement, Object Assembly, Vocabulary and Similarities. Further, females scored significantly higher than males on
Coding. Finally this study again pointed out that the lowest scores for all subjects were on the Arithmetic, Digit Span and Coding Subtests.

In summary, when the literature on the Wechsler scales and their relationship to learning problems is analyzed it seems apparent that learning disabled subjects have the most difficulty with the Arithmetic, Digit Span and Coding subtests. The next part of this section will review studies dealing with the Factor structure of the Wechsler scales, test scatter among the various subtests and comparisons of the subtests in formulating hypothesis.

Factor Structure and Test Scatter of Wechsler Scales

Since its inception the WISC has been subject to many factor analytic studies. Earlier studies by Cohen (1959), Maxwell (1959), Baumeister & Bartlett (1962), Bannatyne (1968), and Bortner & Birch (1969), laid the basis for dividing the WISC subtests into three main categories. The first category, often labelled as a verbal category, generally included the Information, Vocabulary, Similarities, Block Design, and Comprehension subtests. The second category, often labelled a Conceptual or Perceptual category, generally included the Object Assembly, Picture Completion, Picture Arrangement and sometimes the Arithmetic subtests. The third category, often labelled a distractibility or memory factor, usually included the Digit Span, Mazes, Coding and sometimes the Arithmetic subtests.

A factor analysis of Wechsler's standardization group for
the WISC-R by Kaufman (1975) revealed much the same findings as previous factor analysis on the WISC. Another study by Lombard & Riedel (1978) reported on a sample of 76 subjects who had been referred for various learning problems. Again, a factor analysis of their WISC-R scores indicated three categories which were consistent with the previous research. In this study the Coding subtest loaded very highly by itself on a single factor, leading the researchers to conclude that the Coding subtest may be measuring something very different from the other performance subtests.

Because of the unusual loading of the Coding subtest on Factor analytic studies, some researchers claim that this subtest along with Arithmetic, has some diagnostic abilities in terms of profile or scatter analysis (Kaufman, 1979). Tabachnick (1979) reported a study designed to investigate scatter on the WISC-R produced by a sample of 105 learning disabled children of average intellectual potential (IQ = 75-141) and comparing it to scatter from Kaufman's (1975) standardization sample as controls. No significant differences between learning disabled and controls in scatter for the Verbal subtests was found. There was however, significant Performance scale scatter for the learning disabled group as compared to the controls. The author concludes that:

The difference in WISC-R scatter between learning disabled and normal children is reliable and produced by learning disabled children showing consistently more scatter within the performance subtests and between verbal and performance subtests rather than within verbal subtests. Furthermore, these learning disabled children tend to have particular difficulty with Coding, with scores deviating substantially from all other subtests. This suggests that Coding scores may be of singular diagnostic import (p. 628).
In summary then, some factor analytic research on the Wechsler scales has revealed that the Coding subtest measures something different from the other subtests, and even from the general IQ scores themselves. Furthermore, Coding seems to have a unique ability to identify learning disabled children. The next section will review literature dealing with what the Coding subtest measures and if it can be used as a measure of learning potential.

Coding. In the various factor analytic studies reviewed previously, Coding often loaded by itself on a factor then usually labelled the distractibility or sometimes, memory, factor. Since this is a label that has been invented by the researchers it does not necessarily hold that Coding measures mainly the distractibility, attentional skills, or motivation that a subject may have. In fact, research tends to dispel the idea that Coding is a measure of distractibility or motivation.

Nalven & Puleo (1968) reported a study on 60 subjects, 30 males and 30 females, randomly selected from grades two to four, who were each administered the Digit Span subtest of the WISC. Each child was then rated on a distractibility scale by his classroom teacher. The distractibility measure had a high test-retest reliability of .92. When the distractibility ratings were intercorrelated with the Digit Span scores, it was found they were unrelated, r's ranging from .05 for raw scores to -.07 for scaled scores. The authors concluded that it is untenable to consider Digit Span a measure of classroom distractibility. Since Coding loads with Digit Span on the same distractibility category this research supports the idea
that Coding may not be a measure of distractibility. Further support for this idea comes from research conducted by Lyle & Johnson (1973) who studied the relationship between performance on the WISC Coding subtest and speed of writing and copying symbols. The effect of reinforcement on all three was also examined. The researchers compared 40 good coders (i.e. scaled scores >10) to 40 poor coders (scaled scores <8). An ANOVA found good coders significantly superior to poor coders in speed of writing X's and copying symbols. Reinforcement was not effective in increasing performance. When good and poor coders were randomly assigned to reinforcement and non-reinforcement treatment groups a significant groups effect (p < .05) was found, but the treatment effect and a group x treatment effect was found to be non-significant. The authors concluded that the "lack of significance for any of the group x treatment interactions discounted the possibility that the differences between good and bad coders was merely a matter of motivation" (p. 214). The view that the third category of which Coding is part, may not be appropriately labelled is also supported by Sattler (1982) who believes there is some difficulty in interpreting the meaning of the third factor. Kaufman (1979) adds his support by stating:

It is easy to see how children may score very poorly on the three WISC-R subtests constituting the third factor because of distractible behavior, but it is more difficult to visualize children scoring very well on the three subtests merely or primarily because of close attention to the tasks. Thus the possibility that the third factor may reflect a cognitive ability rather than a behavioral attribute is very real and must be considered as an active hypotheses when interpreting any child's WISC-R profile (p. 70).
Furthermore, no conclusive research has been published which shows a link between distractibility or motivation and Coding scores.

Very little research has been reported in which Coding alone has been investigated for the properties that it does measure. One study which did investigate the properties of the Coding test was that of Royer (1971). After testing 553 college students with the Digit Symbol subtest of the WAIS, a test similar to the Coding subtest of the WISC-R but normed for an adult population, Royer concluded that this subtest is a direct measure of the rate of information processing of visual symbols.

Among other researchers Kaufman (1979) claims that Coding requires analytic and sequential skills and demands a great deal of left-brain, right-brain integration. Ross (1977) claims that Coding is best viewed as a test of the ability to acquire new learning. Sattler (1982) claims that Coding:
- requires the ability to learn an unfamiliar task
- involves speed and accuracy of eye-hand coordination
- involves attentional skills
- requires short term memory
- possibly involves motivation
- requires the ability to learn combinations of symbols and shapes
- requires the ability to make associations quickly and accurately.

Estes (1974) claims that Coding involves a verbal encoding process as a major component.
In summary, although the WISC-R Coding subtest has often been classified as a measure of distractibility, research has not borne this out. Instead some researchers have claimed that Coding may really be measuring some cognitive abilities. No conclusive studies have been reported that have identified what properties Coding does measure. The following section will review what properties Coding may have as a measure of learning ability according to some researchers.

Validity of Using Coding as a Measure of Learning Ability

In the previously reviewed literature the properties of learning that Coding seems to measure have been outlined. To see if Coding can be useful in measuring a subject's learning abilities this section will examine the properties which some authors consider to comprise learning ability. First, Gagne (1970) has listed seven phases of learning. These are shown in Figure 1. An examination of the properties that Coding purports to measure and Gagne's Phases of Learning shows that indeed the Coding subtest would seem to measure all phases of learning.

Mercer (1983) has listed some selected common learning difficulties of learning disabled students. These are presented in Figure 2. Again a comparison with the properties that Coding purports to measure seems to indicate that Coding may measure some selected common learning difficulties of learning disabled students.
### Figure 1

**Phases of Learning**  
Gagne, R.M.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>learning experience provides incentive for learning</td>
</tr>
<tr>
<td>Apprehension</td>
<td>selective attention</td>
</tr>
<tr>
<td>Acquisition</td>
<td>material to be learned is stored in memory</td>
</tr>
<tr>
<td>Retention &amp; Recall</td>
<td>retention and recalling of material in memory</td>
</tr>
<tr>
<td>Generalization</td>
<td>using acquired information in different circumstances</td>
</tr>
<tr>
<td>Performance</td>
<td>observable process that something was learned</td>
</tr>
<tr>
<td>Feedback</td>
<td>information given as to adequacy of response results in motivation - completing cycle</td>
</tr>
</tbody>
</table>

### Figure 2

**Some Selected Common Learning Difficulties of Learning Disabled Students Affecting Math Performance**

<table>
<thead>
<tr>
<th>Learning Difficulty</th>
<th>Behavioral Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual</td>
<td>Copying Shapes</td>
</tr>
<tr>
<td>Memory</td>
<td>Retaining the meaning of symbols</td>
</tr>
<tr>
<td>Behavior Patterns</td>
<td>Attending to detail Switching from one operation to another</td>
</tr>
<tr>
<td>Motor</td>
<td>Writing numbers legibly with speed and accuracy</td>
</tr>
</tbody>
</table>
The last section of this review will examine first of all the studies that indicate the feasibility of using a test-retest method to measure learning potential. Secondly, it will review test-retest studies that have been conducted using the Wechsler scales and more specifically the Coding Subtest.

Test-Retest As a Measure of Learning Ability

A number of procedures that go beyond standard assessment techniques have been developed recently. These techniques are reviewed here because they demonstrate one way in which Coding might possibly be used to measure learning potential. Although these procedures are still experimental, enough research has been conducted on them to give them a measure of credibility.

Sattler has recommended such techniques as supplementary procedures "that can provide additional information useful in evaluating handicapped children and children referred because of poor school performance, and in developing remediation strategies" (Sattler, 1982, pg. 343). One such technique is the Learning Potential Assessment procedure developed and investigated variously by Budoff and his associates (1976) and Feuerstein (1979).

Budoff and Gottlieb (1976) reported that the Learning Potential Assessment procedure, which Budoff and his associates have developed, is an alternative to traditional verbally based intelligent tests for estimating general ability to reason. This assessment approach is based on a conceptualization of intelligence that stresses the ability of an individual to profit from learning experiences. In this assessment procedure
the individual is given reasoning tasks which are administered in a test-train-retest sequence. Training is given because it allows the individual to understand how to solve problems whose content may be strange and involve solving strategies not readily apparent to him. The tests used are an altered version of Kohs Block Designs, Raven's Progressive Matrices and the Series Learning Potential Test (SLPT).

The SLPT's major task is the completion of a series of pictures or geometric forms arranged in a pattern in which the figures change systematically. Each item consists of a horizontal row of cells each of which contains a stimulus figure. One cell is left blank and the subject must identify from among multiple choices which picture best completes the series.

In Folman and Budoff's (1971) study an interview survey was reported examining present vocational status and development of vocational goals in low income special and regular class adolescents. It was found that those adolescents classified as mentally retarded who seemed to have low learning potential functioned as the mentally retarded are often described, while those who seemed to have a higher learning potential are educationally retarded.

In a study by Babad and Budoff (1974) the authors attempted to investigate the sensitivity and validity of the Learning Potential Assessment procedure. They divided 207 white third grade children into three groups according to IQ scores: Bright-Normal, Dull-Average, and Subnormal. First the students were given the SLPT and some standardized training
while the teachers completed rating scales on all the subjects. The SLPT was given as a posttest three days later and this was followed by a test of General Ability several days later by the same tester. The results indicated that the learning potential predictions for the subnormal and dull-average sample were higher than their IQ predictions. Further, the dull-average group gained from practice significantly more than the subnormal group (t = 2.54, df = 60, p < .01). It was also found that both the subnormal and dull-average group gained more from training than the bright normal group.

These results indicated that learning potential testing showed a higher level of differentiation among low IQ, low SES subjects than a standard test of intelligence. Using a learning potential assessment procedure confirmed a considerable ability to reason among low IQ children which was not indicated by conventional standard measures of intelligence.

A study by Budoff and Corman (1974) examined demographic and psychometric factors related to performance on the Kohs learning potential procedure. In this study demographic and family characteristics along with WISC Verbal IQ and and Stanford-Binet scores for 627 EMR subjects were related to pre-and-post training Kohs learning potential scores. Partial correlation coefficients between performance on the Kohs test and demographic and psychometric factors were obtained from a stepwise multiple regression procedure. It was found that post-training Kohs scores were not related to race or SES, while pre-training Kohs, WISC Verbal IQ and Stanford-Binet
scores were related to factors indicating psychosocial vulnerability when the effects of all other independent variables were partialled out. This result supports the idea that a learning potential assessment procedure is in a sense, culture free, while standardized tests of IQ are often criticized as being culturally biased.

One significant aspect of the above study was the use of a multiple regression technique. The use of simple gain scores in statistical analysis has been criticized (Cronbach, 1960) because of the unreliability inherent in a score derived from the subtraction of pretest from posttest scores. In the multiple regression technique the gain for each subject can be thought of as the difference between his actual score and his predicted score as calculated from the regression weights of a given equation.

In a year long study of EMR children who were tested by the learning potential assessment technique and then randomly assigned to regular grades or special classes, Budoff and Gottlieb (1976) found further support for the use of the learning potential assessment technique. It was reported that children classified as high able by the learning potential procedure performed more competently academically than low able classified students, regardless of placement.

Feuerstein (1979) has developed a technique which he calls Learning Potential Assessment Device (LPAD) that he claims also measures a person's learning potential. This is similar to the techniques of Budoff and his associates in that it is a test-teach-test procedure in which the examiner and examinee
interact so as to better elicit change in the examinee. Feuerstein admits this contaminates the reliability of standard psychometric measures, but claims that his system models an ideal learning situation. This he claims, provides a framework within which the opportunity for success is maximized, making it possible to acquire insights into an individual's learning potential that would fail to surface in a standardized testing situation. Change produced during the course of assessment is interpreted as evidence of the individual's potential modifiability.

One of the studies which Feuerstein and his associates (1981) reported was to ascertain to what extent conventional tests accurately reflected the abilities of 34 eighth grade subjects from a rural school defined by the Israeli Ministry of Education as disadvantaged. The subjects were first tested on a standardized adult series of the Raven's Matrices, and then given a group administration of LPAD. The results for the Ravens Matrices (M = 29.5, SD = 8.8) placed the subjects in a well below average category, thus not eligible for academic High School. The results from the LPAD suggested that the Raven test severely underestimated ability.

In a second study Feuerstein et al. (1981) investigated to see if the low performance of some students in classes for students of low ability accurately reflected their abilities. In this study the students from two high functioning classes and two low functioning classes were tested on the Primary Mental Abilities (PMA) test (Thurstone, 1938) and the LPAD. Results showed that on the PMA the low functioning groups
scored lower than the high functioning groups, but on the LPAD tests only two of six comparisons yielded significant differences. The groups were then merged into heterogeneous classes. After one year the same tests were readministered. All groups improved on all the tests. On the PMA no significant differences were found between any of the groups. Some students from the high performing classes who were not included in the mixed classes provided a control against the possibility that high performing students came down to the level of the low performing ones.

Although research in learning potential has been limited, these studies, and especially those of Budoff and his associates which used large numbers of subjects, provide some evidence that a learning potential assessment based on a test-retest technique is a viable procedure for measuring the learning abilities of students.

In summary, studies have been reviewed in this section in which researchers have examined several experimental procedures for measuring learning potential. These procedures are based on a test-train-retest method which uses the gain on the retest of a certain test as a measure of learning potential. Although experimental and limited in number, the studies were reliable and indicate this procedure may have some validity in measuring learning potential. They are important to the present study as they indicate one way that the WISC-R Coding subtest might be used to see if this subtest may measure learning potential. The next section will review studies in which test-retest studies of the Wechsler scales, and especially the Coding
subtest have been carried out.

**Test-Retest Studies of the Wechsler Scales.** One of the earlier test-retest studies on the Wechsler scales was the reliability study by Derner et al. (1950), on the Wechsler-Bellvue scale. The purpose of this study was to determine subtest reliability and the effect on reliability of varying lengths of time before retesting. Three groups of normal subjects were retested. One group of 38 subjects was retested with a six month interval between tests, another group of 60 subjects was retested with a four week interval, and the third group of 60 subjects was retested with a one week interval between tests. Ages for the subjects ranged from 21.5 to 49.6 years and full scale IQ scores from 110.1 to 118.5. It was found that every group mean increased significantly in the retest. It was also found that the six month test interval group increased less than the other two groups and the four week interval group increased less than the one week test interval group.

A t-test for the significance of the difference between coefficients of relative variation, which decreased the size of the standard error so as to make small differences significant, indicated that every subtest showed a significant difference on the retest. The most stable subtests were; Vocabulary, Information, Block Design, Picture Completion and Digit Symbol (Coding). Since the reliability coefficient, as determined by retesting, shows to what degree a subject's relative position in a sample group remains the same over time, the consistency of the practice effect can be noted, as practice effect may
cause the score on the retest to be higher than on the first administration. Therefore this study seems to indicate that as Digit Symbol (Coding) has a high test-retest reliability, ($r = .78 - .85$ over 1 week and 6 months), its practice effect will be consistent over time. Furthermore, it also seems to indicate that the practice effect will be lessened as the interval between retests is increased.

Lazarus and Erickson (1952) compared high and low achievers on a test-retest study of the WAIS. Results of their study indicated that high achievers improved and low achievers did more poorly on the second administration of the Digit Symbol (Coding) subtest.

In a study by Irwin (1966) the reliability of the WISC at two selected age levels was investigated. Sixty subjects of comparable intelligence, aged 5-7 to 6-6 years or 10-7 to 11-7, were retested at 28 or 35 days respectively. Split-half reliability coefficients indicated a general trend for an increase in reliability from the six year to the eleven year age group. The high reliability found for the Coding subtest ($r = .67$ and .88 respectively) added further support to the earlier finding of Derner et al. (1950).

Quereshi (1968) retested 328 subjects, at five age levels between five and fourteen years, over a three month period with the WISC. An analysis of variance revealed that practice effects for Coding were significant at all age brackets ($p < .001$). Additional support for earlier studies was the finding that the Information, Vocabulary, Block Design and Coding subtests yielded the most stable scores on test-retest
correlations.

Two further studies which found the Coding subtest to be one of the most stable of the Wechsler scales' subtests were those of Matarazzo et al. (1973), and Tuma and Appelbaum (1980). The study by Matarazzo found Coding to have the highest reliability of the WAIS subtests \( r = .87 \) for normal men over a three to five month retest period. Furthermore, the mean gain for this subtest was found to be one point with no relationship being noted between initial IQ and size of gain. In Tuma and Appelbaum's (1980) study Block Design and Coding were found to be the most stable of the WISC-R Performance scale subtests among normal children over a six month retest period \( r = .78 \) for both. A net gain for Coding was found to be the largest for all of the subtests except for Picture Completion and Arrangement. However both the Picture Completion and Arrangement subtests were also found to be the most unstable \( r = .65 \) and .54 respectively.

In test-retest reliability studies among populations with learning problems the Coding subtest was usually found to be very reliable but, and in contrast to studies with normal children, very little gain was exhibited on the retest. In studies by Gironda (1977), and Catron and Catron (1977), where EMR children's WISC-R scores were compared with previously administered WISC scores over a three year time interval there was generally over a one point loss for the Coding subtest. The authors admit that the reason for a one point loss on the Coding retest may be due to more stringent norms on the revised WISC-R making it harder to score as well on the WISC-R as on
the WISC. This was evident not only in the Coding scores but, in both studies, there was a loss on most subtests of the WISC-R as well. In Catron and Catron's study Coding showed the greatest loss of all the subtests of the WISC-R when compared to previously given WISC scores. The time interval for the retest in this study was three weeks.

A study by Solly (1977) compared the WISC and WISC-R scores of gifted and EMR children. Twelve gifted and twelve EMR children randomly selected were administered the WISC and WISC-R in counterbalanced order, to minimize practice effect, within 72 hours of each other. Using a 2 x 2 x 2 repeated measures analysis the author found that mean WISC scores were significantly higher than WISC-R scores in both the gifted and retarded groups (p < .001). However the Coding subtest seemed to show least practice effect for subtests in the disabled group.

Lombard and Riedel (1978) compared the old (WISC) and new (WISC-R) formats of the Coding B subtest during a factor analytic study of the WISC-R among rural children with learning problems. Subjects were given the entire WISC-R with some receiving the old (WISC) form of the Coding subtest early in the testing and the new (WISC-R) form at the end, while the other subjects received the two tests in the opposite order. No order effects were found, indicating that whatever practice effect existed was too small to measure. The authors found this to be a concern because they had found a strong and significant practice effect with college age subjects.

Smith (1978) administered the WISC-R to 161 learning
disabled children and then readministered it eight months later. A comparison of the test-retest results found the profiles almost identical with a very small increase in scores on the second administration. The only exception was vocabulary which showed a decrease. The mean gain on the Coding subtest was .4 of a scaled score point. Along with Block Design (gain = .1) Coding was least susceptible to the influence of practice. The relative magnitudes of the mean subtest changes in this study corresponded closely to those reported by Wechsler (1974).

This section reviewed studies dealing with test-retest studies of the WISC and WISC-R Coding subtest. These studies indicated that normal or gifted subjects generally improved significantly on a retest while learning disabled subjects did not. Furthermore, these studies indicated that the increase on a retest of this subtest was greater over a short time interval than over a longer period of time. However this subtest was also found to be reliable with the increase on the retest being consistent over time. These studies add further support to the idea that the Coding subtest of the WISC-R might be used as a measure of learning potential if the test-retest scores are used to differentiate between normal and learning disabled subjects.

Summary

This review of the literature examined studies which dealt with the problems of the assessment of learning potential. While some investigators claimed that standardized tests may
not be a valid measure of a child's intellectual potential, others claimed that some subtests of the WISC-R may be thought of as learning tasks. One of these is Coding which they claim may be a test of a subject's ability to acquire new learning.

In the next section of this review factor analytic studies of the WISC and WISC-R were examined. It was concluded from these studies that learning disabled subjects seemed to have the most difficulty with the Arithmetic, Digit Span and Coding subtests. Further studies in this area indicated that the Coding subtest measures something different from the other subtests and perhaps even from the general IQ scores. Coding also seemed to identify learning disabled children. Although factor analytic studies put the Coding subtest in a category labelled "Distractibility," studies reviewed seemed to indicate that Coding does not measure distractible behavior to any significant degree. Researchers indicated that in fact it may measure some cognitive ability, and although some suggestions of which cognitive functions it may measure were listed, no studies were reported which precisely defined which ones it really measures.

The next section of this review analyzed studies by some researchers which advocated the use of a test-train-retest procedure to measure learning potential. Although these researchers admit this is an experimental procedure these studies have good reliability and in some cases used large numbers of subjects to provide some evidence that this procedure may be a viable way of measuring the learning potential of students.
The last section of this review examined test-retest studies of the Wechsler Intelligence Scales. It was found that generally normal and gifted subjects of all ages improved significantly on the retest of most of the WISC and WISC-R subtests, and specifically the Coding subtest. Learning disabled subjects generally did not improve significantly and in some cases did worse on the retest. This effect was consistent over time for both the normal and learning disabled subjects with a greater increase over the shorter retest period.

Chapter 3 will outline the methods and procedures of this study. The selection of subjects will be explained as well as a description of the tests used. Lastly the procedures for analyzing the data will be described.
CHAPTER III

Method

Subjects

The purpose of this study was to compare two samples, one comprised of a learning disabled group of students, and the other of normal students, in terms of their performance on a test-retest administration of the WISC-R Coding subtest. The samples for this study were drawn from two school districts; Chilliwack School District and Kamloops School District. Learning disabled students were drawn from the regional education centers in each district. The Chilliwack school from which the normal sample was drawn was located in a rural setting, its population comprised basically of rural children of lower socio-economic status (SES). The Kamloops school from which the normal sample was drawn was in a suburban setting, its population comprised mainly of urban children from middle to upper middle class backgrounds. After consultation with the children's teachers in both districts, it was assumed, that the SES of the normal sample group was similar to that of the learning disabled group.

Students from grades two to six were selected for the sample as this was the same age used in other studies on practice effects of the WISC-R (Tuma & Appelbaum 1980, Smith 1978, Lombard & Reidel 1978). The number of subjects for each group was determined by the number of students available from the regional learning disabled education centers. Thus for each learning disabled student selected from the regional center, one child was randomly selected from the public school
for inclusion in the normal group. The selection of public schools was dictated by the school district administration.

**Normal Groups.** To qualify for one of the two groups of normal students, children were to:

- be in grades two to six
- have no known learning disability
- be performing at an adequate level in all subjects as determined by their teacher; and
- have a learning potential in the normal to above normal range as determined by a WISC-R IQ score.

Most of the children from the regular classrooms did not have a WISC-R IQ score available. In its place their B.C.Q.U.I.E.T. scores were interpreted so that if average to above scores were obtained in all four subtests, this would indicate a normal IQ range (Wormeli, 1982).

**Disabled Groups.** To qualify for one of the two learning disabled groups children were to:

- be in grades two to six
- have been referred to a regional education center because they were suspected of having a learning disability
- be performing one or more years below grade level on one or more academic subjects
- have a learning potential in the normal to above normal range as determined by a WISC-R IQ score.

**Instruments**

The instruments used in this study were the Coding Subtest of the WISC-R (Wechsler, 1974), and the B.C.Q.U.I.E.T. (Wormeli, 1982).
**Coding.** The Coding subtest of the WISC-R (Wechsler 1974) is composed of two parts. Coding A is administered to children under 8 years of age. It consists of five shapes: a star, circle, triangle, cross, and square. Each shape has a different mark in it. The five shapes are followed by five practice shapes and the forty-three shapes of the subtest proper. The child is required to place in each of the shapes of the subtest the mark that is found in the initial five sample shapes.

Coding B, which is administered to children 8 years old and over, consists of boxes containing the numbers 1 through 9 and a symbol below each number. The child is required to copy the symbol associated with the appropriate number in an empty box under the 93 boxes of numbers that make up the subtest proper. The time limit is 120 seconds for both Coding A and B.

According to research Coding requires the ability to learn an unfamiliar task, involves speed and accuracy of eye hand coordination, attentional skills, short term memory and motivation (Sattler 1982, p. 186). Coding is a somewhat reliable subtest of the WISC-R (r = .72), but has a low correlation with the Full Scale WISC-R IQ (r = .38) with the Performance Scale (r = .33) and the Verbal Scale (r = .36) (Sattler 1982).

The low correlation of Coding with the other subtests of the WISC-R, plus the fact that on Factor Analytic studies Coding does not fit well into any of the given factors (Kaufman 1975) suggests that the Coding subtest may be measuring something other than what is measured by the WISC-R. This has
led some researchers to suggest that it may have singular diagnostic importance (Tabachnick 1979).

**B.C.Q.U.I.E.T.** The B.C. Quick Individual Educational Test (Wormeli, 1982), consists of four subtests which may be administered together or separately. The subtests are designed to be used at the elementary level (grades one to seven), and measure students progress in Spelling, Arithmetic, Word Identification and Passage Comprehension. The items in the subtests are all selected from B.C. Ministry of Education prescribed textbooks, or represent learning outcomes of the Ministry’s Curriculum Guides.

Each of the subtests are administered individually to students and take about fifteen minutes to complete. After a student’s raw score is determined these are then converted into Normal Curve Equivalents (NCE’s) which have a range of 1 to 100 and a mean of 50. Since the NCE is a standard score it can be readily used in statistical analysis.

The author (Wormeli, 1982) claims that the B.C.Q.U.I.E.T. can be used as a screening device to identify students who are eligible for referral to remedial services. A validation study is shown which demonstrates that the Word Identification subtest identified better than 90% of those grade 3 students receiving remedial instruction in reading. For the Spelling and Arithmetic subtests this figure was 85%. For grade 7 the figures were 93%, 92% and 63% respectively. When one takes into consideration the widely differing standards by which learning disabled children are identified throughout the Province this test seems to have excellent reliability in
identifying learning disabled pupils.

The B.C.Q.U.I.E.T. was normed on approximately 150 pupils at each of the seven elementary grade levels. Internal reliability is good for all subtests in all grade levels (r = .75 to .96). The test's validity for measuring the academic learning of British Columbia students is excellent as the test is based on materials and curricula used in British Columbia schools.

Procedure

Normal group. Each of the subjects was tested individually. The subjects in the normal groups were first administered the Coding subtest of the WISC-R, followed immediately by the four subtests of the B.C.Q.U.I.E.T. Subjects were then told they would be given one of the tests again, as a check-up. Subjects were tested in the afternoon with the Coding retest written the next morning. All tests were administered by the author according to standardized procedure following all instructions in the appropriate manual.

Learning disabled group. The subjects in the learning disabled groups were not administered the B.C.Q.U.I.E.T., as all had been given that test between one to eight weeks earlier, by learning center staff. These subjects were first given the Coding subtest in the morning with a promise that they would do it again later as a "check." Each subject was then readministered the test the next morning. Both the initial test and retest of the Coding subtest was administered by the author according to published standardized procedures.
Testing of the learning disabled and normal groups on the WISC-R Coding subtest was done during the second and third weeks of June. Motivation of the students in doing the tests was felt to be very good. The students seemed to enjoy getting out of the regular class for a while and seemed to want to impress the test administrator with what they knew. Motivation on the retest of the Coding subtest was felt to be especially good as the test took only a very short time to do and some students seemed to perceive it as a "game" or "puzzle."

Analysis of the Data

Hypotheses 1-3. The first three hypotheses, which question whether there is a difference between "normal" and "learning disabled" subjects on pre and posttest Coding scores were analyzed using an appropriate t-test (Ferguson 1981). The t-test was used for these analyses because it assumes normality of distributions in the populations from which the samples are drawn. Furthermore it assumes that these populations have equal variances. Since both the Coding subtest of the WISC-R and the B.C.Q.U.I.E.T. use quasi-interval measurement scales the above assumptions are met in using the t-test to test the first three hypotheses. A further reason for selecting the t-test was that this test is quite robust even for very small samples (Ferguson 1981, p. 181), and in this study a relatively small number of subjects was available.

Hypothesis 4. is designed to examine what correlations exist between the pre and posttest Coding scores of the WISC-R and the four subtests of the B.C.Q.U.I.E.T. This hypothesis
was analyzed using the Pearson product-moment correlation coefficient (Ferguson, 1981). Again, because this statistic is used with interval-ratio data it was an appropriate one to use with both the WISC-R Coding subtest and the B.C.Q.U.I.E.T. whose scales are measured in a quasi-interval, standard score form. The results obtained by this statistic must be interpreted with caution since it is believed that the N in this statistic should be 30 or more (Glass & Stanley, 1970) and in this study the N in the groups was less (17 and 21). However when the Pearson correlation coefficient statistic was performed on the WISC-R and B.C.Q.U.I.E.T scores of the combined learning disabled and normal group, the total N exceeded 30 and thus this statistic can be interpreted with confidence.

Hypothesis 5. is concerned with differences between "normal" and "learning disabled" groups as a function of each of their WISC-R Coding and B.C.Q.U.I.E.T. subtest scores. This was analyzed using a multivariate Discriminant Analysis. This is a particular case of multiple regression which assigns weights to independent variables in order that the weighted sum of scores will provide the best possible differentiation or discrimination between two criterion groups. An assumption made by this analysis is that the data is expressed in standard score form (Ferguson 1981, p. 473). This assumption is met since both the WISC-R Coding and B.C.Q.U.I.E.T. scores are recorded in this form. This analysis shows what subtest or combination of subtests has the greatest effect on classifying someone as a member of either the "normal" or "learning
disabled" group.

Summary

Four groups of subjects, two consisting of students defined as normal and two defined as learning disabled were selected from two school districts, Chilliwack and Kamloops. Each student was administered a WISC-R Coding subtest and the four subtests of the B.C.Q.U.I.E.T., according to their published standardized procedure, on the same day. The morning following this administration each student was retested with the WISC-R Coding subtest. Data from these tests were compiled and appropriate t-tests (dependant or independent) were performed to test the first three hypotheses, to see whether significant test-retest differences occur between the normal and learning disabled groups. Pearson product-moment correlation coefficients were calculated between the WISC-R and B.C.Q.U.I.E.T. subtest scores to see if any significant correlations existed among any of these subtests. Finally a multivariate discriminant analysis was performed on the results from the subtests administered to see which subtest or combination thereof had the greatest effect on classifying a student as a member of either of the two groups.

The next chapter will present the results of the study. It will analyze the data and tables will show the statistical analyses performed.
CHAPTER IV

Results

Analysis of the data

This chapter presents the descriptive data and the results from statistical analyses of the data. These data are then related to the five hypotheses tested in this investigation.

Forty subjects from grades two to six were administered the Coding subtest of the WISC-R in a test-retest format with the retest taking place the following day. After the administration of the Coding pretest, the students who were classified as normals were administered the four subtests of the B.C.Q.U.I.E.T. The subjects classified as learning disabled had all been given the subtests of the B.C.Q.U.I.E.T. within the last 8 weeks. The subjects were drawn from two elementary schools in two school districts of British Columbia, and two learning centers for learning disabled students associated with the two school districts.

Subjects from the two elementary schools were classified as normals if inspection of their B.C.Q.U.I.E.T. scores revealed that all of the four subtest scores were average to above, that is a normal-curve equivalent (NCE) score of 29.0 or over. Two subjects failed this criteria and were discarded from further analysis. The subjects from the learning centers were classified as learning disabled if their WISC-R IQ scores were in a normal to above range and if their scores on the B.C.Q.U.I.E.T. were below average for their age grade level, that is a NCE score of 28.9 or less (Wormeli, 1982). This criteria is similar to that used in other studies which
labelled subjects as learning disabled if their IQ was in a normal to above range and they had been referred to a learning or resource center (Hale, 1978; Lyle & Goyen, 1969; Tabachnick, 1979; Vance et al., 1980). This classification resulted in four groups being formed. The two normal groups from the Chilliwack and Kamloops School Districts had 10 and 11 subjects respectively, and the two learning disabled groups from these two areas had 10 and 7 subjects respectively.

Prior to any statistical analysis of the five main hypotheses, data were analyzed to see if the four groups could be pooled into two, one normal and one learning disabled group. The greater number in each group by pooling would provide greater power for any statistical analysis. Independent t-tests on all four measures of the B.C.Q.U.I.E.T., comparing the Chilliwack and Kamloops normal groups indicated no significant differences between the groups on any of the measures. This suggested that both the Chilliwack and Kamloops groups could be pooled to form one group labelled "normal." A similar analysis of the learning disabled groups showed it was also possible to pool the subjects from the Kamloops and Chilliwack regional centers into a group labelled "learning disabled." Results of these analyses are found in Tables 1 and 2.
Table 1

Means, standard deviations and t-test values for four B.C.Q.U.I.E.T. subtests
(Normal groups: C-Chilliwack; K-Kamloops).

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Group</th>
<th>X</th>
<th>s</th>
<th>n</th>
<th>t-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spelling</td>
<td>CPS</td>
<td>66.34</td>
<td>12.87</td>
<td>10</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>KPS</td>
<td>57.98</td>
<td>20.78</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>CPS</td>
<td>52.41</td>
<td>20.58</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KPS</td>
<td>59.42</td>
<td>17.21</td>
<td>11</td>
<td>-0.85</td>
</tr>
<tr>
<td>Word ID</td>
<td>CPS</td>
<td>51.44</td>
<td>8.83</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KPS</td>
<td>55.74</td>
<td>17.86</td>
<td>11</td>
<td>0.56</td>
</tr>
<tr>
<td>Pass Comp.</td>
<td>CPS</td>
<td>52.24</td>
<td>12.19</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KPS</td>
<td>59.07</td>
<td>13.20</td>
<td>11</td>
<td>-1.23</td>
</tr>
</tbody>
</table>

*Value of t for significance = 2.09 (p < .05)

Table 2

Means, standard deviations and t-test values for four B.C.Q.U.I.E.T. subtests
(Learning disabled groups: C-Chilliwack; K-Kamloops).

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Group</th>
<th>X</th>
<th>s</th>
<th>n</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spelling</td>
<td>CLC</td>
<td>3.65</td>
<td>2.57</td>
<td>10</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>KLC</td>
<td>1.91</td>
<td>0.95</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>CLC</td>
<td>3.70</td>
<td>3.40</td>
<td>10</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>KLC</td>
<td>3.11</td>
<td>3.76</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Word ID</td>
<td>CLC</td>
<td>7.71</td>
<td>2.05</td>
<td>10</td>
<td>-0.15</td>
</tr>
<tr>
<td></td>
<td>KLC</td>
<td>8.60</td>
<td>2.28</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Pass Comp.</td>
<td>CLC</td>
<td>9.36</td>
<td>5.54</td>
<td>10</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>KLC</td>
<td>5.44</td>
<td>2.34</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*Level of t for significance = 2.13 (p < .05)
The main hypotheses were analyzed using the pooled scores for the two groups. Dependent t-tests (Ferguson, 1981) were used to analyze the significance of gains on the Coding subtest for the two groups. The data from these analyses are presented in Tables 3 and 4. An independent t-test (Ferguson, 1981) was used to test the significance of the difference between the two groups based on their Coding scores. This statistic is presented in Tables 5 and 6. Table 7 shows the correlation between the Coding and B.C.Q.U.I.E.T. subtests for the two groups. Table 8 shows the correlation for the B.C.Q.U.I.E.T. and Coding subtests for the two groups combined. Results of a discriminant analysis were computed using the OWMAR (UBC) computer program. They are presented in Table 9 and Appendix A. The results of these analyses are important to a discussion of the hypotheses.

**Hypothesis One:** There will be no statistically significant test-retest mean score difference on the Coding subtest for "normal" students at the .05 confidence level. This hypothesis was rejected. As Table 3 indicates there was clearly a significant test-retest mean score difference for the normal group \( t = 6.48, p < .05 \). This means that for the normal group, students scored significantly higher on the retest. It also indicates that some measurable learning took place between the two tests which may be an indicator of learning potential in this group.
Table 3

Means, standard deviations and t-test value for normal subjects
(Test-retest: WISC-R Coding Subtest)

<table>
<thead>
<tr>
<th></th>
<th>( \bar{X} )</th>
<th>s</th>
<th>n</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>10.57</td>
<td>2.60</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Retest</td>
<td>13.05</td>
<td>2.72</td>
<td>21</td>
<td>-6.48</td>
</tr>
</tbody>
</table>

Value of t for significance = 2.09 (\( p < .05 \))
Hypothesis Two: There will be no statistically significant test-retest mean score difference on the Coding subtest for "learning disabled" students at the .05 confidence level. As Table 4 indicates this hypothesis was supported at the .001 level but not at the .05 level. This result concurs with other studies at the .001 level (Solly 1977, Smith 1978) which supported this hypothesis. This finding seems to indicate that these students have a limited potential to learn from the first test, perhaps also indicating a measure of their learning potential.
Table 4

Means, standard deviations and t-test values for learning disabled subjects
(Test-retest: WISC-R Coding Subtest)

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>s</th>
<th>n</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>8.00</td>
<td>2.45</td>
<td>17</td>
<td>-2.98</td>
</tr>
<tr>
<td>retest</td>
<td>9.18</td>
<td>3.05</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

*Value of t for significance = 4.01 (p < .001)
Hypothesis Three: There will be no statistically significant mean score difference between "normal" and "learning disabled" students on the initial and retest Coding score at the .05 confidence level. This hypothesis was rejected. As Table 5 indicates the normal subjects clearly scored significantly higher than the learning disabled group on the initial administration of the Coding subtest ($t = 3.11, p < .05$). An analysis of their retest scores as presented in Table 6 clearly indicates that again the normal subjects scored significantly higher than the learning disabled subjects ($t = 4.13, p < .05$).

Results from analyzing the data of Hypothesis three seem to indicate that the normal subjects scored higher on the Coding subtest than the learning disabled students. This was true not only of their scores on the initial administration of the test but also on the retest. Furthermore, the normal group seemed to exhibit a greater gain between the initial test score ($X = 10.57$) and the retest score ($X = 13.05$), as compared to the initial test ($X = 8.00$) and retest scores ($X = 9.18$) of the learning disabled group. This finding compares favourably to that of previous research (Solly, 1977) which found similar results.
Table 5

Means, standard deviations and t-test value between normal and learning disabled subjects (WISC-R Coding Subtest)

<table>
<thead>
<tr>
<th>Groups</th>
<th>$\bar{X}$</th>
<th>s</th>
<th>n</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normals</td>
<td>10.57</td>
<td>2.60</td>
<td>21</td>
<td>3.11</td>
</tr>
<tr>
<td>Disabled</td>
<td>8.00</td>
<td>2.45</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

*Value of t for significance = 2.04 ($p < .05$)

Table 6

Means standard deviations and t-test value between normal and learning disabled subjects (Retest: WISC-R Coding Subtest)

<table>
<thead>
<tr>
<th>Groups</th>
<th>$\bar{X}$</th>
<th>s</th>
<th>n</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normals</td>
<td>13.05</td>
<td>2.72</td>
<td>21</td>
<td>4.13</td>
</tr>
<tr>
<td>Disabled</td>
<td>9.18</td>
<td>3.05</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

*Value of t for significance = 2.04 ($p < .05$)
Hypothesis Four: There will be no statistically significant correlation between the Coding subtest scores and each of the four subtest scores of the B.C.Q.U.I.E.T. for both "normal" and "learning disabled" students, first separately and then combined, at the .05 confidence level. This Hypothesis was supported. As Table 7 indicates there clearly was no positive correlation between the initial Coding score and any of the subtests of the B.C.Q.U.I.E.T. for either normal or learning disabled subjects. Another finding was that the posttest Coding score did not correlate significantly with the pretest Coding score for the normal group, but correlated significantly to the pretest Coding score for the learning disabled group. Furthermore, for the normal group the posttest Coding score correlated significantly with all the subtests of the B.C.Q.U.I.E.T. Conversely, this was not true for the learning disabled group. Their posttest score did not correlate significantly with any of the B.C.Q.U.I.E.T. subtests.

Table 8 shows a correlation matrix for the total combined sample population. As this analysis used a sample of 38 it can be confidently interpreted (Ferguson, 1981). This supports the previous analysis in that it shows no significant correlations between the Coding pretest and any of the other subtests. Again however, the Coding posttest seems to be significantly correlated with Spelling, Word Identification, and the Passage Comprehension subtests of the B.C.Q.U.I.E.T.
Another finding was that in all of the correlation analysis the Math subtest of the B.C.Q.U.I.E.T. did not correlate significantly with either the pre or posttest Coding scores. An exception was in the case of Coding posttest in the normal group where it was statistically but not practically significant.
Table 7
Pearson r correlation coefficients between WISC-R Coding and B.C.Q.U.I.E.T. subtest scores
(Normals—upper half, Learning Disabled—lower)

<table>
<thead>
<tr>
<th></th>
<th>Coding</th>
<th>Spelling</th>
<th>Math</th>
<th>Word ID</th>
<th>Pass Comp</th>
<th>Coding2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding</td>
<td>-</td>
<td>0.08</td>
<td>0.06</td>
<td>-0.05</td>
<td>0.07</td>
<td>-0.03</td>
</tr>
<tr>
<td>Spelling</td>
<td>-0.15</td>
<td>-</td>
<td>0.71*</td>
<td>0.86*</td>
<td>0.77*</td>
<td>0.60*</td>
</tr>
<tr>
<td>Math</td>
<td>-0.10</td>
<td>-0.14</td>
<td>-</td>
<td>0.85*</td>
<td>0.72*</td>
<td>0.49*</td>
</tr>
<tr>
<td>Word ID</td>
<td>-0.37</td>
<td>0.01</td>
<td>0.75*</td>
<td>-</td>
<td>0.83*</td>
<td>0.69*</td>
</tr>
<tr>
<td>Pass Comp</td>
<td>-0.05</td>
<td>0.18</td>
<td>-0.11</td>
<td>-0.01</td>
<td>-</td>
<td>0.71*</td>
</tr>
<tr>
<td>Coding2</td>
<td>0.93*</td>
<td>-0.04</td>
<td>-0.04</td>
<td>-0.27</td>
<td>-0.23</td>
<td>-</td>
</tr>
</tbody>
</table>

* p < .05

Table 8
Pearson r correlation coefficients between WISC-R Coding and B.C.Q.U.I.E.T. subtest scores
(Normal and Learning Disabled scores pooled)

<table>
<thead>
<tr>
<th></th>
<th>Spelling</th>
<th>Math</th>
<th>Word ID</th>
<th>Pass Comp</th>
<th>Coding2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding</td>
<td>0.033</td>
<td>-0.065</td>
<td>-0.180</td>
<td>0.063</td>
<td>0.329*</td>
</tr>
<tr>
<td>Spelling</td>
<td>-</td>
<td>0.253</td>
<td>0.637*</td>
<td>0.624*</td>
<td>0.413*</td>
</tr>
<tr>
<td>Math</td>
<td>-</td>
<td>-</td>
<td>0.713*</td>
<td>0.180</td>
<td>0.123</td>
</tr>
<tr>
<td>Word ID</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.506*</td>
<td>0.257</td>
</tr>
<tr>
<td>Pass Comp</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.315</td>
</tr>
</tbody>
</table>

* p < .05
Hypothesis Five: There will be no statistically significant difference between the "normal" and "learning disabled" students on the combined mean score of the WISC-R Coding subtest and the four subtests of the B.C.Q.U.I.E.T. This hypothesis was rejected after being tested by a discriminant analysis using the OWMAR (UBC) computer program. The results of a Bartlett-Box Homogeneity of Dispersion Test, a multivariate analysis of variance, shows that there is a clearly significant difference between the normal and learning disabled groups as a result of their combined scores on all six of the subtests (F = 3.25, p < .0001).

Table 9 presents the weights to be assigned to the individual subtest scores to determine whether or not the individual belongs in the normal or learning disabled group. A list of each individual's combined, weighted score is presented in Appendix A. This shows that the discriminant analysis accurately placed each individual in the appropriate group (i.e. all the subjects in the normal group stayed in that group, likewise for the learning disabled).

Further examination of Table 9 shows that the variable that was the greatest contributor to the difference was Word Identification. This was followed by the Math, Spelling, Coding, Coding2 and Passage Comprehension subtests.

This means that a subject's combined WISC-R Coding and B.C.Q.U.I.E.T. score, weighted by the discriminant analysis, could be used to place a subject in either the normal or learning disabled group.
Table 9

Discriminant Analysis

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Normalized Raw Score Weights for Classification</th>
<th>Normalized Standard Score Weights for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding</td>
<td>0.179967</td>
<td>0.206385</td>
</tr>
<tr>
<td>Spelling</td>
<td>0.495041</td>
<td>0.280641</td>
</tr>
<tr>
<td>Math</td>
<td>-0.243312</td>
<td>-0.466642</td>
</tr>
<tr>
<td>Word ID</td>
<td>0.757098</td>
<td>0.777135</td>
</tr>
<tr>
<td>Pass. Comp.</td>
<td>-0.237169</td>
<td>-0.124579</td>
</tr>
<tr>
<td>Coding2</td>
<td>-0.184117</td>
<td>-0.203547</td>
</tr>
</tbody>
</table>

Eigenvalue = 11.758572

* If combined weighted score exceeded Eigenvalue, subject was classified as normal, otherwise as learning disabled.
Summary

In this chapter data was collected in the form of WISC-R Coding subtest pre and posttest scores along with scores from administering the four subtests of the B.C.Q.U.I.E.T. to 17 subjects classified as "learning disabled" and 21 subjects classified as "normal." Since the subjects came from two separate schools in two separate school districts and learning centers, subjects' scores were first analyzed to see if they could be pooled so that further analyses could derive greater weight from the larger number of pooled scores. Statistical analyses using t-tests found that there was a difference between the pre and posttest Coding scores for the normal group, and between the normal and learning disabled group. No significant pre and posttest differences on the Coding test by learning disabled subjects were found to exist at the .001 level of confidence. A Pearson r correlation coefficient analysis found significant between all four of the B.C.Q.U.I.E.T. subtests and the posttest Coding score for normal subjects. For the learning disabled subjects Coding correlated significantly with the Coding retest. A multivariate discriminant analysis supported the analysis using t-tests and found that subjects could be classified as normal or learning disabled by using a combination of their Coding and B.C.Q.U.I.E.T. subtest scores.

The next chapter will discuss the implications of these analyses. It will also discuss the limitations of the study and give directions for future research.
CHAPTER V
Discussion and Implications

The purpose of this section is to interpret and discuss the results of the data presented in Chapter IV as well as to integrate these results with previous research. The implications of this study will be presented as well as its limitations. These implications will focus on three main areas which were investigated in the study. These are:

- Implications of test-retest and practice effect on the WISC-R Coding subtest.
- The results of correlations between the WISC-R Coding subtest and the four subtests of the B.C.Q.U.I.E.T.
- Results of the multivariate discriminant analysis.

Finally a view toward possible directions future studies could take will be described.

Practice effect on WISC-R Coding subtest

Some researchers, notably Budoff (1972), and Feuerstein (1979) have reasoned that a test-retest procedure could measure learning potential. The greater the practice effect, determined by the test-retest procedure, the more learning potential the subject has. Previous test-retest studies on the WISC-R (Matarrazzo et al., 1973; Quereshi, 1968; Tuma & Applebaum, 1980), had reported significant gains in the Coding subtest by normal populations. These studies lend support to the idea that there is a significant practice effect on the retest of the WISC-R Coding subtest for normal subjects. This also suggests that if the practice effect is very small or
non-existent, as has been found in some studies with learning disabled subjects (Lombard & Reidel, 1978; Smith, 1978; Solly, 1977), it may be possible to use the effect to evaluate whether a student is normal or learning disabled. This may be appropriate if there is any question in determining whether a student is truly learning disabled or has been previously misdiagnosed.

Except perhaps for Solly's (1977) study, which compared gifted to retarded students no research has been reported in which test-retest data on the WISC-R Coding subtest for normal students has been compared to students with learning problems. This study has attempted to compare test-retest data from normal students to that obtained from learning disabled students, matched in terms of age, SES, and locality, thus providing a better design for determining if the two groups could be distinguished by their performance on the WISC-R Coding subtest.

In this study two samples of students from public schools in British Columbia were compared by their scores on the four subtests of the B.C.Q.U.I.E.T. (Wormeli, 1982) and a pre and posttest of the WISC-R Coding subtest (Wechsler, 1974). One group was composed of "normal" students from regular classrooms and the other of "learning disabled" students from learning centers associated with the districts from which the "normal" sample was drawn. The normal group consisted of 21 subjects, the learning disabled group of 17. The criteria for selecting the learning disabled students was similar to that of other studies on the Wechsler Intelligence Scales, in that they were
referred to a learning center because of learning difficulties in school, but had average to above IQ scores (Hale, 1978; Lyle & Goyen, 1969; Tabachnick, 1979; Vance et al. 1980).

It was believed that over a short retest period there would be a significant gain for the normal subjects on the WISC-R Coding subtest. This hypothesis was supported by the data. It adds further support to studies which found significant gains in the Coding subtest by normal populations in test-retest studies on the WISC-R (Matarrazzo et al., 1973; Quereshi, 1968; Tuma & Appelbaum, 1980).

It was believed that this study would support the literature in finding no significant gain in the retest scores of the WISC-R Coding subtest of learning disabled subjects, thus implying that the learning potential of this group was less than that of normal subjects. It was found in this study that there was no significant gain by the learning disabled subjects at the .001 level of probability. The result at the .001 level supported other research which found similar results with other learning disabled subjects (Lombard & Reidel, 1978; Catron & Catron, 1977).

This result also supports the idea that the learning disabled subjects have a lower mean gain on the retest of the WISC-R Coding subtest than normal subjects. Support for this is given by the rejection of hypothesis three, that there is no difference between the normal and learning disabled groups as a result of their Coding scores. An analysis of the data shows there are significant differences between the two groups both on their pre and posttest scores on the WISC-R
Coding subtest.

WISC-R Coding and B.C.Q.U.I.E.T. correlations

In previous factor analysis the WISC-R Coding subtest was put into a category with the WISC-R Arithmetic subtest because the Coding subtest correlated most highly with the Arithmetic subtest (Kaufman, 1975). However, in the case of both normal and learning disabled groups in this study, neither the pre or posttest Coding scores correlated significantly with the B.C.Q.U.I.E.T. Arithmetic subtest. A conclusion which may be drawn from this is that the WISC-R Arithmetic subtest, being verbally based, measures something different than the Arithmetic subtest of the B.C.Q.U.I.E.T., which is performance based, even though superficially the two tests seem to be measuring the same thing.

Another finding was that the Coding pretest, which is the subtest score used in the WISC-R assessment process, did not correlate significantly with any of the B.C.Q.U.I.E.T. subtest scores for either the normal or learning disabled group. On the other hand, the Coding posttest scores correlated significantly with all of the B.C.Q.U.I.E.T. subtests for the normal group. Since in most other research (Kaufman, 1979) the WISC-R Coding subtest has seldom correlated very highly with any other subtest of the WISC-R, or any achievement test score for that matter, does this imply that perhaps the WISC-R Coding subtest should be administered a second time shortly after the first for this subtest to have assessment value? Perhaps this is why most factor analyses done on the WISC-R Coding subtest
point out that Coding measures something unique, not related to any of the other WISC-R subtests. If Coding were readministered shortly after the first test session and this score included in the factor analysis would Coding then show a closer relationship to other subtests of the WISC-R?

It was also interesting to note the absence of any relationship between the Coding pretest and posttest scores for normal children ($r = -0.03$). This may signify that normal children have different levels of learning potential, that some learn more from the pretest than others. However this finding was not supported by previous research. Generally Coding has been found to be among the most stable of the WISC-R subtests with high test-retest reliability ($r = .67$ to $.88$) in most studies. As most previous studies have shown the Coding subtest retest reliability coefficients to become more stable over time, and since previous studies were often conducted over longer retest periods of from one week to three years, the very short (24 hours) retest period of this study may have contributed significantly to the low test-retest correlation coefficient.

For learning disabled subjects however, there was a very high test-retest correlation coefficient ($r = .93$). This shows that for this group the practice effect was very stable and perhaps indicates that the members of this group have relatively equal levels of learning potential. This finding was in accordance with much of the previous literature on test-retest reliability of the WISC-R which shows Coding to be a relatively stable subtest. One implication of the findings
in this study may be that for learning disabled children test-retest reliability of the WISC-R Coding subtest is stable over both long term and very short time intervals.

These findings seem to support the idea that the WISC-R Coding subtest may measure learning potential. First the test-retest correlation of the normal group on the Coding subtest is minimal \((r = -0.03)\) indicating differing levels of learning (from the pretest) ability. Second the learning disabled group had a high \((r = .93)\) test-retest correlation on the Coding subtest indicating a similar ability of the members of this group to learn from the pretest. Third, t-tests on the test-retest scores of the Coding subtest show significant differences for the normal group, indicating the posttest score was significantly higher than the pretest score. Finally, the normal group scored significantly higher on both the pre and posttest Coding subtest than the learning disabled group.

**Multivariate discriminant analysis**

The results of the discriminant analysis show that there is a significant difference between the normal and learning disabled groups as a result of their combined scores on all six measures (Appendix A). The clear distinction between the two groups that was made by the discriminant analysis may make this analysis, using these subtests, a more efficient method of identifying learning disabled students in British Columbia. The short administration time of the B.C.Q.U.I.E.T. and WISC-R Coding subtests compares favorably to that of current screening methods which have a much longer administration time.
In this analysis the Word Identification, Math and Spelling subtests of the B.C.Q.U.I.E.T. were greater contributors to the difference than either the pre or posttest Coding scores. This seems to imply that Coding is an inferior discriminator.

The reason for Word Identification, Math and Spelling subtests providing greater weight to the discriminant analysis could be the fact that the learning disabled group did so poorly on these measures, often scoring only in the first percentile. Furthermore, their ability on these measures was directly influenced by what they had learned previously. Being learning disabled, they would have had difficulty learning academic material, thus scoring poorly on tests that measure their academic achievement. Coding on the other hand is not influenced by previous academic learning and so scores on this test should not be as different between normal and learning disabled students as their scores on an achievement measure. In other words the WISC-R Coding subtest is a different type of measure than the B.C.Q.U.I.E.T. That the two groups might also have been separated by using only their Coding scores is supported by the fact that t-tests differentiated between the normal and learning disabled groups by reason of both their pre and posttest Coding scores.

Limitations of the study

This study was intended to research the idea that the Coding subtest of the WISC-R could be a possible measure of learning potential and to provide insights into what areas of
academic learning Coding might be associated with. It was not intended to be a definitive study on the WISC-R Coding subtest. Furthermore as the sample was relatively small (38 subjects) some of the statistical analysis must be accepted with reservation, especially the correlations between the WISC-R Coding subtest and the B.C.Q.U.I.E.T. subtests. Both the normal and learning disabled 'groups contained less than 30 subjects which is the least number required for acceptable correlation reliability (Ferguson, 1981). Finally the time interval between the test and the retest of the Coding subtest was very short which some researchers claim has a great deal of influence on the practice effect (Matarazzo et al, 1973).

Directions for future research

Future research in this area should be done with larger samples. Furthermore the time interval between retesting needs to be researched. It would also be interesting to add a third group comprised of "gifted" or "bright" subjects to a similar study to see if there would be any difference between them and the "normal" subjects as a result of their Coding scores. It may also be pertinent to investigate the size of the gain upon readministration of the WISC-R Coding subtest. Since the stability of the Coding subtest has by now been well established the amount of error in the gain score may not be too significant. This may allow us to use the gain as an indication of a subject's learning potential.

Finally the technique of using a discriminant analysis with the subtests used in this study should be replicated to
establish that the results obtained in this study were not due to chance. If the results obtained in this study are upheld this technique may prove a better, more efficient, and less time consuming way of screening learning disabled students.
BIBLIOGRAPHY


Burks, H.F., & Bruce, P. The characteristics of poor and good readers as disclosed by the WISC. *Journal of Educational Psychology, 1955 46*, 7, 488-493.


OWMAR One way multivariate analysis of variance computer program. University of British Columbia.


Thorndike, E.L. Measurement of intelligence. Teacher's College, Columbus University, New York, 1926.


APPENDIX

Classification of Subjects by the 1th Discriminant Function
(Normals-1: Disabled-2)

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Groups 1</th>
<th>Groups 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>-12.066</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>-9.673</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>-1.832</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>-0.744</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>-0.642</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>-0.491</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>-0.445</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>0.656</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0.676</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>0.855</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>0.936</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>1.910</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>3.924</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>5.957</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>6.788</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>7.503</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>32.147</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>32.322</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>32.896</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>33.751</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>34.748</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>35.511</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>36.662</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>37.123</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>36.155</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>38.532</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>40.377</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>42.120</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>42.246</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>42.885</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>42.972</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>45.565</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>46.343</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>49.919</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>51.231</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>52.768</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>53.580</td>
<td></td>
</tr>
</tbody>
</table>

1th discriminant function = 11.7586

*Note  Student numbers 1 to 21 represented students from normal group. Student numbers 22 to 32 represented learning disabled group. If weighted score exceeded 1th discriminant function students were classified as normal (group 1).