Motor, perceptual-motor and cognitive factors responsible for differentiating between above- and below-average legibility scores of second grade students

by William John Nikola-Lisa

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
The purpose of this study was to identify those factors responsible for contributing toward the discrimination between above-and below-average handwriting legibility. Two hundred and ninety-seven second grade students attending three different Montana school systems during the 1985-86 school year participated in the study. A battery of motor, perceptual-motor and cognitive tests was administered during a two-month period. Additionally, a manuscript handwriting sample was collected from each student.

The test measures were scored by the principal investigator and two three-member panels. A discriminant analysis was run using the dichotomous grouping variables above- and below-average handwriting legibility and the criterion variables age, gender, handedness and scores on the PMAT Spatial Relations (PMASR) and Perceptual Speed (PMAPS) subtests, the Developmental Test of Visual-Motor Integration (DTVMI), the Human Figures Drawing Test (HFDT), the Torrance Picture Completion Test (TPCT), the Children's Embedded Figures Test (CEFT), and the DTLA Motor Speed and Precision (DTLAMSP) subtest. The discriminant function produced a Wilks' Lambda of .73 which was significant at the .05 level (p=.0006) identifying six variables as having discriminant capabilities—PMAPS, gender, age, PMASR, DTVMI and the TPCT. Although only 26% of the variance could be accounted for, a classification analysis correctly classified 72.34% of the total sample.

Six two-way ANOVAS were also conducted to test further the interrelationships between the discriminating variables. In these main analyses, only the interaction between gender and handedness proved to be significant (p<.05). No significant (p<.05) interactions were found between creativity and cognitive style, creativity and handedness, creativity and gender, cognitive style and gender, or cognitive style and handedness.

Due to unexpectedly low cell counts in a number of the main analyses' interaction cells, a series of five post hoc two-way ANOVAS were conducted to test further the interrelationships between the discriminating variables. Using modified defining criteria for the variables creativity and cognitive style, no further significant (p<.05) interactions were found.

The study concluded with a reiteration of the importance of perceptual and perceptual—motor abilities in the production of handwriting, along with the seeming importance of gender and age factors. Furthermore, continued research was encouraged into the effect of creativity on handwriting performance.

MOTOR, PERCEPTUAL-MOTOR AND COGNITIVE FACTORS RESPONSIBLE FOR DIFFERENTIATING BETWEEN ABOVE- AND BELOW-AVERAGE LEGIBILITY SCORES OF SECOND GRADE STUDENTS

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APPROVAL

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William John Nikola-Lisa

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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VITA

William John Nikola-Lisa was born in Jersey City, New Jersey, June 15, 1951, to Mr. and Mrs. William H. Nikola. He completed his grade school education in Falfurrias, Texas. After moving to Pompano Beach, Florida with his family, William graduated from Pine Crest Prep School, a private college-prep school, in 1969.

In 1974, William received his B.A. in Comparative Religion from the University of Florida in Gainesville, Florida. Two years later he received his M.Ed. in Elementary Education from the same institution.

William moved with his wife and daughter to Bozeman, Montana in 1976 to begin his teaching career. He taught at the World Family School, a small private grade school, for two years. After the birth of a second daughter, William joined the staff of the Bozeman Public Schools where he taught second grade for five years at Irving School.

In 1983, William became a Teaching Assistant in the Department of Elementary Education at Montana State University. He remained in this position until the completion of his doctoral program three years later.

William has authored articles for educational journals, been involved with in-service training in the region, has given numerous workshops on language development and learning at state and regional conferences, and has co-directed a gifted student summer institute held on the Montana State University campus for three years. In 1984, William received a Research and Creativity Grant from the Office of Graduate Studies which enabled him to study briefly at the Harvard Graduate School of Education. In 1985, William was named the Outstanding Graduate Student of the Year by the Montana State Reading Council.

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TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF TABLES--Continued

LIST OF TABLES--Continued

ABSTRACT

The purpose of this study was to identify those factors responsible for contributing toward the discrimination between above- and below-average handwriting legibility. Two hundred and ninety-seven second grade students attending three different Montana school systems during the 1985-86 school year participated in the study. A battery of motor, perceptual-motor and cognitive tests was administered during a two-month period. Additionally, a manuscript handwriting sample was collected from each student.

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CHAPTER 1

DEVELOPMENT OF THE PROBLEM

Introduction

Children become interested in writing at an early age. Although the initial motivation to write stems from sheer sensorimotor delight, even the earliest marks a child makes form a microgenetic pattern (Gardner, 1980). By the age of three the young child has even developed the capacity to distinguish between graphic marks of a linguistic and non-linguistic nature (Lavine, 1977). With further development, facility with graphic production extends clearly in two distinct, though complementary, directions: on the one hand, pictorial development enables the child to represent the world through progressively realistic figurative drawings; while, at the same time, linguistic development, using basic graphic elements common to drawing, enables the child to communicate abstractly. It is at this point--where the pictorial and the linguistic separate--that the development of handwriting begins (Gardner, 1980).

Early theories of instruction viewed handwriting as a problem of pure motor development defining it as an athletic skill (Cole, 1956). As a result, many studies appearing in the first half of the century concentrated on the specificity of arm-hand movements (Freeman, 1918, 1921), questions of rhythm and velocity (West, 1922), and the development of precise measuring instruments to monitor such motor responses (Vernon, 1934; Wenger, 1948). Instructionally, this approach stressed strict conformity to a standardized model, little individual deviation, and an overlearning of the fine motor skills involved (Enstrom, 1968).

By the nineteen sixties, however, influenced by a synthesis of the research in perceptual learning by Gibson (1963), researchers began to move away from exclusively motor-oriented studies as the role of perception in handwriting became more widely acknowledged. Furner (1969a, 1969b, 1970), Sovik (1976) and Hayes (1982) explored the differences between instructional programs utilizing various perceptual-motor strategies. Jones, Trap and Cooper (1977) and Burkhalter and Wright (1984) became interested in the use of transparent overlays as immediate self-corrective feedback mechanisms. Hirsh and Niedermeyer (1973), Askov and Greff (1975) and Sims and Weisberg (1984) studied the use of perceptual prompts in copying activities.

A similar interest arose in assessing the perceptual and perceptual-motor factors related to handwriting production, and in identifying instruments capable of predicting handwriting success. Some of the tests employed to measure perceptual abilities included: the Primary Mental Abilities Test (Kaplan, 1957), the Bender Visual Motor Gestalt (Kaplan, 1957) and the revised Bender Gestalt Test for Young Children (Wedell & Horne, 1969; Engleman, 1978), the Slingerland

Screening Tests for Children with Specific Language Disability (Engleman, 1978), the Frostig Developmental Test of Visual Perception (Chapman & Wedell, 1972; Yost & Lesiak, 1980), and the Developmental Test of Visual-Motor Integration (Engleman, 1978). Although some studies found no apparent relationship between visual-perceptual-motor processes and handwriting performance (Yost & Lesiak, 1980; McKenzie, 1984), many generally reported a positive but low relationship (Kaplan, 1957; Wedell & Horne, 1969; Chapman & Wedell, 1972; Engleman, 1978).

By the nineteen eighties, partly as a result of the work just cited above and the work of Rand (1973), Goodnow and Levine (1973) and Ninio and Lieblich (1976)--all of whom had become interested in children's utilization of drawing rules--a redefinition of the perceptual-motor theory of handwriting instruction began to emerge. According to Kirk (1980:29), who cogently summarized this research, what children learn is not a motor pattern, "but a set of rules or strategies that enables them to copy from a model." This new thrust, reiterated by Furner (1983), highlighted clearly the role of cognition in the handwriting act. However, whereas cognition in the early decades of this century was equated with a general intelligence quotient or function, by the early nineteen eighties that definition had evolved to include a more multi-faceted, factor-structured view of cognitive abilities.

Along with this more complex "structure-of-the-intellect" model (Guilford, 1967), researchers began to deal with specific cognitive capacities. Castelnuovo-Tedesco (1948) and Epstein, Hartford and Tumarkin (1961) investigated the relationship between creativity and handwriting performance. Linton, Epstein and Hartford (1961) and Berent (1974) probed the relationship between cognitive style and handwriting performance. In a similar manner, Newland (1984) looked into the role handedness and cognitive style played in handwriting performance. Despite these new avenues of research incorporating different elements of cognitive capabilities, however, these few studies stand out as isolated cases; and, furthermore, are applicable to adult populations only. (In some cases the sample population was extremely narrow, as in the case of Berent (1974) who used only adult female psychiatric patients.)

Consequently, if understanding the factors which impinge upon the production of legible handwriting in young children is important to educators, then the inclusion of specific cognitive measures beyond general intelligence quotients, along with motor and perceptual-motor measures, must be deemed critical. If, as Harris (1960:622) noted some twenty-five years ago, "progress in handwriting instruction will be promoted as those factors involved in student behavior in learning to produce handwriting are more clealy understood," then studies involving a multi-dimensional, factor-structured approach are certainly warranted.

Statement of the Problem

The problem of this study, then, was to determine whether a combination of ten psychoeducational factors--ranging from motor, perceptual-motor and cognitive measures--is capable of discriminating between high and low handwriting legibility scores of second grade students. More specifically, this study sought to determine whether degree of cognitive maturation, type of cognitive style, ability to think creatively, performance on a battery of perceptual-motor and motor tests, gender, handedness and age could discriminate between above-average handwriting performance and below-average handwriting performance of second grade students attending school in three different public school districts in the state of Montana during the 1985-86 school year.

Additionally, this study attempted to determine if significant interaction existed between the legibility scores of second grade students when level of creative thinking ability and type of cognitive style, level of creative thinking ability and handedness, level of creative thinking ability and gender, type of cognitive style and handedness, type of cognitive style and gender, and handedness and gender respectively acted as independent variables.

Overall Need for the Study

Reviews of the literature in the area of handwriting instruction over the last three decades have consistently reported that not only does handwriting continue to be an inadequately researched field (Leavitt & Hein, 1969), but that most decisions concerning pedagogical approaches are based on tradition and not firm research findings (Groff, 1960). Otto and Andersen (1969:577) have admitted that in the area of handwriting instruction "there seems to be more interest in finding out what is being done and in telling people what they should be doing than in testing hypotheses or creating new ones." Although Peck, Askov and Fairchild (1980), in a review of the literature, found fewer surveys of existing practices and an increased emphasis on experimental research, Askov and Peck (1982) noted that current practices in handwriting instruction, more than in any other elementary school subject area, still are guided by traditional wisdom and commercial materials.

The call for research studies in this area, however, has not always been general. Groff (1960) and Andersen (1965) called for more research in the area of the transition from manuscript to cursive. Herrick (1960) argued for more research investigating the young child's ability to make constructive evaluations of his own writing. Askov, Otto and Askov (1970) called for more extensive comparisons of the effects of different instructional systems upon students' handwriting achievement. Peck, Askov and Fairchild (1980) recommended that more experimentation be done on the handwriting of learning disabled and other atypical populations. And, Harris (1960), as already mentioned, argued for further basic research into the factors directly involved in the handwriting process. The impetus behind such suggestions resides in the sincere effort to find the best match between student performance and instructional approach. The perceptual-motor model, which places maximum emphasis upon student participation in the educational process, has for a number of years stressed the optimization of conditions which heighten individual learning and performance. Sovik (1979), in a survey of instructional parameters related to children's copying performance, stated emphatically that at the heart of this "best match" is the responsibility of the educator to understand the individual differences that underlie student performance. In the area of handwriting research, few studies have risen to meet this need (Harris, 1960).

Specific Need for the Study

Attempts to isolate specific factors responsible for handwriting production have concentrated, for the most part, on the obvious--visual-perceptual-motor processing systems (Wedell & Horne, 1968; Chapman & Horne, 1972; Engleman, 1978). When measures of intelligence have been involved, they have typically been general measures (McKenzie, 1984), and as such have proved to be of little value when fine distinctions in handwriting performance are called for. On the other hand, studies which have taken on a more factor-structured orientation (Berent, 1974; Newland, 1984), either have been confined exclusively to adult populations, or have been so restrictive as to preclude broad generalizations.

It is, however, with the repeated attempt to cast the handwriting process within a perceptual-motor framework (Furner, 1970; Sovik, 1976; Hayes, 1982), and the increased focus on its cognitive dimensions (Kirk, 1980; Askov & Peck, 1982), that this study finds its real need. It is no accident that the suggested relationship between learning the mechanics of handwriting and principles of cognition comes at a time when information-processing models are dominant in the literature of contemporary psychology (Goldstein & Blackman, 1978). Cognitive theorists have repeatedly been concerned with defining the various mediating structures that facilitate the complex process of information transformation. This effort, reflecting concomitantly a widespread dissatisfaction with general IQ measures, has in turn affected educational practice.

Banas and Wills (1976, 1978), responding to the changing conceptions of intellectual development, described in detail suggested prescriptive uses of the subtests of two major intelligence tests in two multi-series articles. While such a practice reflects, in part, a response to the new directions cognitive psychology has taken, it still does not fulfill the need to use more factor-structured measures sensitive to finer distinctions of personality development (Witkin & Goodenough, 1981). Kogan (1983), in a recent review of the literature related to the assessment of cognitive abilities in young children, justified the separate discussion of general intellectual functioning and the phenomena of stylistic variations, i.e. cognitive style, by pointing to the fact that the two areas, although showing a modicum of overlap, had distinctly different theoretical foundations.

Consequently, if defining explicitly those factors that influence the development of a particular skill is important, then studies that admit to more than just general cognitive functioning are necessary. In the area of handwriting performance, a skill which more and more has been characterized as a cognitive, rule-governed task, this should certainly be so. In recognition of this fact, the study executed herein takes such an approach.

Questions to be Answered

1. Can a combination of related factors--degree of cognitive maturation, type of cognitive style, ability to think creatively, performance on a battery of perceptual-motor tests, gender, handedness and age--discriminate between above-average handwriting and below-average handwriting scores of second grade students?

2. When level of creative thinking ability and type of cognitive style act as the independent variables is there a significant difference in second graders' handwriting sample scores?

3. When level of creative thinking ability and handedness act as the independent variables is there a significant difference in second graders' handwriting sample scores?

4. When level of creative thinking ability and gender act as the independent variables is there a significant difference in second graders' handwriting sample scores?

5. When type of cognitive style and handedness act as the independent variables is there a significant difference in second graders' handwriting sample scores?

6. When type of cognitive style and gender act as the independent variables is there a significant difference in second graders' handwriting sample scores?

7. When handedness and gender act as the independent variables is there a significant difference in second graders' handwriting sample scores?

General Procedures

The following general procedures were adhered to while conducting this study:

1. Selected second grade students attending public school in three Montana school districts during the 1985-86 school year were selected to participate in the study.

2. Fourteen intact classes were selected from the combined three districts to participate in the study. The total sample for the study equalled three hundred and five second grade students.

3. Eight students with identified visual-motor and/or learning disabilities were omitted from the study.

4. Classroom teachers were trained by the principal investigator to collect one handwriting sample from each student. The handwriting sample was collected by having students copy the near-point, static model "The quick red fox jumped over the lazy brown dogs" (Lamme & Ayris, 1983).

5. A psychoeducational battery of tests was administered by the principal investigator to students attending each of the fourteen second

grade classes. The classroom teacher was present for each administration and fulfilled the role of test proctor. The battery of tests included the Primary Mental Abilities Test's (PMAT) "Spatial Relations" and "Perceptual Speed" subtests, the Human Figures Drawing Test (HFDT), the Developmental Test of Visual-Motor Integration (DTVMI), the Torrance Picture Completion Test (TPCT), the Children's Embedded Figures Test (CEFT), and the Detroit Tests of Learning Aptitude's (DTLA) "Motor Speed and Precision" subtest.

6. The test administration span at any one school district site covered a one week period. Three test periods, lasting no longer than forty minutes each, were involved for each class. Test order for each group administration was rotated to minimize a possible "order-effect."

7. Due to the objectivity of scoring procedures, the DTLA subtest, the PMAT subtests, the HFDT and the CEFT were scored by the principal investigator. On the other hand, the DTVMI, the TPCT and the handwriting samples, which require interpretive scoring procedures, were scored by a group of three trained scorers.

8. Individual data was collected on each student participating in the study by the principal investigator. Data included chronological age, gender, and handedness.

9. A discriminant analysis was run on the grouping variables cognitive maturation, cognitive style, creative thinking ability, perceptual-motor performance, gender, handedness and age to determine the ability of these variables to differentiate between above-average and below-average handwriting performance.

10. Six two-way analyses of variance were run using second grade students´ handwriting sample scores as the criterion variable. The six pairs of independent variables included level of creative thinking ability and type of cognitive style, level of creative thinking ability and handedness, level of creative thinking ability and gender, type of cognitive style and handedess, type of cognitive style and gender, and handedness and gender respectively.

Limitations and Delimitations

The following are limitations of the study:

1. The population sample was limited to fourteen intact second grade classes sampled from three public school districts in the State of Montana. The classes represented a broad representation of socioeconomic and ethnic factors as well as a diversity of school practices.

2. All fourteen classes have used the D´Nealian Handwriting Program (Thurber, 1978) in their handwriting instructional program for at least two academic years.

3. The study was conducted during the second half of the 1985-86 school year and utilized the manuscript writing of the second grade students prior to the systematic exposure to cursive writing.

4. The research done for the review of literature section was conducted using the research facilities available at Montana State University. The services of Interlibrary Loan were used extensively. The facilities of the Suzallo Library on the University of Washington

campus were also used to locate salient bibliographic material pertaining to the literature on cognitive style.

5. A computer search using the ERIC system was conducted. Descriptors associated with studies related to handwriting legibility were used covering a time period from 1966-1985. The following descriptors, when combined with the general area of handwriting and/or penmanship, were also found effective: motor development, movement, manual dexterity, rhythm, handedness, lateral dominance, age and gender factors, perceptual-motor development, cognitive style, intelligence, and copying ability.

6. A manual search covering the last ten years of the following resources was also conducted: Psychological Abstracts, Dissertation Abstracts International, Journal of Educational Research, Perceptual and Motor Skills, Elementary School Journal, and Language Arts.

The following are delimitations of the study:

1. Only selected second grade students from three Montana school districts who had no visual-motor problems and/or learning disabilities were considered for the study.

2. Students who were absent for more than one day of testing were not included in the study.

3. Students who were absent on the day when the handwriting sample was collected were still included in the study. The classroom teacher rescheduled the handwriting sample collection for those students on another day using the same collection procedures.

4. The effects of student interest or motivation on handwriting legibility were partially accounted for by using the meaningful stimulus sentence "The quick red fox jumped over the lazy brown dogs" (Enstrom, 1964). Beyond this, however, the effects of student motivation--as influenced by having children write for a meaningful audience--were not accounted for in this study.

Definitions

1. Above-average handwriting legibility - handwriting samples which exemplify the qualities of correct letter formation, uniformity of size and slant, consistent spacing between letters and words, and steady alignment. Operationally, above-average handwriting legibility is defined as handwriting sample scores equal to or above one standard deviation from the mean.

2. Below-average handwriting legibility - handwriting samples that do not exemplify the qualities of correct letter formation, uniformity of size and slant, consistent spacing between letters and words, and steady alignment. Operationally, below-average handwriting legibility is defined as handwriting sample scores equal to or below one standard deviation from the mean.

3. Cognitive maturation - a measure of mental maturity (Koppitz, 1968) as defined by a score on the Human Figures Drawing Test (HFDT).

4. Cognitive style - characteristic self-consistencies in information processing that develop in congenial ways around underlying

personality trends (Messick, 1984:61). Operationally, cognitive style is denoted as field-dependent-independent (FDI) and measured by the group-administered Children's Embedded Figures Test (CEFT) designed by Cromack and Stone (1980).

5. Creative thinking ability - a measure of a subject's degree of divergent thinking or creativity as measured by an "originality" score on the Torrance Picture Completion Test (TPCT). Operationally, low creative thinking ability is defined by scores on the TPCT that fall between 0-7 points. High creative thinking ability is defined by scores on the TPCT that fall between 13-20 points.

6. D'Nealian Handwriting - the style of writing developed by Donald N. Thurber in the nineteen seventies and published by Scott Foresman Company which, in response to Hildreth's (1963) call for a more simplified handwriting style, blends elements of both manuscript and cursive writing (Duvall, 1984).

7. Fine-motor coordination - a measure of the control of the small sets of voluntary muscles involved in writing (Harris & Hodges, 1981), as defined by a score on the Detroit Tests of Learning Aptitude's (DTLA) subtest "Motor Speed and Precision."

8. Fixed field-dependence (FD) - the inability of a subject to overcome embedding contexts in perceptual functioning (Goodenough, 1976). Operationally, FD is defined by scores on the CEFT that fall between 0-9 points.

9. Fixed field-independence (FI) - the ability of a subject to overcome embedding contexts in perceptual functioning (Goodenough,

1976). Operationally, FI is defined by scores on the CEFT that fall between 16-25 points.

10. Handedness - the hand with which a subject writes most often. Operationally, designated either left- or right-handed by teacher observation.

11. Handwriting sample - a handwriting sample obtained when a subject copies directly from the static, near-point model "The quick brown fox jumped over the lazy dogs" (Lamme & Ayris, 1983).

12. Legibility - the ease with which writing can be read (Graham & Miller, 1980). The five most important elements used to evaluate legibility include: letter formation, spacing, slant, letter height and size, and alignment (Quant, 1946; Freeman, 1959; Herrick & Erlebacher, 1963; Bell, 1969; Ziviani & Elkinds, 1984). Operationally, legibility refers to the average point score a subject receives on his or her handwriting sample when the above-mentioned legibility factors, rated on a five-point scale, represent the evaluating criteria.

13. Perceptual-motor integration - a measure of the interacting relationship of vision to body movement (Harris & Hodges, 1981), as defined by a score on the Developmental Test of Visual-Motor Integration (VMI).

14. Spatial orientation - a measure of the ability to relate spatial concepts to oneself as defined by a score on the Primary Mental Abilities Test's (PMAT) subtest "Spatial Orientation."

15. Visual Discrimination - a measure of the ability to visually associate similar critical features of an object, as defined by a score

on the Primary Mental Abilities Test's (PMAT) subtest "Perceptual Speed."

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The history of handwriting research is long but not extensive with periods marked by great effort and periods devoid of original research (Andersen, 1965). Although Herrick (1963) listed 1,754 entries in a comprehensive bibliography dating back to 1890, more than seventy-five percent of the entries listed were of a non-technical, descriptive nature. It has only been in the last twenty years that a predominance of empirical research has characterized this broad subject area (Askov & Peck, 1982).

The trends involving handwriting research, fortunately, are more discernable. During the first three decades of this century, studies appeared treating handwriting as a formal isolated skill focusing primarily on its motoric aspects (Hildreth, 1960); while, concurrently, studies attempting to determine the relationship between handwriting and general intelligence factors gained in acceptance. Both avenues of inquiry, however, faded as the country was hit by a major economic depression and a second world war (Herrick & Okada, 1963). Although research related to handwriting increased after these catastrophic events, a shift in focus had occurred. Studies involving a perceptual-motor orientation (Furner, 1969a, 1969b, 1970) and, later, a cognitive emphasis (Kirk, 1980; Hayes, 1982) predominated.

It is from this historic overview that this review of the literature ultimately derives its general organization. Specifically, the first section describes almost exclusively studies interested in the motoric nature of handwriting production. The first part of the second section focuses on studies interested in the relationship between general intelligence factors and handwriting ability, while studies exploring the relationship between handwriting ability and specific cognitive influences, which typically have appeared in the literature only within the last two decades, characterize the second half of the section. The last section--also broken into two parts--focuses on the rise of the perceptual-motor theory of handwriting instruction (Furner, 1969a, 1969b, 1970), and the subsequent emphasis researchers placed on handwriting's cognitive or analytic components as characterized by the young child's systematic utilization of drawing rules (Rand, 1973; Goodnow & Levine, 1976; Ninio & Lieblich, 1976).

The Motoric Nature of Handwriting Production

Early in this century studies of handwriting performance focused on the question of arm-hand movements and the related question of handwriting's rhythmical nature. Drever (1915:185) summed up this position cogently: "Looked at from the outside, and regarded purely as a mechanical process, the writing act consists of certain movements and co-ordinations of movement of the fingers, hand, forehand, and shoulder." The research of the next thirty-five years followed this line of reasoning.

Freeman (1921), using a kinetoscopic camera to photograph the arm and hand movements of writing subjects, found that the most legible writers paused longer at those points where there was a radical change in direction of movement, a factor contributing to the conclusion that rhythm and legibility were unrelated. West (1922) found similar results, adding that younger children had the greatest amount of variation in their handwriting movements. Later, Irish (1949) argued that if handwriting was rhythmical then the time recorded for single letters would vary from letter to letter depending on the length and directional variance of each stroke. Finding that the time for writing any single letter was very close to the time for writing any other letter, Irish (1949), consequently, concluded that handwriting lacked any discernable rhythmical nature.

Boraas (1951), in a more closely detailed study, photographed good and poor writers as they copied three variations of the letters F, T and G. Results indicated that the most frequent errors regarding stroke execution occurred around points of radical direction change--an observation made by Freeman (1921) thirty years earlier. Other results indicated that straight lines were generally written most rapidly and with the least amount of deterioration and deformation; double-curved lines tended to be made with excessive initial speed and much deterioration; and, speed changes for any stroke could be erratic for good as well as poor writers. In the final recommendations, Boraas (1951) suggested that simplicity of letter forms might be the best aid in the improvement of handwriting legibility--a consideration not taken seriously until Hildreth (1960) and Thurber (1978).

The last major studies to focus on motoric elements of handwriting production appeared in the late nineteen fifties and early nineteen sixties and were sponsored by the University of Wisconsin's Committee for Research in Handwriting, which was in turn underwritten by the Parker Pen Company. Harris and Rarick (1957), in one of three major studies, examined the point pressure patterns of adult cursive handwriters. A low, positive correlation was found between point pressure and legibility (r=.18) and between point pressure and rate of writing (r=.22). On the other hand, a high, positive correlation (r=.86) was found between point pressure and fine motor control, wherein Harris and Rarick (1957) argued that point pressure for writing samples might be considered a useful index of a subject's fine motor coordination.

Working with students in fourth, sixth and tenth grade, Harris and Rarick (1959) again studied the relationship between point pressure and handwriting legibility. The results indicated that variability among subjects in point pressure remained high in grades four and six even though the average writing pressure declined. It was only in grade ten that the standard deviations for writing pressure were sufficiently low indicating some uniformity among subjects in the application of point pressure. Correlation analyses between point pressure and legibility (r=.20), point pressure and rate of writing (r=.20), and point pressure and fine motor control (r=.71) obtained similar results as the previous study (Harris & Rarick, 1957). Commenting on the generally lower correlations for the younger age sample, Harris and Rarick (1957) suggested that a stabilized motor pattern for handwriting may not be achieved until adulthood.

In the last major study examining the physiological and/or motor correlates of handwriting legibility, Harris and Rarick (1963) monitored the galvanic skin responses and electromyographic recordings of thirty fifth and sixth grade students divided equally into bright, average and slow-learning groups. The major findings of the study included: that fine motor control was significantly affected by the type of writing condition--"use your best handwriting" and "use your fastest handwriting"-- at the $p<.01$ level; that for the combined bright and average intelligence groups only the conditions of writing and not sex or intelligence were significant at the $p<.01$ level; and, with respect to the rank-order patterning of the galvanic and electromyographic measures, that there were no differences between bright, average and slow-learning subjects.

Handwriting and Related Intelligence Factors

General Intelligence Factors

While studying the relationship between handwriting and motoric development, researchers in the first few decades of this century were also interested in the relationship between handwriting and general intelligence factors (Harris, 1960). Gesell (1906), examining the handwriting of students in grades one through nine, found a striking relationship between handwriting ability and both school achievement and general intelligence. (Only a comparison of the percentages of the number of students in a particular cell was made; no statistical comparison was made beyond this.) Rather than conclude that legible handwriting indicated a high order of intelligence, Gesell (1906:403) pointed to differences in motor skill, nervous system development (perceptual development), and to differences between the sexes as contributing to this relationship: in essence, accuracy in handwriting might indicate more a kind rather than a grade of intelligence.

Gates and LaSalle (1924) used two measures of general intelligence--the Stanford-Binet Intelligence Test and the National Intelligence Test (NIT)--in their study of handwriting legibility. An analysis of the data indicated that writing ability was unrelated to the Stanford-Binet (r=.01) but positively related to the NIT (r=.48). In their summarizing discussion, Gates and LaSalle (1924) suggested that, with regard to the extremely low correlation between the Stanford-Binet and writing ability, the results might indicate that the general relationship between these two factors might be positive but slight in the lower end of the distribution, zero in the upper half and, as a consquence, slightly positive for the whole range. Regarding the stronger correlation between the NIT and writing ability, Gates and LaSalle (1924:212) offered this suggestion: if writing ability--particularly speed--is a factor in the success of taking the NIT, then both tests may reflect to a degree a common general factor, not primarily intellectual but educational.

Finally, Whittler (1929), interested in both motor development and intelligence factors, worked with a population of five hundred and fifty third through sixth grade students in a two-stage study. The first phase involved assessing each student's "anatomical index"--a measure of physical maturity as defined by the degree of ossification of the wrist bones. No significant relationship was found between this measure and handwriting ability. However, in the second phase of the study, when handwriting ability was correlated with general intelligence, a low to moderate coefficient, r=.41, for both rate and quality of writing combined was found. Quick to point out that this did not necessarily presume that handwriting ability was indicative of high intelligence, Whittler (1929:850), in a caveat similar to Gesell (1906), suggested that the combined factors of manual dexterity, student attitude and intelligence were more likely the contributing factors.

Specific Cognitive and Related Personality Traits

Although the next two decades were marked by a lull in the research related to handwriting (Herrick & Okada, 1963), by West's (1950) review of the literature both descriptive and empirical studies were on the rise. However, no longer were researchers interested in the classical problem of the relationship between general intelligence factors and handwriting ability. Instead, researchers focused on more specific personality traits which included aspects of intellectual development. Castelnuovo-Tedesco (1948) examined the relationship between handwriting, intelligence and creativity. Focusing not on how close a subject could copy a model but on the departures from it, Castelnuovo-Tedesco (1948) had six judges rate one hundred adult handwriting samples for intelligence and originality. These were in turn correlated with standardly-measured IQ scores. Although the correlation between the judges' intelligence ratings and IQ scores was not significant, the relationship between the creativity measures and IQ scores was .50 ($p<.01$) which lead Castelnuovo-Tedesco (1948) to conclude that poor legibility might not always be the result of poor motor or psychomotor ability, but rather the composite of an individual's intellectual and creative makeup.

Epstein and Hartford (1959), working under the auspices of the Handwriting Foundation, Washington, D.C., compared adult male subjects' primary and secondary beginning stroke ratio with the total index of the Human Figures Drawing Test (using scoring procedures established by Machover (Witkin, et al.,1954)) and found a correlation of .23 ($p<.01$).

In a follow-up study focusing only on secondary beginning strokes, Linton, Epstein and Hartford (1961) found that subjects exhibiting a high presence of this particular set of beginning strokes scored significantly ($p<.05$) higher on the M-type sign of the Rorschach test in the direction of unassertiveness than did subjects who rarely included secondary beginning strokes in their writing. Linton, Epstein and Hartford (1961) also found that there was no significant difference between the presence or absence of secondary beginning strokes in subjects' handwriting and scores on the HFDT when scaled for field-dependence-independence. However, subjects who exhibited a high presence of secondary beginnng strokes scored significantly ($p<.001$) lower on the American Council on Education Test, a scholastic aptitude test. On the other hand, Linton, Epstein and Hartford (1962), in a follow-up study, found no correlation between use of primary beginning strokes and scholastic aptitude scores.

Following more closely the original avenue of research of Castelnuovo-Tedesco (1948), Epstein, Hartford and Tumarkin (1961), examined the graphological variations of three specific letters--D, F, and G--from the handwriting samples of one hundred and fifty female subjects ranging in age fifteen to fifty-five. Based on the evaluative factors originality, simplification and economy of stroke, the researchers found that educational level and IQ correlated ($r=.23$; $p<.01$) in a low but positive manner with the letter G variants that were considered the most economized and original. Subjects' G variants which were closest to the stimulus model correlated negatively ($r=-.22$; $p<.01$)

with level of education. The results of the study lead Epstein, Hartford and Tumarkin (1961:391) to conjecture that "the female adult who continues to write in the fashion that would have pleased her elementary school teacher is less likely to be as well educated, as bright, or as mature as the adult who has worked her way out of the school-copy rut and has evolved a more efficient and original way of writing." Unfortunately, with the withdrawal of financial support from the Handwriting Foundation in the mid-nineteen sixties, no further studies were published by this group of researchers.

Finally, in some unrelated studies, Berent (1974) found that the handwriting of field-dependent female psychiatric out-patients was significantly ($p<.01$) less legible, less well oriented on the page, less neat and generally poorer in overall quality than their field-independent counterparts. Newland (1984) found that left-handed writers were significantly ($p<.05$) more field-independent than right-handers. And, Lester and Hoyd (1981) found no correlation between handwriting slant and college students' scores on the thinking/feeling subscale of the Myers-Briggs Type Indicator.

Handwriting As A Rule-Governed, Perceptual Learning Process

The Rise of a Cogent Perceptual-Motor Theory

The role of perception in handwriting was first empirically introduced to the field by Leggitt (1940) who, working from the assumption that handwriting was best defined as an act involving both the perfection of movement through practice and the perception of form, gave junior high school remedial-handwriting students a matching-to-sample task that involved the discrimination of discrete letter strokes. Students worked in pairs, each pair keeping track of their errors and the time required for each trial. Ten trials were allowed for the matching-to-sample task. Students were also given a pre- and post-test to assess handwriting progress. The results indicated that not only did students improve their matching ability of the letter strokes through time--showing the most improvement during the first three trials--but also increased their handwriting scores by as much as thirty points.

Although Leggitt's (1940) study was important in its emphasis on the relationship between the perception of form and handwriting, it did not distinguish sufficiently between the variables responsible for increased legibility, i.e., between the matching-to-sample task, the use of paired subjects, the recording of errors and trial times, etc. Subsequent studies by different researchers attempted to explicate in greater detail the effect of perceptual training on handwriting performance.

Furner (1969a, 1969b, 1970) conducted a three-year longitudinal study with first through third grade subjects using treatment groups trained in perceptual-motor techniques and a control group for each grade level. The specific perceptual training the treatment groups received included: the development of a mental set for learning, the building of a vivid image of the letter or feature of writing skill involved, provision for many guided, multisensory exposures to the stimulus, student verbalization of the stroke or letter formation act, and immediate self-correction allowing each student a means of comparing his procedure to the desired one. At each of the three different grade levels, comparisons of the quality of writing was significant ($p < .05$) favoring the treatment group.

Sovik (1976) found similar results in a study involving third grade students who received various phases of a three-part instructional sequence involving simple instructions, active demonstration of the stimulus model, and detailed explanation of the stroke movements. Subjects who received all three of the stages significantly ($p < .05$) outperformed subects on a handwriting task who had received none, one or only two of the instructional stages. And, Trap, Milner-Davis, Joseph and Cooper (1978), using a multiple-baseline design, found that after three successive interventions--employing verbal and visual feedback, verbal and visual feedback plus immediate rewriting of trained letters with one or more incorrect letter strokes, and potential reinforcement on cursive letter strokes--first grade students continued to improve their handwriting by increasing the percentage of correct letter strokes at baseline from 23.95 to 37.56, 59.80 and 71.68 respectively.

In one of the most definitive studies involving perceptual training, Hayes (1982) gave kindergarten and third grade students a copying practice task that involved five distinct levels of perceptual prompting. Subjects from each grade level were randomly assigned to one of five conditions: control, copying practice with no prompting, visual demonstration with copying practice, visual and verbal demonstration with copying practice, or visual and verbal demonstration plus subject verbalization with copying practice. The resulting two-way factorial design, with age being crossed with level of perceptual prompting, provided clear evidence in support of the effect of perceptual training. Both kindergarten and third grade students who received training which included visual and verbal demonstration plus student verbalization with copying practice demonstrated significanly ($p<.05$) better copying performance than did students in any other treatment or control groups. Furthermore, kindergarten students who received this latter training performed significantly ($p<.05$) better than did third grade students who had no perceptual training at all.

Along with the development of a cogent theory of perceptual-motor learning, interest in different types of feedback systems and behavior reinforcements emerged. Salzberg, Wheeler, Devar and Hopkins (1971) studied kindergarteners' copying performance when given access to a play room as reinforcement for correct letter strokes. Sovik (1974) looked at the effect different forms of displaced feedback might have on the accuracy and time scores of students' handwriting performance. In another study, Sovik (1979) investigated the effect of varying the graphic model from close display to distant display, and from a static presentation to a dynamic one. A three-way factorial design, with the additional assessment of age effects, generated a significant ($p<.01$) interaction between figure-type and distance variables. Sovik (1979), emphasizing the cybernetic qualities of the handwriting process, concluded that the teaching of handwriting should emphasize relatively close, dynamic presentations of the copying model employed. This finding was later supported by Wright and Wright (1980) who found that subjects using a mechanical flipbook which displayed the letter formation process in a dynamic manner significantly (p<.05) outperformed subjects relying only on static workbook models.

In other studies involving feedback systems, Jones, Trap and Cooper (1977), using transparent overlays developed by Helwig, Johns, Norman and Cooper (1976), taught first grade students to successfully monitor their own handwriting performance. Training involved visual and verbal demonstration, student alignment of the overlays, a series of four training sheets, and three practice sheets. Students learned to use the overlays in approximately eighty to one hundred and twenty minutes of instruction and practice. Encouraged by these results, Burkhalter and Wright (1984) divided eighty first grade students into two groups--a treatment and control group--to determine whether use of the transparent overlays as a self-correcting feedback mechanism would prove more instructionally efficient than traditional copybook methods. No significant difference, other than sex (p<.05), was found to support the instuctional use of the overlays, at least at the first grade level.

The precepts of perceptual training in handwriting generated studies not only aimed at improving instructional techniques, but also created an interest in research efforts designed to assess the relationship between handwriting and perceptual-motor abilities. Just as Freeman (1918, 1921), Irish (1949) and Boraas (1951) had attempted to isolate the motoric factors responsible for handwriting performance, researchers were similarly intent upon isolating the contributing perceptual-motor influences.

Kaplan (1957) correlated handwriting performance with form perception. One hundred and forty-four fourth, sixth and tenth graders, divided equally by sex and grade, were administered a battery of perceptual and perceptual-motor tests: the "Perceptual Speed" subtest of the Primary Mental Abilities Test (PMAT), the Bender Visual Motor Gestalt (BVMG), and the Benton Visual Retention Test (BVRT). Only correlations between the BVMG and handwriting legibility reached significance ($p<.05$), although all correlations were generally positive. Additionally, Wedell and Horne (1969), using the revised Bender Gestalt Test for Young Children (BGTYC), found that high-scoring subjects significantly ($p<.05$) outperformed low-scoring subjects on four motor tasks related to handwriting--a matching task, a tracing task, a plasticene copying task and a pencil copying task.

In another study, Chapman and Wedell (1972) divided second grade students into "reverser" and "non-reverser" groups and then compared their scores on a battery of perceptual and perceptual-motor measures. Out of thirteen statistical comparisons, only three were significant ($p<.05$) favoring the non-reverser group: the total Perceptual Quotient of the Frostig Developmental Test of Visual Perception (FDTVP), subtest four-"Position in Space"--of the FDTVP, and Kephart's "Crossing the Midline". In contradistinction, Yost and Lesiak (1980), divided sixty first grade children into "poor" and "good" handwriters, administered the full battery of the FTDVP, and subsequently found no correlation between scores on the FDTVP and handwriting ability.

Engleman (1978), in another attempt to determine the relationship between perceptual abilities and handwriting performance, gave first grade subjects the BGTYC, the Developmetal Test of Visual Motor Integration (DTVMI), a word discrimination test, and the Slingerland Screening Tests for Identifying Children with Specific Language Disability (Slingerland). Using a multiple regression equation, Engleman (1978) found that the BGTYC, in combination with the word discrimination test, contributed to over thirty percent of the variance. With the addition of subtests 1, 2, and 5 of the Slingerland, a total of thirty-seven percent of the variance was accounted for. Using an alternate scoring system that maximized both letter- and space-scores, the amount of variance accounted for jumped to fifty-seven percent, and was primarily represented by the three Slingerland subtests. Engleman (1978:122) concluded that, for a child who has attained a minimum of handwriting skill, the Slingerland--which is both short and easy to administer--may provide a valuable indicator of subsequent classroom handwriting achievement.

Finally, McKenzie (1984), using a diagnostic battery of motor, perceptual-motor and visual-motor tests, as well as reading performance tests, found that there was a low, positive relationship between handwriting and visual perception. Additionally, McKenzie (1984) reported that visual memory and manual dexterity were significantly ($p<.05$) related to far-point copying but not to near-point copying, that general intelligence had a low, positive correlation with copying ability, and that subjects who had good copying efficiency tended to be better readers and spellers.

Handwriting as a Cognitive, Rule-Governed Activity

An interest in the relationship between visual discrimination and copying performance arose as a result of the emphasis perceptual-motor theorists placed on the role of perception in handwriting (Furner, 1969a). Maccoby (1968), in particular, proposed that young children produce inadequate letter forms because they fail to discriminate sufficient distinctive features of the stimulus. In support of this observation, Goodson (1967) and Brittain (1969) found that children produced more accurate copies after receiving discrimination training. Bee and Walker (1968), Birch and Lefford (1967) and Olson (1968), on the other hand, found no connection between discrimination and copying performance.

In response to the conflicting data, Rand (1973), working with preschool subjects, looked at the effect both visual analysis training and drawing-rule training had on copying performance. An analysis of the results indicated that drawing-rule utilization resulted in improved copying accuracy ($p<.05$) but did not improve discrimination ability, while training in visual analysis resulted in improved discrimination ability ($p<.05$) but not improved copying ability. Consequently, Rand (1973:52) concluded that children's primary deficit in copying performance was not their inability to analyze the model, but their inability to reconstruct segment-whole relationships.

Focusing on the specific type of rule structures children utilized in copying practice, Goodnow and Levine (1973:86), supported by the work of Ames and Ilg (1951), Reed and Smith (1964) and Weiss (1969, 1971), found that among preschool and primary school-aged children a number of consistent rules or principles could be identified dealing either with beginning points or directionality. Goodnow and Levine (1973) suggested that perhaps graphic behavior may have a covert phrase structure in much the same manner that linguistic behavior has an identifiable syntactic structure. Ninio and Lieblich (1976:848-49), in summarizing their own research on this topic, lent further support to this notion:

> Our study provides support for the claim that the progression of copying a design is mainly determined by the requirements of the total design, which seems to be analogous to the phrase structure of a verbal utterance. Although it was demonstrated that there are some rules of linear order, such as moving from top or from left, in young children there are some systematic departures from these rules. These departures seem to fit a hypothesis based on minimization of informational load, namely, that children prefer starting points for which one of the coordinates is already given and avoid those strategies which necessitate selection of starting points based on many "imaginary," stored characteristics of the model.

The interest in drawing-rule utilization had immediate appeal to researchers concerned with the differences between tracing and copying. Hirsh and Niedermeyer (1973), comparing the instructional efficacy of a faded tracing technique with more traditional copying strategies, found a significant ($p<.05$) difference favoring copying. Askov and Greff

(1975), in a replication study which modified slightly the tracing technique and used simple shorthand forms rather than manuscript letters for the pre- and post-tests, achieved similar results finding a significant ($p<.02$) advantage of copying over tracing at both the kindergarten and second grade levels. On the other hand, Sims and Weisberg (1984), using two different scoring techniques, found that whereas teacher ratings of handwriting performance failed to distinquish between copying and tracing tasks, the use of evaluative transparent overlays indicated a significant ($p<.01$) difference in favor of tracing--a finding that suggested that overlay measurement may be appropriate for evaluating stroke quality during the early stages of a handwriting program when tracing and other strongly prompted cues predominate, but may be inappropriate during later stages when students write under the control of very weak stimulus prompts (Sims & Weisberg, 1984:364-65).

Summary

The research related to identifying the psychomotor correlates responsible for the production of legible handwriting falls into three distinct categories: motor correlates, general and specific intelligence factors, and rule-governed, perceptual influences. Regarding motor development, no apparent relationship appears to exist between rhythmical arm-hand movements and handwriting legibility (Freeman, 1918, 1921; West, 1922; Irish, 1949; Boraas, 1951). On the other hand, Harris and Rarick (1957, 1959, 1963) found a high correlation between point pressure and fine motor control ($r=.86$).

The relationship between handwriting ability and general intelligence appears to be of a positive, but generally low, nature (Gesell, 1906; Gates & LaSalle, 1924; Whitter, 1929). Studies that have involved more specific indices of intellectual functioning, appearing typically after the middle of the century, have resulted in no discernable pattern. Castelnuovo-Tedesco (1948) found a correlation ($r=.50$) between creativity factors expressed in subjects' handwriting samples and IQ scores. Linton, Epstein and Hartford (1961) found that subjects' using secondary beginning strokes scored significantly ($p<.05$) higher on the Rorschach M-type, unassertiveness indicator. Similarly, Epstein, Hartford and Tumarkin (1961) found that educational level and IQ related slightly ($r=.23$; $p<05$) to the production of letter variaions characterized by originality, simplicity and economy of stoke. And, Berent (1974) found that field-dependent subjects had significantly ($p<.01$) less legible handwriting than their field-independent counterparts.

In studies involving the role of perception in handwriting production, Furner (1969a, 1969b, 1970), Sovik (1976), Trap, Milner-Davis, Joseph and Cooper (1978), and Hayes (1982) found that the combination of visual and verbal stimulus presentation plus subject verbalization with copying practice provided maximum handwriting proficiency. Sovik (1974, 1979) and Wright and Wright (1980) found that the presence of a dynamically close stimulus produced significantly

($p<.01$) better handwriting than a static handwriting model. In two other studies related to the effect of feedback on handwriting, Jones, Trap and Cooper (1977) taught first grade students to successfully use transparent overlays to monitor their writing samples, but Burkhalter and Wright (1984) found no significant difference between the presence or absence of such self-correcting overlays.

In studies that focused on specific perceptual factors, Wedell and Horne (1969) found that subjects scoring high on the Bender Gestalt Test for Young Children also obtained high legibility scores. Chapman and Wedell (1972) found that non-reverser subjects significantly ($p<.05$) outperformed subjects who demonstrated consistent reversals on three of thirteen perceptual measures. And, Engleman (1978) and McKenzie (1984), both using a battery of perceptual and perceptual-motor measures, found a low positive relationship ($r=.37$) between visual perception and handwriting ability.

Interested in the tacit rule structure children tend to follow when producing handwriting, Rand (1973) found that drawing-rule utilization resulted in improved copying accuracy ($p<.05$) but not discriminating ability. Goodnow and Levine (1973) and Ninio and Lieblich (1976), articulating some of those rules, redefined copying performance as a cognitive skill that followed an implicit phrase structure. Finally, interested in the application of drawing-rule utilization to handwriting, Hirsh and Niedermeyer (1973) and Askov and Greff (1975) found a significant ($p<.02$) advantage of copying over tracing at two different grade levels; while Sims and Weisberg (1984) found that only when a precise scoring method using transparent overlays was employed was there a significant ($p<.01$) difference favoring copying.

All in all, the combined effect of research related to drawing-rule utilization, especially studies dealing with directional preferences in young children, lead Kirk (1980:31) to characterize the handwriting act as a predominantly cognitive, rule-governed task employing elements of sequence and syntax. However, when the full body of literature related to handwriting production is taken into account, this definition finds a more comprehensive statement in Furner (1983:50): handwriting is a rule-governed, perceptual learning task in which cognitive elements are instrumental. Whether it is merely a matter of emphasis, it is still a long way from Drever's (1915) characterization of handwriting as a purely mechanical process.

CHAPTER 3

PROCEDURES

Introduction

The purpose of this study was to determine whether a combination of ten psychoeducational factors is capable of discriminating between high and low handwriting legibility scores of second grade students. In light of this stated purpose, this chapter discusses the specific research methodology employed. The first section describes the population and sampling procedures utilized. This is followed by an account of the method of collecting, scoring and organizing the data related to student handwriting samples, a battery of motor, perceptual-motor, and cognitive measures, and other relevant population characteristics. A statement of the research hypotheses follows, along with a discussion of the methods of data analysis. The chapter concludes with a brief account of the precautions taken for statistical accuracy.

Population Description and Sampling Procedures

Subjects participating in the study were three hundred and five second grade students attending public elementary school in three different locations in the state of Montana. One hundred and thirty-one students participated from the Butte public school system (known hereafter as School System A); one hundred and thirty-two students participated from the Bozeman public school system (known hereafter as School System B); and forty-two students participated from the Belgrade public school system (known hereafter as School System C). The total population represents a cluster sample of fourteen intact second grade classes where, in each of the three participating school districts, beginning-of-the-year classroom placement procedures are conducted in a random, non-tracking manner contributing to a heterogeneous classroom population.

Second grade students were selected to participate in the study based on the work of Beery (1967) and Sovik (1976) who noted that the developmental trends in the copying performance of young children show the fastest rate of development between the ages of five and eight. Consequently, as Stanley and Pershin (1978) point out, second grade students--typically at the upper end of this developmental spectrum--should have fairly well developed two-dimensional copying skills, a factor necessary in the attempt to control the degree of variability of copying responses based on immaturity alone.

Students were screened for identified visual-motor problems and/or learning disabilities. The screening process was conducted by the principal investigator who interviewed each classroom teacher regarding the learning disabilities of those students attending resource programs. Of the three hundred and five students initially identified as qualifying for participation in the study, eight were removed from the sample population due to interfering learning disabilities and/or excessive absences. A letter of intent describing the nature of the study was then sent to the parents of the remaining two hundred and ninety-seven participating students.

Method of Collecting and Scoring Handwriting Samples

Handwriting Sample Collection

A handwriting sample was collected from each participating subject and involved having students copy a sample sentence from a near-point, static model (Sovik, 1979). The sample sentence copied was "The quick red fox jumped over the lazy brown dogs" (Lamme & Ayris, 1983). The sample sentence was written in D'Nealian manuscript on an 8 1/2" by 11" sheet of paper following the letter forms and spacing guidelines suggested in Book 2 of the D'Nealian handwriting program (Thurber, 1978). (See Appendix for an example of the handwriting sample collection sheet and a description of the scoring criteria.)

After the handwriting sample sheets were distributed, students were instructed to write their first name and last initial on the appropriate line at the top of the page. The classroom teacher then read the sentence to the class to be sure students understood what the words to be copied meant (Lamme & Ayris, 1983). When this was completed, students were instructed to copy the model sentence using their best manuscript handwriting (Yost & Lesiak, 1980). Upon completion of the writing task, the classroom teacher collected the samples, placed them in a manilla envelope, and held them for the principal investigator to pick up.

Handwriting Sample Scoring

The handwriting samples were prepared for scoring by the principal investigator. All student names were replaced by an identifying number. The identifying number was entered into a master data file which stored all relevant student data for the study. Only the principal investigator had access to the master data file and a knowledge of the numerical codes.

Scoring the handwriting samples involved the selection of three scorers (Halpin & Halpin, 1976; Feldt, 1962; Yost & Lesiak, 1980; Rand, 1973). Minimum standards for selection included: an undergradate degree in elementary education, English as a first language, and a minimum of two years elementary school teaching and/or substitute teaching experience (Enstrom, 1964).

The handwriting samples were rated on five legibility factors: letter formation, alignment, uniformity of spacing between letters and words, uniformity of slant, and letter size (Armitage & Ratzlaff, 1985;

Ziviani & Elkins, 1984; Burkhalter & Wright, 1984; Wright & Wright, 1980; Halpin & Halpin, 1976; Andersen, 1969; Bell, 1969; Freeman, 1959; Quant, 1946). Each legibility factor was rated on a five point scale where five indicated the highest achievement of the critical feature involved. All three scorers rated each handwriting sample independently and, according to procedures established by Enstrom (1964), the final score for any one handwriting sample was calculated by taking the average of the three independently derived scores.

Scorers were trained by the principal investigator following procedures established by Feldt (1962). First, the principal investigator and the three scorers discussed the individual components of the handwriting scale, i.e., letter formation, alignment, spacing, slant, and size. Next, the principal investigator projected on a screen a number of handwriting samples taken from second grade students not participating in the study. The scorers viewed the samples, made tentative evaluations of the quality using the pre-established criteria, compared ratings, and then discussed their results.

To further insure reliability among the three scorers, ten handwriting samples taken from ten second grade students not participating in the study, and collected under similar conditions outlined previously, were scored by the panel of three trained scorers. A Pearson product-moment correlation coefficient was calculated, and the procedure was repeated until a correlation coefficient of .85 or better was obtained.

After the training session was completed, the three scorers rated the handwriting samples collected under study conditions separately. The samples were identified only by code number and were submitted to each scorer in a different random order. Each scorer recorded her ratings on a separate score sheet. When all samples had been rated, the principal investigator collected the handwriting samples and the three score sheets. Each student's triad of scores was then entered into the master data file and an average score, representing that student's final legibiliy index, was calculated.

Method of Administering and Scoring Test Battery

A battery of psychoeducational tests was administered to each student participating in the study. Tests were administered on three separate occasions with each intact class representing a single testing unit. The three test periods lasted no more than forty minutes each. All tests were administered by the principal investigator with the aid of the classroom teacher who acted as an additional test proctor.

The tests, rotated at each different class administration, were administered at any one testing site over the course of a regular school week. One period of testing included administration of the Primary Mental Abilities' (PMAT) subtests "Spatial Relations" and "Perceptual Speed" and the Human Figures Drawing Test (HFDT). Another testing period included administration of the Developmental Test of Visual-Motor Integration (DTVMI) and the Torrance Picture Completion Test (TPCT). Finally, the third test group included administration of the Children's

Embedded Figures Test (CEFT) and the Detroit Test of Learning Aptitude's (DTLA) "Motor Speed and Precision" subtest.

Tests which are scored against standardized, objective criteria were scored by the principal investigator. These tests included the DTLA "Motor Speed and Precision" subtest, the PMAT "Spatial Relations" and "Perceptual Speed" subtests, the HFDT, and the CEFT. Tests which involve more subjective scoring criteria were scored by a panel of three trained scorers. These tests included the DTVMI and the TPCT.

Scorers were trained by the principal investigator according to the following procedures: (1) the principal investigator read through the administration guidelines, familiarized the scorers with the particular test in question, and demonstrated scoring procedures; (2) a discussion focusing on scoring procedures followed emphasizing the scorers' verbalization of the scoring process; (3) scorers scored five sample tests, compared the results, and then discussed similarities and differences, and (4) scorers demonstrated a Pearson product-moment correlation coefficient of .85 or better scoring sample tests before the study's sample population's tests were scored.

For both the DTVMI and the TPCT, student test booklets were randomly divided into three groups. Each trained scorer then scored separately the test booklets. To insure consistency and a high degree of reliability among the scorers, after each set of thirty test booklets were scored an inter-rater reliability coefficient was calculated ($r > .85$). At the conclusion of the scoring process, all scores were recorded on a master score sheet and later transferred to the master data file by the principal investigator. At no time did any of the three trained scorers know the full extent of the proposed study.

Primary Mental Abilities´ (PMAT) "Spatial Relations" and "Perceptual Speed" Subtests

Two subtests of the PMAT were used to measure spatial orientation and perceptual-motor abilities. The PMAT was originally designed to provide multi-factored and general intelligence indices for students kindergarten through twelfth grade. For the purpose of this study only the "Spatial Relations" and the "Perceptual Speed" subtests were given.

Thurstone (1965) defined spatial relations as the ability to visualize how parts of objects or figures fit together, what their relationships are, and what they look like when rotated in space. This ability has been thought to relate to handwriting performance especially in the area of letter reversals. Chapman and Wedell (1972) found a significant ($p<.05$) correlation between scores on the Frostig "Position in Space" subtest and young children´s reversal tendencies, however no significant correlation was found between scores on the Frostig "Spatial Relations" subtest and reversal tendencies.

The PMAT "Spatial Relations" subtest requires a subject to find the drawing that best completes the partially drawn square in the stimulus column of each test item row. The test examiner first demonstrates the procedure on the chalkboard using the first example given in the test booklet. Three sample items follow, and when these have been completed, subjects are given exactly six minutes to complete the twenty-seven remaining test items. A score on the "Spatial Relations" subtest, equal to the amount of correct responses in six minutes, indicates the strength of a subject's ability to mentally rotate complimentary geometric shapes. Related abilities measured include visual discrimination, visual memory and visual closure.

The PMAT "Perceptual Speed" subtest measures a subject's ability to recognize likenesses and differences between objects and symbols quickly and accurately (Thurstone, 1965). Furner (1983) has identified the ability to distinguish between critical features of letters as an important subskill in the production of handwriting. The PMAT subtest "Perceptual Speed" asks a subject to mark the two pictures out of four that are exactly alike. Students are given five minutes to complete the fifty test items. Prior to beginning, the test examiner demonstrates one item and then subjects practice three sample items in their test booklets. A score on the PMAT subtest "Perceptual Speed," equal to the number of correct responses in five minutes, indicates the strength of a subject's ability to recognize likenesses and differences between objects.

Concerning the test-retest reliability of the PMAT, reliability coefficients and standard errors of measurement were determined twice, once with a one-week interval between tests and once with a four-week interval between tests. The median reliability coefficient for the Total PMAT score was .91. The test-retest median coefficients at the second grade level for the "Spatial Relations" and "Perceptual Speed" subtests were .71 and .84 respectively.

Validity data for the PMAT were obtained through the cooperation of four schools located at varying distances along the eastern seaboard of the United States. Correlations were computed between PMAT scores and end-of-year-average grades for each grade in all four schools--a correlation of .59 was obtained at the second grade level. When correlated with specific subject area grades, the PMAT correlated with Language Arts at .61.

Human Figures Drawing Test (HFDT)

The HFDT was used to measure cognitive maturation. Developed originally by Goodenough (1926), and restandardized by Harris (1963), the HFDT is based upon the assumption that children's drawings are determined primarily by the developmental factors of chronological age and cognitive maturation. Although clinical interpretations seek to establish an emotional and/or attitudinal dimension, the HFDT used in this study follows closely guidelines established by Koppitz (1968) relating children's drawings to a standardized set of developmental or maturational factors.

Directions for the HFDT require that a subject draw "a whole person," the age and gender of the figure left completely to the discretion of the subject (Koppitz, 1968). Although in a clinical setting individual administration is preferred, the HFDT can be administered to an entire classroom using the following instructions: "On a piece of paper, I would like you to draw a whole person. It can be any kind of a person you want to draw, just make sure that it is a whole person and not a stick figure or cartoon" (Koppitz, 1968:6). There is no time limit to the HFDT, however most subjects finish their drawing within ten minutes.

HFDT scores are based on the presence or absence of certain developmental factors established through time for different age levels. Koppitz (1968:9) defined a developmental item as an item that occurs only on relatively few HFDTs of children of a younger age level and then increases in frequency of occurence as the age of the children increases, until it gets to be a regular feature of many or most HFDTs at a given age level. Such items include: eyes, eyebrows, nose, lips, arms, arms down, legs, etc. These items or factors, scored as either "Expected" or "Exceptional" according to the Koppitz (1968) scoring system, were derived primarily from the Goodenough-Harris scoring system and were included exclusively in the development of an HFDT suitable for elementary school-age children by Koppitz (1968).

The validity of the HFDT as a measure of cognitive maturation relies heavily on studies concerned with concurrent validity. Harris (1963) reported that the reliability coefficients between the HFDT and the Stanford-Binet Intelligence Test, in particular, have ranged from .72 to .92.

In test-retest reliability studies, Harris (1963) reported correlation coefficients between .60 and .70 for tests administered with a three month interval. On the other hand, Laosa, Schwartz and Holtzman (1973) reported test-retest reliability coefficients as high as .72 with as much as a three-year interval between tests.

Developmental Test of Visual-Motor Integration (DTVMI)

The DTVMI was used in this study to measure the degree of integration between visual and sensorimotor systems. Developed originally by Beery and Buktenica (1967), the DTVMI consists of twenty-four geometric forms that are copied by the subject in the test booklet. These geometric forms are arranged in order of increasing difficulty. A subject's score is calculated as the number of forms that are copied successfully prior to three consecutive failures (Klein, 1978).

The DTVMI was designed primarily for preschool and early grade level children, though it can be administered successfully to learning disabled adults. It can be administered in either a group or individual setting by clinicians, resource teachers, and classroom teachers (Beery, 1982). Curtis, Michael and Michael (1979) obtained a correlation coefficient of .65 between two sets of scores arising from group and individual modes of administration involving a time lapse of ten weeks. Beery (1982), interested in only the group-administered format, found a test-retest coefficient of .92 over a two-week period. In split-half studies correlation coefficients have ranged from .66 to .93 (Beery, 1982).

Concurrent validity for the DTVMI has been established in a number of areas. Beery (1982) reported correlations between the DTVMI and readiness tests (.50), reading and other academic tests (.60), chronological age (.89), and handwriting perfomance (.42). Concerning