

Effectiveness of Occupational Therapy in Remediating Handwriting Difficulties in  
Primary Students: Cognitive Versus Multisensory Interventions

by

Jill G. Zwicker  
B.A., B.Sc. (O.T.), Queen's University, 1990

A Thesis Submitted in Partial Fulfillment  
of the Requirements for the Degree of

MASTER OF ARTS

in the Department of Educational Psychology and Leadership Studies

□ Jill G. Zwicker, 2005  
University of Victoria

All rights reserved. This thesis may not be reproduced in whole or in part, by photocopy  
or other means, without the permission of the author.

Effectiveness of Occupational Therapy in Remediating Handwriting Difficulties in  
Primary Students: Cognitive Versus Multisensory Interventions

by

Jill G. Zwicker  
B.A., B.Sc. (O.T.), Queen's University, 1990

Supervisory Committee

Dr. Allyson Hadwin, (Department of Educational Psychology and Leadership Studies)  
Supervisor

Dr. Jillian Roberts, (Department of Educational Psychology and Leadership Studies)  
Departmental Member

Dr. Kimberley Kerns, (Department of Psychology)  
Outside Member

Supervisory Committee

Dr. Allyson Hadwin, (Department of Educational Psychology and Leadership Studies)  
Supervisor

Dr. Jillian Roberts, (Department of Educational Psychology and Leadership Studies)  
Departmental Member

Dr. Kimberley Kerns, (Department of Psychology)  
Outside Member

### Abstract

The purpose of this study was to compare the effect of cognitive versus multisensory interventions on handwriting legibility of primary students referred to occupational therapy for handwriting difficulties. Using a randomized three-group research design, 72 first and second-grade students were assigned to either a cognitive intervention, multisensory intervention, or no intervention (control) group. Letter legibility was measured before and after 10 weeks of intervention. Analysis of variance of difference scores showed no statistically significant difference between the intervention groups. Grade 1 students improved with or without intervention, but grade 2 students showed dramatic improvement with cognitive intervention compared to multisensory intervention ( $d = 1.09$ ) or no intervention ( $d = .92$ ). Several students in both grades showed declining performance in the multisensory and control groups, but no students had lower legibility after cognitive intervention. These results challenge current occupational therapy practice of using a multisensory approach for remediation of handwriting difficulties, especially for students in grade 2.

## Table of Contents

Supervisory Committee .....	ii
Abstract .....	iii
Table of Contents .....	iv
List of Tables .....	viii
List of Figures .....	ix
Acknowledgments.....	x
Chapter 1: Introduction .....	1
Overview.....	1
Statement of the Problem.....	3
Purpose of the Study .....	4
Hypotheses .....	4
Definition of Terms.....	4
Delimitations of the Study .....	6
Assumptions.....	6
Summary of Chapter One .....	7
Chapter 2: Literature Review .....	8
Overview of Chapter Two .....	8
Review of Literature .....	8
Development of handwriting skills.....	8
Handwriting instruction.....	9
Factors contributing to handwriting difficulties.....	11
Assessment of handwriting .....	13

When to begin handwriting instruction or remediation.....	15
Multisensory handwriting interventions.....	16
Cognitive handwriting interventions.....	20
Summary of Chapter Two.....	26
Chapter 3: Methodology.....	28
Overview of Chapter Three.....	28
Research Design.....	28
Sampling.....	29
Treatments.....	30
Cognitive Intervention.....	31
Multisensory Intervention.....	32
Instrumentation.....	34
Procedure.....	36
Summary of Chapter Three.....	38
Chapter 4: Results.....	40
Overview of Chapter Four.....	40
Preliminary Analyses.....	40
What was the composition of the sample?.....	40
Were the groups equivalent prior to the start of intervention?.....	41
Primary Analyses.....	42
Hypothesis 1.....	45
Hypothesis 2.....	46
Secondary Analyses.....	46

Was there a statistically significant difference in the improvement letter legibility of boys versus girls in the different intervention conditions? .....	46
Was there a statistically significant difference in how children in grades 1 and 2 responded to the different interventions?.....	47
Was there a difference in the number of children who improved with each intervention? .....	49
Was there a statistically significant difference in how children with ADHD responded to the interventions compared to children without ADHD?.....	51
Summary of Chapter Four .....	51
Chapter 5: Discussion .....	52
Overview of Chapter Five.....	52
Summary of Results.....	52
Explanation of Findings.....	53
Why were the hypotheses of the study not supported?.....	53
Why did grade 2 students respond differently to intervention than grade 1 students? .....	55
Implications of Findings .....	56
Theoretical Implications. ....	56
Research Implications.....	60
Practical Implications.....	61
Limitations .....	62
Future Directions .....	63
Summary of Chapter Five.....	64

References.....	65
Appendix A Sample Treatment Protocol for Cognitive Intervention.....	76
Appendix B Sample Treatment Protocol for Multisensory Intervention.....	78
Appendix C Parent Consent Letter .....	80
Appendix D Child Consent Form .....	83

## List of Tables

Table 1. Chi-square Analysis of Sample Distribution by Gender and Grade per Intervention Group.....	41
Table 2. Analysis of Variance for Pretest Total Letter Legibility .....	42
Table 3. Total Letter Legibility Scores by Intervention Group .....	43
Table 4. Analysis of Variance for Difference Scores of Total Letter Legibility .....	46
Table 5. Total Letter Legibility Difference Scores: Group x Grade.....	47
Table 6. Percentage of Children With Declining Performance, No Change or Improvement in Total Letter Legibility Per Intervention Group .....	49
Table 7. Percentage of Grade 1 Students With Declining Performance, No Change or Improvement in Total Letter Legibility Per Intervention Group .....	50
Table 8. Percentage of Grade 2 Students With Declining Performance, No Change or Improvement in Total Letter Legibility Per Intervention Group .....	50

List of Figures

Figure 1. Boxplots of Posttest Total Letter Legibility Scores by Intervention Group..... 44

Figure 2. Boxplots of Difference Scores by Intervention Group..... 45

Figure 3. Pretest and Posttest Means of Total Letter Legibility for Grade 1 Students..... 48

Figure 4. Pretest and Posttest Means of Total Letter Legibility for Grade 2 Students..... 48

## Acknowledgments

I would like to extend my sincere thanks to my supervisor, Dr. Allyson Hadwin, for her guidance and support throughout my thesis. Her encouragement, belief in me, and enthusiasm for the project were grounding influences that kept me moving forward in my journey.

I would like to thank my committee members, Dr. Jillian Roberts and Dr. Kimberley Kerns, for their positive and constructive feedback on my research proposal and the final document, as well as my external examiner, Dr. Nancy Perry, for her feedback and thought-provoking questions at my oral defense.

Thanks goes to Dr. John Walsh who was not on my committee, but who made himself available to answer questions and give feedback during the planning stages of this study.

I would like to thank my friend and fellow graduate student, Lisa Blodgett, who was a constant source of support through my Master's journey. Coffee dates, squash games, and wine nights were only a few of the strategies we used to cope with stress and maintain our friendship through the hectic times. Lisa was such a good friend that she even agreed to score many handwriting assessments as my second rater (trust me...it was not a fun task!).

Special thanks go to my husband, Jamie, and daughters, Alecia and Rebecca, who were very patient as I pursued my studies. Their sacrifices and unwavering support helped me to achieve my goal, for which I am truly grateful. My Master's degree is as much theirs as it is mine.

There were many friends who supported me throughout my journey. I would like to give special thanks to Tina Morgan who has the knack of making me laugh whenever we are together. Her sense of humour helped to keep me sane and to enjoy “the moment”. I would also like to thank Alison & Keith Hayton and Marianna & Nick Fiocco for their regular gifts of food, laughter, and fun. Our dinner parties were always something to look forward to, especially if I wasn’t cooking!

I would like to give special acknowledgment to the children, families, and teachers who participated in this study. Without them, this project would not have been possible! I would also like to thank the therapists and staff from Queen Alexandra Centre for Children’s Health who were involved with this study: Len Anderson, Barbara Boyle, Fran Bitonti, Karen Davies, Carrie DeBoer, Alison Doyle, Shelly Fathers, Audrey Gibson, Rachel Hammett, Hilary LeRoy, Christine Lynch, Sharon Montgomery, Carolyn Neil, Maureen O’Neill, Erie Pentland, Kerri Rideout, Pat Robinson, Julie Southward, Jan Wardill, and Cara Webster. I thank you for your commitment and dedication to this project.

Finally, I would like to acknowledge the funding agencies that supported this project and believed in its value: Queen Alexandra Foundation, Vancouver Island Health Authority, British Columbia Society of Occupational Therapists, Michael Smith Foundation for Health Research, and the University of Victoria.

## Chapter 1: Introduction

### *Overview*

Handwriting constitutes one of the main means of communicating ideas in written form. Despite advances in technology and access to computers, much of a child's schoolwork in the elementary school years requires mastery of the printed word. Failure to achieve this foundational skill may have implications for the child's future academic performance. Difficulty with handwriting requires greater attentional resources to be directed to letter formation, which can interfere with a child's confidence and competence as a compositional writer (Case-Smith, 2002; Graham, Harris, & Fink, 2000; Graham & Weintraub, 1996). Poor legibility can interfere with teachers' perceptions and grading of students' written work (Briggs, 1970; Markham, 1976). Academic failure as well as lowered self-esteem can result from problems associated with poor handwriting (Rubin & Henderson, 1982; Tseng & Cermak, 1993).

The prevalence of handwriting problems in typically developing children has been estimated to range from 5% to 25% (Hamstra-Bletz, 1993 and Smits-Engelmanns, 1995 as cited in Jongmans, Linthorst-Bakker, Westenberg, and Smits-Engelmanns, 2003; Rubin & Henderson, 1982). The incidence of handwriting difficulties is anticipated to be much greater in children with the diagnoses of developmental coordination disorder or learning disability (disorder of written expression), as poor handwriting is a diagnostic indicator of these conditions (American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders 4<sup>th</sup> ed.-Text Revision, 2000).

Children experiencing difficulty with handwriting are often referred to occupational therapy for assessment and intervention. Occupational therapists assess the

child's development in a variety of component skills required for handwriting, including fine-motor skills, visual perception, visual motor integration, and postural skills. The child in relation to the task and learning environment is also assessed. The school-based occupational therapist then assists the child to overcome handwriting difficulties through remedial or compensatory interventions.

A survey of 198 school-based occupational therapists practicing in the United States indicated that 92.1% of the therapists used a multisensory approach for remediating handwriting difficulties (Woodward & Swinth, 2002). Similar results were found in a survey of 50 Canadian pediatric occupational therapists. Feder, Majnemer, and Synnes (2000) reported that all therapists used an eclectic approach for treating handwriting problems but indicated that a sensorimotor approach to treatment was selected by 90% of therapists. Although a multisensory approach for remediating handwriting difficulties is used by an overwhelming majority of occupational therapists, the empirical evidence to support such practice is sparse and inconclusive.

A pilot study conducted by occupational therapists examined the effectiveness of a cognitive treatment for children with developmental coordination disorder (Miller, Polatajko, Missuina, Mandich, & Macnab, 2001). These researchers found that the cognitive intervention was more effective than contemporary occupational therapy intervention in achieving client-centred goals. Given that children most commonly selected printing or writing as one of their treatment goals, it would appear that a cognitive intervention may be worthy of further investigation in the remediation of handwriting difficulties.

Miller et al. (2001) based their cognitive treatment approach on the self-instructional training model developed by Meichenbaum (1977). Researchers in the Netherlands investigated a similar self-instruction method and determined that it was effective in improving the quality of handwriting in children with poor handwriting (Jongmans et al., 2003). Other researchers have indicated that handwriting instruction that included verbal mediation was more effective than phonological awareness training in improving handwriting skills (Graham et al., 2000).

In light of the preliminary evidence favouring a cognitive approach to handwriting remediation, further investigation is warranted. More research is also required on the effectiveness of a multisensory approach to the treatment of handwriting difficulties given that this approach dominates current school-based occupational therapy practice. As handwriting problems do not disappear without intervention (Hamestra-Bletz & Blöte, 1993; Smits-Engelsman & van Galen, 1997), it is important to determine which interventions are effective in improving the quality of handwriting in children who are having difficulty in learning this skill. In their review of handwriting research, Graham and Weintraub (1996) indicate “research aimed at identifying effective procedures for helping those that struggle with handwriting must continue” (p. 77).

#### *Statement of the Problem*

The problem of the study is expressed by the following question:  
Is a cognitive approach more effective than a multisensory approach in improving the handwriting legibility of primary students referred for occupational therapy?

*Purpose of the Study*

The general purpose of the study was twofold. One aim was to contribute evidence to the literature that children with handwriting difficulties who receive intervention will demonstrate significant improvement in handwriting legibility compared to children with handwriting difficulties who do not receive intervention. The main purpose of the study was to determine whether a cognitive intervention or multisensory intervention is more effective in the treatment of handwriting difficulties. To date, the effectiveness these two approaches to handwriting remediation has not been empirically compared.

The specific purpose of this study was to compare the effectiveness of cognitive versus multisensory interventions in improving the handwriting legibility of children in grades 1 and 2 who have been referred to school-based occupational therapy.

*Hypotheses*

This study examines two research hypotheses:

1. There will be a statistically significant improvement in the handwriting legibility of children who receive cognitive or multisensory intervention compared to the children who receive no intervention.
2. There will be a statistically significant improvement in the handwriting legibility of children who receive cognitive intervention compared to the children who receive multisensory intervention.

*Definition of Terms*

The following definitions are offered to ensure proper interpretation of the terminology used in this study.

1. Cognitive approach to handwriting remediation – involves strategies such as modeling, imitation, discussion, practice, and self-evaluation. (Graham et al., 2000).
2. Developmental coordination disorder – “marked impairment in the development of motor coordination...that significantly interferes with academic achievement or activities of daily living” (DSM-IV-TR, 2000, p. 56-57).
3. Dysgraphia – “a written language disorder that concerns mechanical writing skills” (Chu, 1997, p. 515).
4. Handwriting – refers to the physical skill of writing (Alston & Taylor, 1987); manuscript (printing) is the focus of this study.
5. Legibility – defined as a letter or word that is recognizable out of context at first glance (Amundson, 1995). Letter formation, size, slant, spacing, and alignment contribute to legibility (Alston, 1983; Amundson, 1995).
6. Multisensory approach to handwriting remediation - involves using a variety of sensory experiences, media, and instructional materials to stimulate the child’s sensory systems, including the proprioceptive, vestibular, tactile, visual, and auditory senses (Woodward & Swinth, 2002).
7. Occupational therapy – a health care profession that “help[s] people who have been challenged by accident, handicap, emotional problems, developmental difficulties or disease to develop or maintain independent lives and activities at home and in the community” (College of Occupational Therapists, 2003). School-based occupational therapists assist students with special needs “to

develop skills, restore function, maintain ability, and prevent dysfunction” in order to improve their ability to perform in the student role (Canadian Association of Occupational Therapists, 1990, p. 4).

8. Visual motor integration – ‘the degree to which visual perception and finger-hand movements are well coordinated’ (Beery & Beery, 2004, p. 12). Visual motor integration has been operationally defined as the ability to copy geometric shapes (Tseng & Cermak, 1993).

### *Delimitations of the Study*

The following limitations were imposed by the researcher:

1. The study was limited to children in grades 1 and 2 who were referred school-based occupational therapy for handwriting difficulties as identified by their parents or teacher.
2. Children with medical or educational diagnoses that may confound the results were excluded from the study (e.g. autism, mental retardation, foetal alcohol spectrum disorder, severe developmental delay, etc.).
3. The study was limited to the following variables: independent variables of cognitive intervention, multisensory intervention, and no intervention and dependent variable of handwriting legibility.
4. The study was limited to data collected from October 2004 to June 2005.
5. All variables, conditions, or populations not specified in this study were considered beyond the scope of this investigation.

### *Assumptions*

The following assumptions were expected to prevail throughout the study:

1. The students participating in the study were motivated to improve their handwriting.
2. Students in all groups continued to receive handwriting instruction as part of their school curriculum.
3. The occupational therapists participating in the study made every effort to implement the treatment protocols as outlined.

### *Summary of Chapter One*

This chapter highlighted the importance of remediating handwriting problems in developing writers. The need to determine effective interventions for handwriting difficulties was also outlined. In the next chapter, the development of handwriting and the etiology of handwriting problems will be discussed. Handwriting instruction and assessment will also be reviewed, followed by an examination of studies on various handwriting remediation approaches. Chapter Three will outline the research methodology for comparing the effectiveness of cognitive versus multisensory interventions in improving handwriting legibility.

## Chapter 2: Literature Review

### *Overview of Chapter Two*

Handwriting difficulties are the main reason for referral to school-based occupational therapy (Case-Smith, 2002; Feder et al; 2000). The need for identifying effective interventions for handwriting problems has been documented in occupational therapy, special education, and educational psychology literature. This chapter reviews previous studies conducted on multisensory and cognitive-based interventions and the theory behind the respective approaches. Prior to reviewing the interventions for handwriting, it is first necessary to provide some background information on the development of handwriting skills and handwriting instruction practices. Possible factors that may contribute to handwriting difficulties are then outlined. A review of the literature in terms of handwriting assessment and when to begin instruction/remediation is also included.

### *Review of Literature*

#### *Development of handwriting skills.*

Handwriting is a complex skill, requiring the maturation and integration of cognitive, visual perceptual, and fine motor skills (Alston & Taylor, 1987; Chu, 1997; Maeland, 1992; Rubin & Henderson, 1982; Tseng & Chow, 2000). The small muscles of the hand follow a developmental progression of prehension and grasp through infancy, toddlerhood, and the preschool years to prepare a child to grasp and manipulate a writing instrument (de Ajuriaguerra & Auzias, 1975; Ziviani, 1987). A child's early experiences with scribbling pave the way for imitating and copying lines and circles in the preschool years. Eye-hand coordination, visual perception, auditory perception, directionality,

sequencing, and memory also develop with maturation and experience in the early years and are thought to be the underlying components required for handwriting (Alston & Taylor, 1987; Amundson & Weil, 2001). Despite the developmental trends of the component skills, the actual skill of handwriting requires formal instruction at school. Culturally determined conventions of writing are taught and practiced in varying degrees in the school environment (Hamstra-Bletz & Blöte, 1993).

*Handwriting instruction.*

Although the child may have been exposed to printing at home or in the preschool environment, formal instruction in handwriting usually begins when the child enters school. In Canada and the United States, manuscript print is typically taught in grades one and two with cursive script introduced in grade three (Amundson, 1995; Graham, 1992). Handwriting instruction in Kindergarten is an emerging area of research (Edwards, 2003).

In reviewing the literature, there appears to be little consensus on how to teach children how to handwrite. Controversy exists between the styles of letters to teach, the use of lined versus unlined paper, and the types of writing instruments the children should use (Alston & Taylor, 1987; Bergman & McLaughlin, 1988; Graham, 1992; Graham & Miller, 1980; Graham and Weintraub, 1996). According to Rubin and Henderson (1982), much of handwriting instruction that transpires in the classroom appears to be related to tradition rather than empirical research. In a survey of handwriting instruction practices in London, England, these researchers found that teachers could describe their teaching practices in handwriting, but few teachers could cite the sources of their teaching decisions.

In a historical review of handwriting, Simner (2003) indicated that handwriting instruction was a core component of the primary curriculum across Canada from the 1870's to the mid-1970's. Much of handwriting instruction involved tracing and copying letters from commercially available or teacher-constructed handwriting programs. The introduction of the whole language philosophy to learning in the mid-1970's precipitated an incidental approach to handwriting instruction. Letter formation was no longer explicitly taught but was to be addressed by the teacher during writing activities if a child was noted to be having difficulties.

The move to the whole language approach negated the need to teach the mechanics of handwriting in classrooms. This approach has added to the debate on how handwriting skills can best be mastered (Graham, 1992). Goldberg and Simner (1999) contend that the whole language approach is harmful. In a study comparing students taught in the traditional versus whole language approach, these researchers found that not only did the students with traditional instruction produce more legible handwriting, these students also produced 33% more writing than the students taught using the whole language approach.

As there is much debate in the literature in terms of handwriting instruction, the amount of time spent on handwriting and the methods of instruction are presumed to vary greatly between teachers, schools, and districts. Despite the instructional differences, most children learn how to print competently by the age of 6 or 7 years (Tseng & Chow, 2000). There are, however, many children in both regular and special education classrooms that experience handwriting difficulties (Bergman & McLaughlin, 1988).

*Factors contributing to handwriting difficulties.*

The prevalence of handwriting problems in typically developing children has been estimated to range from 5% to 25% (Hamstra-Bletz, 1993 and Smits-Engelmans, 1995 as cited in Jongmans et al., 2003; Rubin & Henderson, 1982). Handwriting difficulties can be a result of problems intrinsic to the child or as a result of external factors, such as poor teaching methods (Alston & Taylor, 1987; Rubin & Henderson, 1982). As previously mentioned, teaching of printing and handwriting in the classroom is not necessarily formal or consistent. If a child does not receive sufficient instruction and feedback when s/he is learning letter formation, errors can become habitual and result in poor legibility (Alston & Taylor, 1987; Graham, 1992; Sassoon, 1983). Trying to teach printing before the child is developmentally ready can also result in poor writing skills (Alston & Taylor, 1987; Weil & Cunningham Amundson, 1994).

Several studies have been conducted to explore potential factors that may contribute to handwriting difficulties. These intrinsic factors include: kinaesthesia, fine motor skills, eye-hand coordination, orthographic coding, visual perceptual skills, and visual motor integration. Research has demonstrated that some of these factors are more significant than others in handwriting performance.

Kinaesthesia, the sense of position and movement, is important for motor learning. Some researchers have indicated that children who have difficulty perceiving or storing kinaesthetic information have difficulty with handwriting as well as improving performance through practice (Bairstow & Laszlo, 1981; Harris & Livesey, 1992; Laszlo & Bairstow, 1983, 1984). Other researchers have found that kinaesthesia was not a significant contributor to handwriting performance (Copley & Ziviani, 1990; Lord &

Hulme, 1987; Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2002; Tseng & Murray, 1994).

Fine motor skills and finger function have been found to contribute to handwriting performance (Berninger & Rutberg, 1992; Cornhill & Case-Smith, 1996; Weintraub & Graham, 2000) but not all children with poor handwriting have poor fine motor skills (Rubin & Henderson, 1982; Tseng & Chow, 2000). A moderate to significant correlation between eye-hand coordination and handwriting has been documented (Cornhill & Case-Smith, 1996; Tseng & Murray, 1994).

Orthographic coding refers “the ability to develop an intact representation of the letters of the alphabet and rapidly and accurately encode and reproduce them from memory” (Weintraub & Graham, 2000, p. 123). Weintraub and Graham did not find that orthographic coding was predictive of handwriting legibility in grade five students, which contrasts other research that found orthographic coding ability contributed significantly to handwriting fluency (Abbott & Berninger, 1993). Visual sequential memory was found to be a significant factor in children who are slow hand writers (Tseng & Chow, 2000), but the influence of other visual perceptual skills in development of handwriting has not been demonstrated through empirical studies (Tseng & Cermak, 1993).

The most consistent finding in the literature is the correlation of visual motor integration to handwriting. Sovik (1975) found that visual motor integration was the most significant predictor of handwriting performance in children aged 7 to 11 years ( $r = .42$ ). Maeland (1992) found that performance on the *Developmental Test of Visual Motor Integration* (VMI) was a significant predictor of handwriting performance for 59 Norwegian fourth grade children. Weil and Cunningham Amundson (1994) and Daly,

Kelley, and Krauss (2003) replicated these findings in kindergarten students, finding a strong correlation between the students' score of visual motor integration and their ability to copy letters legibly ( $r = .64$ ). Tseng and Murray (1994) found that the VMI was the best predictor of legibility and accounted for 30.5% of the variance in good and poor hand writers. Other researchers have also found that performance on the VMI was a predictor of handwriting status (Cornhill & Case-Smith, 1996; Weintraub & Graham, 2000)

In summary, it appears that many factors may contribute to poor handwriting skills. The most consistent and significant finding in empirical studies is the influence of visual motor integration skills on handwriting performance. It is important to note that the above-mentioned studies are correlational in nature and do not imply causation of handwriting difficulties.

*Assessment of handwriting.*

Whether the handwriting difficulty stems from intrinsic factors, external influences, or both, the problem is manifested in illegible handwriting. Several variables have been identified as components of legibility: letter formation, alignment, spacing, slant, and size (Alston, 1983; Amundson, 1995; Bruinsma & Nieuwenhuis, 1991; Sassoon, 1983). Formation of individual letters is thought to contribute more to legibility than any other factor (Graham & Miller, 1980). Speed of writing is also a factor in that children with handwriting difficulties are often slow to write or are unable to complete written work in the specified time. Speed is usually of secondary concern compared to the readability of a child's script (Donoghue, 1990; Graham & Miller, 1980).

Children with illegible handwriting may be described as having dysgraphia, a written language disorder. Simner & Eidlitz (2000) have determined that four factors distinguish dysgraphic handwriting from normal handwriting at the first grade level: distortions in overall shape of the letters, distortions in the relative size of letters, irregular spacing between the letters, and crowding of words. Children with learning disabilities or developmental coordination disorder often have dysgraphic handwriting (Chu, 1997; Miller et al., 2001).

Assessment of handwriting can take many forms. Checklists and standardized assessment tools have been developed to examine the components of legibility, such as slant, size, and alignment; however, these tools can be time consuming to administer and may not provide an accurate reflection of the readability of a child's written work (Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2001). The other approach to rating handwriting legibility is looking at the global legibility of a writing sample, using readability as the primary criterion to determine legibility (Sudsawad et al., 2001). This approach is easy to use and more practical to apply in the classroom setting (Amundson, 1995). Teachers tend to evaluate the legibility of students' handwriting subjectively by judging readability (Rubin & Henderson, 1982). A more objective measure of global legibility can be obtained through the use of a criterion-referenced assessment, such as the *Evaluation Tool of Children's Handwriting* (Amundson, 1995). This measurement tool assesses children's legibility and speed of handwriting in writing tasks that are similar to those required of students in the classroom. Total percentage scores for word legibility, letter legibility, and number legibility are derived from a variety of writing

tasks, which include writing the alphabet from memory, near-point copying, far-point copying, dictation, and sentence composition.

*When to begin handwriting instruction or remediation.*

When to begin formal handwriting instruction is controversial. Some authors believe that children may be ready at age four (Lamme, 1979) where others feel that children are not ready to print until after the age of six (Laszlo & Bairstow, 1984). Beery and Beery (2004) contend that handwriting instruction should not begin before a child is able to copy the first eight geometric designs on the Beery VMI (5<sup>th</sup> ed.). The eight figures are: vertical line, horizontal line, circle, cross, right oblique line, square, left oblique line, and oblique cross. The movements required to copy these shapes are the same as those required to reproduce all the letters of the manuscript alphabet. According to Beery's normative sample, a child is usually able to complete the first nine figures at an age equivalent of 5 years 3 months. Weil and Cunningham Amundson (1994) concluded that the majority of kindergarten children in their study were ready for handwriting instruction in the latter half of the year based on their VMI scores.

According to Sassoon (1983), proper letter formation must be taught as soon as the child enters school to prevent writing errors from becoming engrained. This contention is echoed by Alston and Taylor (1987), who state that "motor skills are resistant to change and the need for them to be developed accurately in the early stages of development is very important for handwriting" (p. 2). These assertions, taken together with the above visual motor integration correlations for kindergarten students, lend support for formal handwriting instruction in kindergarten. It would follow, then, that if children are having difficulty in grade one with letter formation after receiving instruction

in kindergarten, additional support and remedial intervention may be warranted to prevent poor writing habits from developing.

*Multisensory handwriting interventions.*

The multisensory approach to handwriting remediation dominates occupational therapy practice (Feder et al., 2000; Woodward & Swinth, 2002) and stems from a sensory integrative frame of reference. The theory of sensory integration, developed by Ayres (1972), hypothesizes that learning is dependent on the ability to take in and process sensory information. Ayres believed that higher cortical functions were dependent upon the integration of sensory input processed at the subcortical level. She presumed that some children with learning disabilities had difficulty discriminating and integrating sensory input, which interfered with their learning and behaviour. Intervention based on the principles of sensory integration hypothesizes that increasing sensory input through meaningful activity will improve the ability to process sensory information and therefore enhance learning (Bundy & Murray, 2002). Handwriting intervention incorporating a sensory integrative approach employs a variety of sensory experiences, including proprioceptive, tactile, visual, auditory and olfactory input. This multisensory approach is thought to encourage sensory integration and affect the quality of motor output, such as improving legibility of written letters. (Amundson & Weil, 2001). Four studies of the multisensory approach to handwriting remediation are present in the literature. Each of these will be reviewed in turn.

Oliver (1990) conducted a pilot project to examine the effectiveness of a sensorimotor program for improving writing readiness skills in three groups of children aged 5 to 7 years. Group 1 consisted of 12 children of normal intelligence (mean full

scale IQ = 94 on the Wechsler Intelligence Scale-Revised) who attended regular education classes. Group 2 was comprised of 6 children in regular education classes whose verbal IQ was an average of 15 points greater than performance IQ (mean verbal IQ = 86; mean performance IQ = 71). The third group of children included 6 children who were diagnosed with mental retardation of unknown aetiology (mean full scale IQ = 65). All 24 children demonstrated delayed writing readiness skills as none of the children had mastered the first nine designs on the *Developmental Test of Visual Integration* on pretesting.

Treatment consisted of direct occupational therapy intervention for 30 minutes per week during the school year and included multisensory stimulation and large movement patterns during writing readiness activities. The children were asked to copy designs in a variety of media, including a finger trail in sand or drawing on the chalkboard. Bead stringing, block design, parquetry and paper folding were also incorporated into the treatment sessions. A program carried out by parents or school personnel supplemented direct treatment and included drawing designs on the chalkboard, perceptual motor activities, and manuscript letter practice on the board and on paper. The *Developmental Test of Visual Integration* was re-administered one year after pretesting. All children in Group 1 as well as four children in each of the other groups mastered the writing readiness designs. The average gains for children in Groups 1 and 3 were 9.5 months and 12.0 months respectively, which is within the range of expected maturation. The children in Group 2 gained an average of 17.0 months in developmental writing readiness. Oliver concluded that multisensory training may be of benefit for students who have deficits in writing readiness skills, especially when there is a large difference between their verbal

and performance IQ. It is not clear from this study if the therapy had any influence on the children's actual handwriting skills.

Lockhart and Law (1994) examined the effectiveness of a multisensory writing programme for improving the cursive writing ability of 4 children with sensorimotor difficulties. Treatment consisted of five one-hour sessions, with four sessions targeting a group of letters similar in formation and the last session including letters with unique motor patterns. Treatment activities included: tracing large letters on a blackboard with chalk, tracing letters over a rough surface with a marker, forming letters in rice with a finger, copying large letters and groups of letters on paper over a rough surface, and tracing and copying letters and groups of letters on regularly lined paper. The participants were also to complete 15 minutes of homework each evening that involved writing practice of the targeted letters covered in the treatment session. The results of this single case study using multiple baselines indicate that all 4 children demonstrated improvement in handwriting quality on one or more of the letter groups following intervention; however, only one child demonstrated a statistically significant improvement in letter quality. The researchers indicated that the teachers of the children reported a noticeable improvement in the children's handwriting. The small sample size and subjective results of this study provide little empirical support for multisensory handwriting intervention.

Case-Smith (2002) compared 29 students aged 7 to 10 years with poor handwriting legibility that received direct occupational therapy intervention with a control group of 9 students who did not receive services. Treatment consisted of 30 minutes of intervention per week for an average of 16.4 sessions. Interventions were based on the individual needs of the child and included multisensory approaches

(vibration, resisted writing, writing on chalkboard and vertical surfaces), behavioural and motor learning techniques (shaping, stimulus fading, verbalized description of letter formation, self-monitoring) or developmental and behavioural approaches (aimed at letter formation, alignment, spacing, and sizing issues). Seventy-two per cent of the sessions also included visual motor activities. Consultation with teachers and parents was an integral component of the occupational therapy intervention.

Students in the intervention group improved an average of 14.2% in total legibility ( $d = 1.99$ ) as measured by the *Evaluation Tool for Children's Handwriting* whereas students that did not receive intervention remained unchanged over the course of the year (Case-Smith, 2002). Fifteen of 29 students demonstrated good legibility by the end of the school year (>90% total letter legibility). Due to the eclectic nature of the occupational therapy intervention, it is difficult to determine which factors contributed to the improvement in handwriting legibility. Case-Smith concluded that investigation of specific handwriting interventions is necessary to determine which approaches result in optimal outcomes.

Peterson and Nelson (2003) conducted a study to explore the effectiveness of occupational therapy intervention on the printing skills of 59 economically disadvantaged first graders. Although this study incorporated a biomechanical framework and teaching/learning strategies, the main treatment approach appeared to be sensorimotor in nature; therefore, this study is included in the discussion of multisensory interventions. Participants were randomly assigned to an experimental group (handwriting intervention) or control group (no intervention). Intervention sessions were scheduled for 30-minutes twice a week for 10 weeks. The first five minutes of intervention involved groups of

children participating in sensorimotor “heavy work” activities, such as running, jumping, kicking, pushing, pulling, and crawling games. For the next 20-minutes, the children worked individually or in pairs with an occupational therapy student on activities designed to improve motor planning, motor memory, self-monitoring, letter formation, and spacing. Vertical and slanted writing surfaces as well as multisensory modalities (i.e. writing through shaving cream) were used. The last five minutes of treatment was spent practicing handwriting. The results of the study showed that the occupational therapy intervention group improved significantly on the *Minnesota Handwriting Test* from pretest to posttest. The control group demonstrated no change on the handwriting test even though they continued to receive handwriting instruction in class. As with the study by Case-Smith (2002), the intervention in this study was comprised of multiple factors so it is difficult to determine which aspect of the intervention was effective. Peterson and Nelson (2003) recommend that “future research should contrast the relative effects of biomechanical, sensorimotor, and teaching-learning strategies in enhancing handwriting” (p. 158).

*Cognitive handwriting interventions.*

Cognitive interventions use metacognitive skills to guide handwriting performance rather than sensory input. A variety of approaches are employed to improve handwriting, such as self-instruction, modeling and imitation, guided practice, and self-evaluation. Although not explicitly stated in the literature, these interventions appear to stem from the theory of self-regulated learning. Self-regulation “refers to students’ self-generated thoughts, feelings and actions, which are systematically oriented toward attainment of their goals” (Schunk & Zimmerman, 1994). Several theories of self-

regulation are evident in the literature, including Vygotskian, social cognitive, and information processing perspectives (Zimmerman, 2001). This section will review the research on handwriting remediation, starting with verbal guidance and self-instruction.

The Vygotskian view of self-regulation is the use of inner speech as a source of knowledge and self-control (Zimmerman, 2001). This perspective underlies basis of self-instruction training, which is often referred to as “teaching children to talk to themselves” (Fish & Pervan, 1985, p. 83). The use of self-verbalizations to guide letter formation originated from Furner’s work (1969a, 1969b, 1970). The actual technique of self-instructional training was developed by Meichenbaum (1977) and has been applied to a number of academic issues, including handwriting remediation. Self-instructional training involves five steps:

1. Adult models a task while talking out loud (cognitive modeling)
2. Child performs the task while adult provides instructions out loud (overt, external guidance)
3. Child performs the task while verbalizing instructions (overt self-guidance)
4. Child performs the task while whispering instructions (faded, overt-self-guidance)
5. Child performs the task using private speech (covert self-instruction).

Robin, Armel, and O’Leary (1975) assessed the effects of self-instruction on letter formation in kindergarten children. Thirty children with the lowest scores on a handwriting pretest were randomly assigned to one of three groups: self-instruction, direct training, or no treatment. Although the students in the self-instruction group copied more letters correctly than the direct instruction and no treatment groups, the correlation

between handwriting performance and the number of self-instructions was not significant. The authors commented that the self-instructional procedures were too cumbersome to use in a regular classroom.

Graham (1983) studied the use self-instruction and self-evaluation techniques in handwriting instruction of 3 third and fourth grade students with learning disabilities. The students practiced copying, tracing, and writing two letters while verbalizing how to form them. Graham reported that only modest gains were obtained after five hours of instruction and there was little evidence of generalizability to the classroom setting.

Kosiewicz, Hallahan, Lloyd and Graves (1982) found that self-instruction and self-correction were valuable techniques in improving the handwriting of a 9-year old boy with a learning disability. However, the child's handwriting performance deteriorated when treatment was discontinued, albeit not to the baseline level. A "booster" session was employed but only resulted in a temporary improvement.

The results of the above three studies may lead one to question the effectiveness of verbally guided self-instructional procedures on improving handwriting performance. More recent research has incorporated verbal guidance and self-reflection into an overall approach to treating children with developmental coordination disorder (DCD). As children with DCD often experience difficulty with handwriting, a review of this "adapted self-instruction" method is worthy of inclusion in this review.

The Cognitive Orientation to daily Occupational Performance (CO-OP) approach combines Meichenbaum's (1977) verbal guidance and self-instructional training with a global problem solving strategy (Missiuna, Mandich, Polatajko, & Malloy-Miller, 2001; Mandich, Polatajko, Macnab, & Miller, 2001). Miller et al. (2001) compared the

performance of 10 children with DCD (aged 7 to 12 years) who were exposed to the CO-OP approach to the performance of 10 children with DCD who received a contemporary treatment approach (CTA). Contemporary treatment included a variety of approaches, including multisensory intervention. Although this study was not examining effectiveness of handwriting per se, 16 of 20 children involved in the study chose printing or cursive writing as one of their treatment goals. The children's ratings of their performance and satisfaction for their treatment goals from pretest to posttest was greater for the CO-OP group than for the CTA group. Although handwriting performance was not formally measured, Miller and colleagues provide some evidence that verbal guidance and self-instruction is worthy of further investigation in the remediation of handwriting difficulties.

Not all researchers agree that verbal guidance is effective in teaching children how to handwrite. Berninger et al. (1997) indicate that prior research demonstrated that verbal mediation interfered with the automatization process of letter writing in first grade children. Applying an information processing perspective of self-regulation, Berninger et al. contend that "the goal is to automatize the low-level processes [transcription] so that working memory resources are freed for the higher level constructive aspects of composing" (p.652). These researchers hypothesize that automaticity of handwriting is dependent upon being able to retrieve an accurate letter representation from memory. To investigate this hypothesis, 144 first grade students at risk of handwriting problems were randomly assigned to one of six treatment conditions: motoric imitation, visual cues, memory retrieval, visual cues and memory retrieval, copying, or phonological awareness. In all conditions, the children were asked to name the letter they were writing. The use of

numbered arrows combined with memory retrieval was the most effective intervention, confirming the researchers' hypothesis.

The importance of automaticity in handwriting is echoed by Jones and Christensen (1999), although they take more of a social cognitive approach to intervention. These researchers employed teacher modeling, guided practice, and independent practice in their study of 6 and 7 year old children with handwriting difficulties. Nineteen children experiencing difficulty with handwriting were matched with 19 children from the same class who did not demonstrate any handwriting problems. After seven months of handwriting instruction focusing on forming lower case letters and correcting errors in letter formation, there were no differences in written expression between the treatment and control groups. The authors concluded that handwriting difficulties are amenable to intervention.

Graham et al. (2000) combined verbal mediation and modeling with the findings of Berninger et al. (1997) to create a handwriting instruction program for first grade students. Alphabet practice was comprised of five phases: (a) modeling by teacher using visual and verbal demonstration of letter formation; (b) imitation by the child while describing how to form the letter; (c) discussion of letter similarities and differences by teacher and child; (d) practice of letter formation by tracing, copying and writing letters with numbered arrows and stating letter name; and (e) self-evaluation by circling best letter written. This alphabet practice was one of four activities in the handwriting program. This handwriting approach was compared to a phonological awareness training comprised of similar components over nine lessons. A statistically significant difference in handwriting quality was evident on several measures for the children in the

handwriting instruction group, including students with and without an identified disability. Supplemental handwriting instruction also led to greater gains in compositional fluency compared to phonological awareness instruction.

A component of the previous study was self-evaluation, which has been deemed to be a useful strategy for children with special needs (Graham, 1992). In addition to self-evaluation, the need to explore other self-regulation procedures in improving handwriting, such as goal setting and self-reinforcement, has been identified (Graham and Weintraub, 1996). Researchers in the Netherlands have recently studied a task-oriented self-instruction method that encourages students to reflect on their handwriting performance and to identify areas that are problematic (Jongmans et al., 2003). These researchers conducted two studies to investigate the effectiveness of this task-oriented self-instruction method to improve handwriting quality and speed in primary school children. The first study looked at 7 children (mean age of 7.92 years) in regular classrooms who obtained scores in the “dysgraphic” category on a handwriting assessment in comparison to 7 peers who obtained handwriting scores in the “normal” range. Intervention entailed systematic reflection after each writing exercise and consisted of three phases: (1) dynamic movement presentation or motor programme of the letter, (2) writing the same letter over eight times to monitor force control, and (3) having the child circle the best-formed letter and drawing an arrow where attention needs to be directed the next time. The children were also required to write the letter in a word or short story and reflect upon the quality of the written text. Descriptive analysis of the results showed that children with dysgraphic handwriting improved an average of 7.72 points on a handwriting measure compared to a decline in the control group by an

average of 0.43 points. Although the children with dysgraphic handwriting demonstrated improvement, four of the children remained in the dysgraphic category.

The second study conducted by Jongmans et al. (2003) used the same instruction method in a group format with children in special education classes. The control group continued with regular writing instruction while the experimental group used the task-oriented self-instruction method for two 30-minute sessions a week for a period of six months. Children with poor handwriting who received intervention showed a greater improvement in the quality of their handwriting compared to their peers with poor handwriting who did not receive intervention. Seventy-two per cent of children with dysgraphic handwriting who received intervention were not classified as “dysgraphic” on posttesting. It was also found that children with “normal” handwriting who did not receive intervention actually deteriorated at posttesting six months later. The authors concluded that self-instruction improved handwriting quality of children with poor handwriting and “protected” those with “normal” handwriting from deteriorating over the six months of the study.

### *Summary of Chapter Two*

This chapter briefly explored the development of pre-writing skills and the importance of formal instruction in developing handwriting. Several factors thought to contribute to handwriting difficulties were outlined, including poor instruction and elements within the child. Components of handwriting assessment, along with criteria for dysgraphic handwriting, were described. The need for early handwriting instruction and intervention was presented, followed by a review of empirical research on handwriting remediation. Evidence for multisensory intervention was limited with confounding

variables in the treatment procedures. There appeared to be more evidence supporting cognitive interventions, but evidence is inconclusive given the varied approaches and limited replication of studies. The next chapter will outline research methodology for comparing the effectiveness cognitive versus multisensory interventions for improving handwriting legibility of primary students referred to school-based occupational therapy.

## Chapter 3: Methodology

*Overview of Chapter Three*

This chapter describes the research design selected for the study. Sampling procedures and treatment guidelines are outlined in detail, along with instrumentation used in the study. The chapter concludes with an overview of research procedures.

*Research Design*

A true experimental pretest-posttest comparison/control group design was used for this study. This research design effectively controls for eight threats to internal validity: history, maturation, testing, instrumentation, statistical regression, selection bias, experimental mortality, and selection-maturation interaction (Campbell & Stanley, 1963). Random assignment employed in this design is considered the best technique for assuring initial equivalence between different treatment groups (Gall, Borg, & Gall, 1996).

A threat to the external validity of this design is the possible interaction between the pretest and experimental treatments (Gall, Borg, & Gall, 1996). Given that the study will be conducted in the school environment where testing is a regular phenomenon, an undesirable interaction effect is unlikely to occur (Campbell & Stanley, 1963).

The independent variable under study was the type of intervention for handwriting remediation. Three types of intervention were compared: cognitive intervention, multisensory intervention, and no intervention. The dependent variable was a measure of total letter legibility. The following steps were followed in implementing the research design: (1) administration of inclusion criterion test and pretest to prospective participants; (2) random assignment of eligible participants to one of three groups: cognitive intervention group, multisensory intervention group, or control group;

(3) administration of respective treatments to each of the experimental groups but not to the control group; (4) administration of posttest to all three groups.

### *Sampling*

Seventy-two students<sup>1</sup> in grades 1 or 2 that had been referred to school-based occupational therapy for handwriting difficulties were selected for the study.

Occupational therapists employed by Queen Alexandra Centre for Children's Health identified prospective research participants from students on their respective caseloads based on the following criteria:

1. Students had normal or corrected-to-normal vision and hearing as well as cognitive function within normal limits as documented in their school file. Students with the diagnoses of autism, mental retardation, foetal alcohol spectrum disorder, or severe developmental delay were not considered for the study.
2. Students were developmentally ready to learn how to print based on their ability to copy the first eight geometric figures on the Beery VMI (5<sup>th</sup> ed.) (Beery & Beery, 2004).

After informed consent was obtained from prospective participants and their parents, a pretest of handwriting legibility was administered. If the child scored below 85% legibility, s/he was included in the study. Participants were randomly assigned until there were 24 participants in each group: cognitive intervention group, multisensory intervention group, and control group.

---

<sup>1</sup> A statistical software program called *gpower* was used to determine that a sample size of 20 in each group would yield power of 0.98 given the proposed data analysis and a modest effect size. The final sample consisted of 24 in each group. The author acknowledges and gives thanks to Dr. John Walsh for his assistance with this calculation.

*Treatments*

Treatment sessions were 30 minutes in duration. Children in the intervention groups were seen once a week for 10 weeks. Children in the control group did not receive any occupational therapy intervention for the duration of the study, but were seen for treatment of the same timeframe after the study. It was expected that students in all groups continued to receive handwriting instruction as part of their school curriculum.

The principal investigator designed treatment protocols for each intervention group (please refer to Appendices A and B for sample protocols). For consistency, each treatment group was introduced to letters in the same sequence. Although some literature indicates that letters should be taught in the same order as phonological awareness training programs (Simner, 2003), most literature advocates that letters should be introduced on the basis of similar formational characteristics (Alston & Taylor, 1987; Benbow, 1990; Graham et al., 2000; Graham & Miller, 1980; Sassoon, 1983; Taylor, 2001). Introducing letters with similar stroke patterns is thought to reinforce correct motor patterns for letter formation (Benbow, 1990) and to reduce problems of reversals, rotations, & inversions (Alston & Taylor, 1987). Despite the support for introducing letters in this way, there are some minor variations in the literature as to the sequence of letter presentation. For the purposes of this study, the presentation of lower case letters closely followed the sequence outlined by the majority of authors. Both intervention groups were introduced to letters in the following order:

1. Crazy C letters *c, a, d*
2. Crazy C letters *g, q, o*
3. Down and Up Letters *b, h, n*

4. Down and Up Letters *m, p, r*
5. Stop and Go Letters *f, i, j*
6. Stop and Go Letters *k, t, x*
7. Stop and Go Letter *y*; Ski Slope Letters *v, w*
8. One of a Kind Letters *e, l, s*
9. One of a Kind Letters *u, z*
10. Review of three letters that were particularly difficult for the child

Each intervention group spent a comparable amount of time on each letter grouping, but the activities used to review each letter differed.

*Cognitive Intervention.*

The cognitive intervention group followed a similar format to the procedures outlined by Graham et al. (2000):

1. Alphabet Warm-Up: As the ability to name and identify letters can serve as cue for retrieving the motor program for writing the letter (Graham, 1999), the following activities were used a warm-up for each session: (a) therapist and/or child sings the alphabet song; (b) therapist points to each of the target letters on an alphabet strip and asks child to name them; and (c) therapist names each of the target letters and asks child to identify what letter comes before and after it in the alphabet.
2. Modeling: Using the index finger, the therapist demonstrates and describes how to form each letter using cards with numbered arrows that show the order and direction of strokes for each letter.

3. Imitation: Child imitates therapist by tracing each letter while describing how to form it.
4. Discussion: Therapist and child discuss how the letters in the group are similar and different.
5. Practice: Using a pencil and a practice worksheet, the child completes the following activities, working on one letter at a time and naming the letter while writing: (a) tracing a copy of the letter that contains numbered arrows; (b) tracing three copies of the letter without numbered arrows; (c) copying the letter three times. The last stage of practice is writing the letter three times from memory on a sheet of regular lined paper.
6. Evaluation: Child circles the best-formed letter for each target letter.

*Multisensory Intervention.*

The multisensory intervention outlined in this study is based on information in the literature (Amundson & Weil, 2001; Woodward & Swinth, 2002) as well as from feedback from occupational therapists participating in the study. The sensory modalities outlined below are thought to reflect current occupational therapy practice:

1. Therapist describes the letter grouping and demonstrates formation of target letters on the chalkboard using chalk.
2. Child copies each letter three times, one letter at a time, on the chalkboard.
3. Therapist demonstrates and child imitates “sky writing” of each letter three times.
4. Therapist demonstrates and child imitates formation of each letter in a tray of sand or cornmeal three times.

5. Child traces over bumpy glitter glue letters with index finger, three times for each letter.
6. Child traces and then copies each letter three times with marker on a worksheet.
7. Child copies each letter three times with a pencil on regular lined paper.

In both treatment groups, the participants were exposed to verbal description, modeling, imitation, tracing, and copying. The main differences between the two treatment approaches in this study were: (1) the cognitive intervention group placed emphasis on the metacognitive awareness of letter formation and encouraged verbal mediation to guide letter formation, and (2) the multisensory intervention group used verbal input to introduce the letter and how it is formed, but the emphasis of intervention was on learning the *feel* of the letter.

As several occupational therapists provided treatment in the study, it was essential to ensure that treatments were applied consistently across participants and therapists in each treatment condition. The following procedures were implemented to ensure treatment fidelity: (1) specific treatment plans/guidelines each session for each treatment group were documented and provided to each occupational therapist; (2) treating occupational therapists attended in-service training regarding the treatment protocols; (3) occupational therapists documented what was done in each treatment session on researcher-developed checklist; (4) principal investigator observed each therapist with each child in the experimental groups and collected data from these treatment sessions to determine congruence between behaviour and treatment guidelines.

*Instrumentation*

The *Beery VMI* (5<sup>th</sup> ed.) (Beery & Beery, 2004) was administered as part of inclusion criteria. The VMI is a developmental sequence of geometric forms to be copied with paper and pencil. Children who are able to copy the first eight designs on the test are thought to be ready for handwriting instruction (Beery & Beery, 2004). The VMI, and its two supplemental standardized tests of *Visual Perception* and *Motor Coordination*, serve as a useful screening battery for visual motor skills (Beery & Beery, 2004).

The VMI takes approximately 20 minutes to administer and 10 to 15 minutes to score. This standardized assessment tool has an overall reliability of .92 based on an average of inter-scorer, internal consistency, and test-retest reliabilities. The overall reliability of the supplemental tests is .91 and .90 for the visual and motor tests respectively (Beery & Beery, 2004). Content, concurrent, construct, and predictive validity of the test are supported by several studies outlined in the test manual.

The *Evaluation Tool of Children's Handwriting (ETCH) - Manuscript* (Amundson, 1995) was used as the pretest and posttest measure. This standardized assessment tool is comprised of six writing activities that are similar to those required of students in the classroom: writing alphabet from memory, writing numerals from memory, near-point copying, far-point copying, dictation, and sentence composition. The ETCH-M takes 20-25 minutes to administer and 10-20 minutes to score. Only the total letter legibility score was designated as the dependent variable in the study for two reasons: (1) letter formation was the focus on intervention; and (2) total legibility scores are more reliable than individual task scores (Amundson, 1995; Diekema, Deitz, &

Amundson, 1998; Feder & Majnemer, 2003). The total letter legibility score is based on the legibility of letters in all tasks of the assessment and is expressed as a percentage.

The ETCH-M is a criterion-referenced assessment with an interrater reliability of .90 to .92 and ICC = .84 (Amundson, 1995) and test-retest reliability of .77 (Diekema et al., 1998) for total letter legibility scores. Content validity has been supported but construct and criterion-related validity studies have not been carried out (Feder & Majnemer, 2003).

The ETCH-M was selected over other handwriting assessments because it has standard administration procedures and well-defined scoring guidelines. Self-study tutorials are included in the manual for examiners to practice scoring so that 90% scoring competency can be achieved before administering the test (Amundson, 1995). The ETCH-M also evaluates many areas of handwriting that are not included in other handwriting evaluation tools (Feder & Majnemer, 2003). Although the test-retest reliability is lower than desired for test development, is within the range of other handwriting tools for children (Feder & Majnemer, 2003).

The *Conners' Parent Rating Scale - Revised: Short Version* (CPRS –R:S) and *Conners' Teacher Rating Scale – Revised: Short Version* (CTRS – R:S) (Conners, 2000) were given to participants' parents and teachers to complete to gather behavioural information about the sample. The ADHD Index was of particular interest to distinguish children with symptoms of ADHD from nonclinical children, as research has shown that children with ADHD do not benefit from cognitive interventions (Abikoff, 1991). A score of  $\leq 70$  on the ADHD index was considered clinically significant.

The *Conners' Rating Scales – Revised* (CRS –R) have excellent reliability. The total reliability coefficient ranged from .86 to .94 for the CPRS – R:S and from .88 to .95 for the CTRS – R:S (Conners, 2000). Other psychometric properties are outlined throughout the manual, including the discriminant validity of the CRS –R to differentiate individuals with ADHD.

### *Procedure*

The procedure for the study is summarized as follows:

1. The University of Victoria/Vancouver Island Health Authority Joint Committee gave ethical approval for the study (Protocol Number 315-04). Permission was also obtained from School Districts #61, #62 and #63 to conduct research in the school setting within the respective districts.
2. Principal investigator described the study to school-based occupational therapists and provided training sessions to review treatment protocols for both the cognitive and multisensory interventions. The standardized assessment procedures for the *Evaluation Tool of Children's Handwriting* (ETCH) were also reviewed with therapists.
3. Occupational therapists identified prospective participants from their respective caseloads as outlined under *Sampling* section.
4. Occupational therapist approached parent/guardian of the child to invite participation in the research study (see *Appendix C* for Parent Consent Letter). If consent was obtained from parent/guardian, then occupational therapist discussed the study and obtained consent from the child (See *Appendix D* for Child Consent Form).

5. Once consent was obtained, the *Evaluation Tool of Children's Handwriting (ETCH) – Manuscript* was administered by the occupational therapist. If the child scored below 85% legibility, (s)he was eligible to participate in the study.
6. All ETCH assessments were scored by the principal investigator to ensure consistency of scoring. A graduate student in special education served as second-rater and scored 30% of assessments. Both the principal investigator and second rater completed the scoring competency requirements as outlined in the test manual prior to scoring any tests. Interrater reliability was .93. Both raters were blind to the intervention the child received. The second rater was also blind to whether the assessment was a pretest or a posttest.
7. Eligible participants were randomly assigned to one of three groups until there were 24 participants in each group: cognitive intervention group, multisensory intervention group, and control group. Random assignment was achieved by placing 24 pieces of paper labelled with each intervention into a small box. As children were deemed eligible to participate, a clerk drew a piece a paper from the box and assigned the participant to the indicated intervention group.
8. Occupational therapists administered treatment protocol as outlined in the *Treatments* section.
9. Principal investigator observed each therapist with each child in the cognitive and multisensory intervention groups as a measure of treatment fidelity. A tally of observed treatment protocols for each intervention group indicated 98.5% compliance for both interventions.

10. To ensure ongoing consent, a neutral third party contacted parents of experimental group participants during the middle duration of intervention. Forty-six of the 48 parents were contacted and all gave their ongoing consent.
11. Within two weeks of the last intervention session, the occupational therapist re-administered the *Evaluation Tool of Children's Handwriting (ETCH) – Manuscript*. Participants in the control group completed the posttest no sooner than 10 weeks and no later than 12 weeks from the pretest.
12. Once the posttest was completed, participants in the control group began 10 weeks of intervention administered by the occupational therapist. Parent/guardian of the child chose which treatment protocol they wished their child to receive. Nine families selected the cognitive intervention for their child compared to fourteen families who selected the multisensory intervention. One parent declined intervention as her child improved sufficiently during the time in the control group.
13. As the data was collected throughout the study, a clerk assigned a number to each child's information so that the principal investigator or second rater could not identify the child. The original assessments were placed on the child's medical file, as the information may be required for therapeutic purposes in the future.

### *Summary of Chapter Three*

This chapter outlined the rationale for employing a pretest-posttest comparison/control research design to investigate the effectiveness of two interventions for improving handwriting legibility. Details of the research methodology were

described, including sampling of participants, treatment guidelines, and choice of instrumentation. Chapter Four will describe the data analysis used in the study and outline the results of these analyses.

## Chapter 4: Results

*Overview of Chapter Four*

This chapter reviews the statistical analyses conducted in this study. First, preliminary analyses are described to demonstrate that the three groups were equivalent prior to intervention. Second, primary analyses are presented in relation to the hypotheses of the study. Third, the chapter concludes with secondary analyses that explore findings in more depth.

*Preliminary Analyses**What was the composition of the sample?*

Seventy-three students met the inclusion criteria for the study. Parental consent was not received for one child. The final sample consisted of 72 participants, comprised of 71% boys ( $n = 51$ ) and 29% girls ( $n = 21$ ). The boy-to-girl ratio is consistent with gender prevalence in handwriting concerns reported in the literature (Graham & Weintraub, 1996; Tseng & Murray, 1994). Forty-five participants were in grade 1 and 27 were in grade 2. According to the *Conners' Parent Rating Scale – Revised: Short Version* (CPRS – R:S), 12 participants (16.7% of sample) reached clinical significance for Attention Deficit Hyperactivity Disorder (ADHD). Ten children (13.9% of sample) reached clinical significance for ADHD on the *Conners' Teacher Rating Scale – Revised: Short Version* (CTRS – R:S).

Some data were missing or unavailable at the time of analysis. Every participant met the intake criteria on the Beery VMI assessment, but two scores were missing from the data set ( $N = 70$ ). Four participants did not complete the Visual and Motor supplemental tests and two scores were missing ( $N = 66$ ). All of the Conners' Parent and

Teacher Rating Scales were returned, but two parent scales were received after data analysis was completed. One parent scale was excluded from analysis because the form was incomplete ( $N = 69$ ).

*Were the groups equivalent prior to the start of intervention?*

Analyses were carried out to ensure that the three randomly assigned groups were equivalent prior to the start of intervention. As illustrated by the Chi-square analysis in Table 1, there was no statistically significant difference in the distribution of gender and grade between the three groups,  $\chi^2(14, N = 144) = 2.02, p > .05$ . The distribution of children reaching clinical significance for ADHD was also equivalent across the three intervention groups,  $\chi^2(2, N = 24) = 0, p > .05$  (parent ratings) and  $\chi^2(2, N = 20) = 1.65, p > .05$  (teacher ratings).

Table 1.

*Chi-square Analysis of Sample Distribution by Gender and Grade per Intervention*

*Group*

	Cognitive	Multisensory	Control	Total
Grade 1 boys				
observed	11	10	12	33
expected	11	11	11	33
Grade 2 boys				
observed	5	6	7	18
expected	6	6	6	18
Grade 1 girls				
observed	5	5	2	12
expected	4	4	4	12
Grade 2 girls				
observed	3	3	3	9
expected	3	3	3	9
Total	48	48	48	144

As shown in Table 2, one-way analysis of variance (ANOVA) indicated that there was no statistically significant difference among the three intervention groups in terms of pretest total letter legibility scores,  $F(2, 69) = 0.74, p > .05, \eta^2 = .02$ . There were no statistically significant differences between the three groups on inclusion measures<sup>2</sup> of visual motor integration,  $F(2, 67) = 2.11, p > .05, \eta^2 = .06$ ; visual discrimination,  $F(2, 63) = .05, p > .05, \eta^2 = .001$ ; and motor coordination,  $F(2, 63) = 1.27, p > .05, \eta^2 = .04$ .

Table 2.

*Analysis of Variance for Pretest Total Letter Legibility*

	<i>df</i>	Mean Square	<i>F</i>	Sig.
Between Groups	2	249.57	.74	.48
Within Groups	69	335.45		
Total	71			

In summary, results of all preliminary analyses indicated that there were no significant differences between the three randomly assigned groups prior to intervention.

*Primary Analyses*

Means and standard deviations of pretest, posttest and difference scores are listed in Table 3.

<sup>2</sup> Note: Degrees of freedom differ for these analyses because not all intake data were available at the time of analysis (see details on page 40 and 41).

Table 3.

*Total Letter Legibility Scores by Intervention Group*

Group <sup>a</sup>	Pretest		Posttest		Difference	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Cognitive	48.75	21.12	63.11	19.27	14.36	10.57
Multisensory	50.97	19.32	65.02	15.23	14.05	14.78
Control	55.10	13.68	64.22	9.10	9.12	10.36

Note. Maximum Score = 100

<sup>a</sup>*n* = 24 for each group

Although the primary focus of the study was to compare growth or improvement in letter legibility with different interventions, I also compared posttest differences in performance as a result of the different intervention conditions. Examination of posttest total letter legibility scores revealed that there was an outlier in the cognitive intervention and multisensory intervention groups, as illustrated in the boxplots in Figure 1. Levene's Test of Equality of Error Variances was significant,  $F(2, 69) = 4.46, p < .05$ , indicating that the error variance was not equal across groups. As the assumption of homogeneity of variance was violated, an ANOVA could not be conducted to determine group differences. Thus, the primary variable for analysis in this study was difference scores (posttest total letter legibility – pretest total letter legibility). These scores were more normally distributed than posttest scores and were more appropriate to address the hypotheses of the study. Difference scores for each of the intervention groups are illustrated in the boxplots in Figure 2. There is one outlier in the cognitive intervention group due to one child making substantial gains in legibility. The boxplots also illustrate that some children in the multisensory and control groups had negative difference scores,

indicating that their legibility worsened in these conditions. This observation is examined in more detail under *Secondary Analyses*.

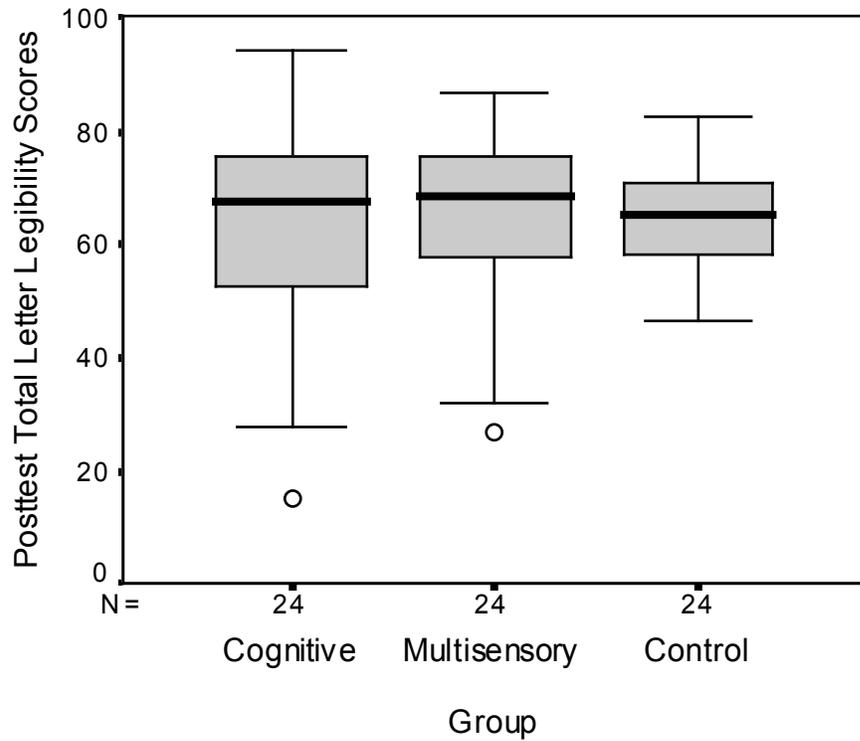


Figure 1.

*Boxplots of Posttest Total Letter Legibility Scores by Intervention Group*

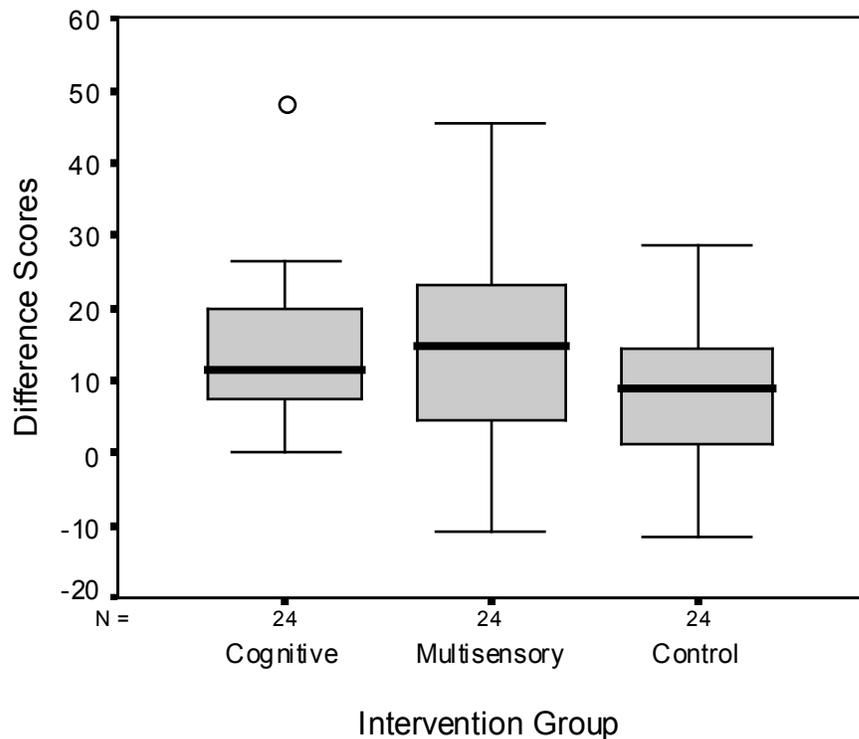


Figure 2.

*Boxplots of Difference Scores by Intervention Group**Hypothesis 1.*

The first hypothesis, that there will be a statistically significant improvement in the handwriting legibility of children who receive cognitive or multisensory intervention compared to the children who receive no intervention, was not supported. As presented in Table 4, ANOVA of difference scores indicates that there was no statistically significant difference between the three groups,  $F(2, 69) = 1.42, p > .05, \eta^2 = .04$ . However, the medium effect size between the cognitive intervention compared to the control group ( $d = .51$ ) and between the multisensory intervention and the control group ( $d = .48$ ) suggests the intervention was having some effect on letter legibility compared to no intervention.

Table 4.

*Analysis of Variance for Difference Scores of Total Letter Legibility*

	<i>df</i>	Mean Square	<i>F</i>	Sig.
Between Groups	2	207.66	1.42	.25
Within Groups	69	145.81		
Total	71			

*Hypothesis 2.*

The second hypothesis, that there will be a statistically significant improvement in the handwriting legibility of children who receive cognitive intervention compared to the children who receive multisensory intervention, was also not supported given the non-significance between groups illustrated in Table 4. There was essentially no difference in effect size between the cognitive and multisensory intervention groups ( $d = .03$ ).

*Secondary Analyses*

Several additional analyses were carried out to examine the data in more depth and answer questions about potential gender differences, the performance of grade 1 versus grade 2 students, the number of children who did not improve or got worse, and the performance of students with potential ADHD.

*Was there a statistically significant difference in the improvement letter legibility of boys versus girls in the different intervention conditions?*

ANOVA of difference scores showed that there was no statistically significant difference between boys and girls across groups,  $F(2, 66) = .25, p > .05, \eta^2 = .007$ .

*Was there a statistically significant difference in how children in grades 1 and 2 responded to the different interventions?*

Means and standard deviations for difference scores by grade and group are shown in Table 5. ANOVA of difference scores indicated there was no significant difference between grade 1 and 2 students across groups,  $F(2, 66) = 2.69, p > .05, \eta^2 = .08$ .

Table 5.

*Total Letter Legibility Difference Scores: Group x Grade*

Group	Grade 1			Grade 2		
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>
Cognitive	15.53	12.20	16	12.03	6.22	8
Multisensory	20.92	12.83	15	2.59	10.19	9
Control	12.71	10.23	14	4.08	8.64	10

Grade 2 students in the cognitive intervention showed greater improvement with much less variance than grade 2 students in the multisensory and control groups. Although this difference was not statistically significant,  $F(2, 24) = 2.92, p > .05, \eta^2 = .20$ , there was a large effect size between the cognitive intervention compared to the multisensory group ( $d = 1.09$ ) and the control group ( $d = .92$ ). To gather more information about grade differences to intervention, mean pretest and posttest scores were calculated for each grade and plotted on graphs in Figures 3 and 4.

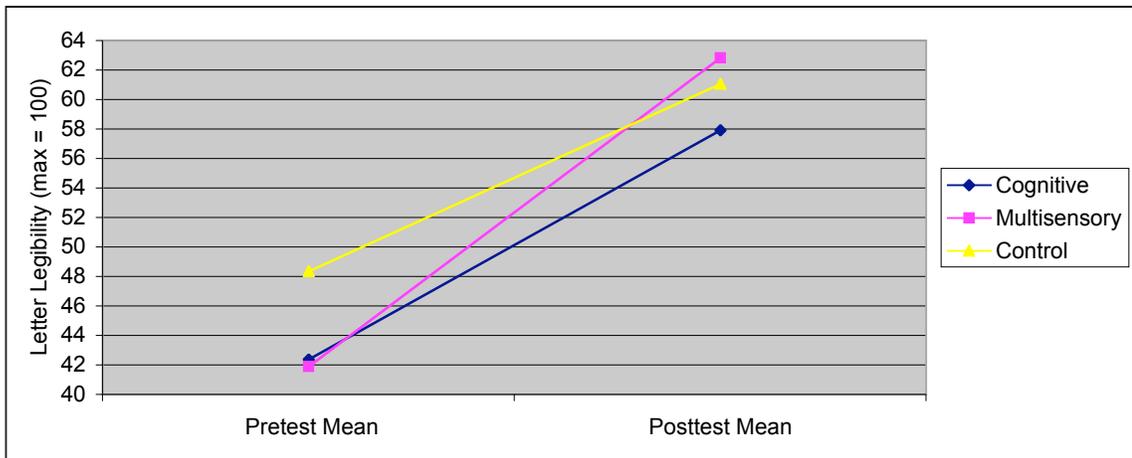


Figure 3.

*Pretest and Posttest Means of Total Letter Legibility for Grade 1 Students (n = 45)*

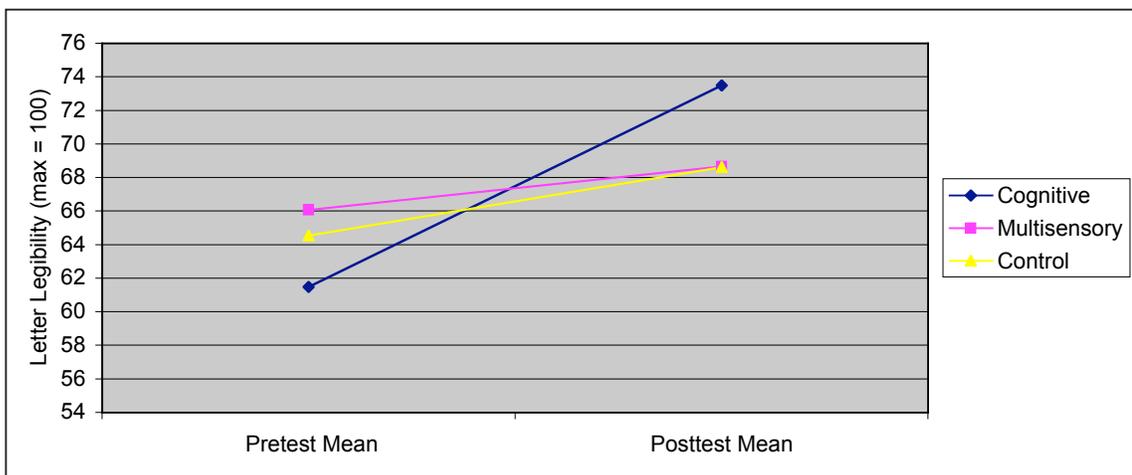


Figure 4.

*Pretest and Posttest Means of Total Letter Legibility for Grade 2 Students (n = 27)*

Examination of the performance profiles of grade 1 and grade 2 students shows that grade 1 students achieved similar results regardless of intervention, with slightly more positive results with the multisensory intervention. Grade 2 students, on the other hand, showed little improvement with the multisensory intervention, achieving comparable gains to having no intervention at all. Grade 2 students showed much greater

performance with the cognitive intervention. These findings suggest that there may be developmental differences in how children respond to the different interventions.

*Was there a difference in the number of children who improved with each intervention?*

As seen in the boxplots of difference scores in Figure 2, some children performed worse after receiving the multisensory intervention or no intervention. Frequency counts were conducted to determine the percentage of children who showed no improvement or worse performance for each intervention group as shown in Table 6.

Table 6.

*Percentage of Children With Declining Performance, No Change or Improvement in Total Letter Legibility Per Intervention Group*

Group <sup>a</sup>	Negative Difference Scores	No Improvement (Difference = $\pm 1\%$ )	Positive Difference Scores
Cognitive	0%	4.2%	95.8%
Multisensory	20.8%	0%	79.2%
Control	16.7%	8.3%	75.0%

<sup>a</sup>*n* = 24 in each group

Although the majority of students showed improvement, it is important to note that 17% of children in the control group and 21% of the children in the multisensory intervention performed worse at posttest. None of the children in the cognitive intervention declined in performance.

Given the grade differences in response to intervention previously described, frequency counts of relative performance were also conducted per grade and intervention group. Results of the frequency counts for each grade are displayed in Tables 7 and 8.

Table 7.

*Percentage of Grade 1 Students With Declining Performance, No Change or*

*Improvement in Total Letter Legibility Per Intervention Group*

Group	<i>n</i>	Negative Difference Scores	No Improvement (Difference = $\pm 1\%$ )	Positive Difference Scores
Cognitive	16	0%	6.2%	93.8%
Multisensory	15	6.7%	0%	93.3%
Control	14	7.1%	7.1%	85.7%

Table 8.

*Percentage of Grade 2 Students With Declining Performance, No Change or*

*Improvement in Total Letter Legibility Per Intervention Group*

Group	<i>n</i>	Negative Difference Scores	No Improvement (Difference = $\pm 1\%$ )	Positive Difference Scores
Cognitive	8	0%	0%	100 %
Multisensory	9	44.4%	0%	55.6%
Control	10	30.0%	10.0%	60.0%

Grade differences are also apparent in difference scores. The majority of grade 1 students showed positive difference scores regardless of intervention. All of the grade 2 students in the cognitive intervention improved, compared to only 56% and 60% of grade 2 students in the multisensory and control groups respectively. The finding that 44% of grade 2 students performed worse after multisensory intervention is alarming. Equally concerning is that the legibility of 30% of grade 2 students who did not receive

intervention worsened over time. These results must be interpreted with caution due to the small sample size.

*Was there a statistically significant difference in how children with ADHD responded to the interventions compared to children without ADHD?*

ANOVA of difference scores was conducted comparing participants who scored in the clinically significant range for ADHD with those who did not. No significant differences were found for children with possible ADHD, either by parent rating,  $F(1, 67) = 1.04, p > .05, \eta^2 = .02$ , or by teacher rating,  $F(1, 70) = .001, p > .05, \eta^2 = .00^3$ .

#### *Summary of Chapter Four*

Descriptive statistics, analyses of variance, and graphical representations of the data were presented in this chapter. In short, there were no statistically significant differences between the three groups before or after intervention. Additional analyses shed some light on subtle differences between the intervention groups compared to the control group. Interpretation of these results and implications of the findings is the subject of the next chapter.

---

<sup>3</sup> Note: Degrees of freedom differ for these analyses because fewer parent rating scales were available at the time of analysis (see details on page 40 and 41).

## Chapter 5: Discussion

*Overview of Chapter Five*

This chapter summarizes findings, integrates the results with past literature, and offers an explanation of the findings. Implications for theory, research and practice are discussed, followed by limitations of the study. The chapter concludes with directions for future research.

*Summary of Results*

This study attempted to address the need for further research in handwriting remediation as recommended by other researchers. Case-Smith (2002) indicated that clinical trials of specific handwriting interventions were necessary to determine which approaches result in optimal outcomes. Peterson and Nelson (2003) echoed this need by stating that “future research should contrast the relative effects of biomechanical, sensorimotor, and teaching-learning strategies in enhancing handwriting” (p. 158). This study investigated the effectiveness of cognitive (teaching-learning) intervention versus multisensory (sensorimotor) intervention, and compared these results to the effect of having no specific intervention. Two hypotheses were established at the outset of the study. Each of these will be reviewed in turn.

The first hypothesis was that there would be a statistically significant improvement in the handwriting legibility of children who received cognitive or multisensory intervention compared to the children who received no intervention. There was sufficient evidence in the literature to suggest that intervention, whether it was cognitive or multisensory, would result in greater gains than having no intervention at all. Findings did not support this hypothesis. There was no statistically significant difference

in improvement of handwriting legibility whether the children received intervention or not. There was, however, a medium effect size for both the cognitive and multisensory interventions compared to the control group that did not receive intervention. This finding suggests that there was something beneficial about receiving intervention.

A review of the literature favoured the theoretical underpinnings of the cognitive approach as opposed to the multisensory approach to intervention, which formed the basis for the second hypothesis: that there would be a statistically significant improvement in the handwriting legibility of children who receive cognitive intervention compared to the children who receive multisensory intervention. This hypothesis was also not supported. There was no statistically significant difference in improvement of handwriting legibility for participants in the cognitive and multisensory intervention groups.

Although the two hypotheses of the study were not supported, there were other findings worthy of mention. Overall, the handwriting legibility of children in grade 1 improved regardless of which intervention they received. The legibility of grade 2 students showed greater improvement with the cognitive intervention. Some students in both grades showed declining performance in the multisensory intervention and control conditions, whereas no children worsened with the cognitive intervention. An explanation of the research findings is the subject of the next section.

### *Explanation of Findings*

#### *Why were the hypotheses of the study not supported?*

There are two main factors that may explain why the hypotheses of this study were not supported. The first explanation is related to the intensity or frequency of

intervention. It is likely that the intervention was not of sufficient intensity to produce dramatic results. Participants were seen once weekly for 30 minutes over 10 weeks. Although 5 hours of intervention in this study was generous in terms of current occupational therapy practice, research in the area of handwriting remediation has looked at greater length and/or frequency of intervention. Graham et al. (2000) saw children three times per week for 15 minutes for a total of 27 sessions (6.75 hours). Petersen and Nelson (2003) doubled the amount of intervention compared to the current study, as they saw children twice per week for 30 minutes over a 10-week period (10 hours). In the study conducted by Case-Smith (2002), children were seen over the course of the school year for an average of 16.4 sessions and 8.8 hours of intervention. It is interesting to note, however, that similar improvements on the same handwriting measure were obtained in the latter study compared to the current study. Participants in Case-Smith's study improved an average of 14.2% in total legibility, which is similar to the mean difference in total letter legibility of 14.4% (cognitive intervention) and 14.1% (multisensory intervention) obtained in this study with less intervention.

The second explanation for statistically non-significant findings is related to the interventions. Although the intent of the study was to examine the effects of cognitive versus multisensory interventions, it was not possible to completely separate the different elements of these interventions. The learning principles of modelling, imitation, and practice were common to both the cognitive and multisensory interventions. The cognitive intervention involved multisensory components by integrating what was seen and heard and by writing the letters on paper. The multisensory intervention could not be

done without cognitive processing. Similar results may have been obtained because the interventions were not mutually exclusive.

Previous occupational therapy research has employed a combination of approaches in the intervention for handwriting difficulties in grade 1 students (Case-Smith, 2002; Peterson & Nelson, 2003). Researchers suggested that further studies be conducted to determine which approach was contributing to the positive effects of intervention. The current study attempted to do just that, but the evidence showed that the cognitive and multisensory intervention protocols used in this study produced similar gains in legibility. Despite the seemingly different interventions across the studies, the results are comparable: grade 1 students showed improvement in their handwriting legibility with intervention. The unique contribution of this study was the effect of different interventions on the legibility of grade 2 students. An explanation of this finding is the topic of the next section.

*Why did grade 2 students respond differently to intervention than grade 1 students?*

In order to answer why the two groups of students respond differently to intervention, it is important to look at the respective development of each age group. Grade 1 students, typically 5 to 6 years of age, are just learning to print. There is a lot of room for improvement and refinement of printing skills over the course of the school year. As this study found, children in grade 1 showed improvement even without intervention. The greater gains in legibility with intervention may have been because the children had more opportunity to practice and refine their skills.

By grade 2, most children have learned to print. The grade 2 children in this study were referred to occupational therapy because they were having difficulty with printing. Even with their struggle to print, these grade 2 students had better legibility than their grade 1 counterparts in the study (please refer back to Figures 3 and 4 in Chapter 4). They had less room for improvement because they had already learned the basics of handwriting. Their handwriting did not improve significantly without intervention, which is consistent with the findings of other research (Hamestra-Bletz & Blöte, 1993; Jongmans et al., 2003). The multisensory intervention had little effect on the handwriting legibility of grade 2 students, and in fact, many students had lower legibility after this type of intervention. In contrast, all grade 2 students receiving cognitive intervention demonstrated improvement in legibility. It is likely that the further cognitive development of 6 to 7 year olds, together with their greater metacognitive skills, may account for the developmental difference in response to cognitive intervention observed in this study. The implications of this and other findings from this study are discussed in the next section.

### *Implications of Findings*

#### *Theoretical Implications.*

The interventions in this study were designed from different theoretical foundations reported in the literature. Although I have already presented information to suggest that the interventions were actually more similar than different, it is important to review the theoretical bases from which the study was designed. Alternative theoretical implications will then be discussed.

The cognitive intervention was well grounded in social cognitive theories of learning. The intervention employed techniques of verbal mediation, modelling, imitation, practice, and self-evaluation. The use of numbered arrow cues to guide letter formation and the reproduction of letters from memory were also incorporated into the treatment protocol, which were features deemed by other researchers to be the most effective treatments for improving handwriting (Berninger et al., 1997; Graham et al., 2000). The multisensory intervention, on the other hand, appears less grounded in theory. It is difficult to support or refute the theory behind the multisensory intervention given that it is not possible to measure the effects of sensory input on subcortical, and ultimately cortical, functions as originally proposed by Ayres (1972). The theory of sensory integration was not intended for handwriting remediation per se, but principles from the theory have been adapted and incorporated by therapists into their practice to improve children's handwriting. The majority of therapists use a multisensory approach to treat handwriting difficulties (Feder et al., 2000; Woodward & Swinth, 2002).

An alternative theoretical basis for the multisensory approach may be related to motivation than to sensory integration. It may be that the sensory experiences of tracing over bumpy letters or making letters in a tray of cornmeal are inherently more motivating and enjoyable for the child than pencil/paper practice. The intrinsic value of a task, defined as the immediate enjoyment one gets from doing the task, has been shown to influence motivation and achievement (Eccles et al., 1983). The novelty of the multisensory intervention may influence the child's engagement and performance (Stipek, 1996). The novelty and intrinsic task value of the multisensory approach may be especially important for young children.

Although both the cognitive and multisensory interventions were based in theory (albeit weakly for the latter), it may be that they were missing key elements from a theoretical perspective to create substantive changes in legibility. In looking at Zimmerman's (2002) model of self-regulated learning, it would seem that several components could have been added to the intervention to make it more theoretically sound. These elements are *choice*, *goal setting*, and *feedback*. Each of these will be discussed in turn.

According to Zimmerman (1994), a key element of self-regulated learning is the opportunity for *choice*. Within the current study, the child was not provided with any choices, as the intervention protocols were prescriptive. It may be that if children had the opportunity to choose from a variety of activities to learn letter formations, they would become more engaged in the learning process. This engagement may have resulted in improved performance on the printing tasks. Self-satisfaction in their performance, in turn, may increase children's motivation to master the task at hand. However, in order to support a child's motivation to learn, the *goals* or expectations of the task must be apparent. All too often, the task of "printing" is incidental in many classrooms, with little explicit instruction. The child is left to copy letters with no understanding of the goals of the task, so it is more like an "exercise" as opposed to a learning experience. The interventions in this study also did not provide clear goals for each session. The goal of learning the formation of three letters per session was "mentioned" to the child (outcome), but the intent of learning "proper" formation (process) was not explicitly outlined.

Although self-evaluation has been cited as an important factor in self-regulated learning, the accuracy of that evaluation is critical. The monitoring of one's performance is a cognitive process that assesses the progress towards a goal and generates feedback to guide future action (Butler & Winne, 1995). If the child's self-evaluation is inaccurate, such that (s)he thinks that (s)he made an acceptable letter formation, no further action will be taken by the child. Thus comes the importance of external *feedback*, which is an essential component to self-regulated learning (Butler & Winne, 1995). Although therapists using the cognitive intervention in the current study had the opportunity to provide feedback during the process of letter formation and on the finished product, the amount and type of feedback was not explicitly outlined in the treatment protocols. The multisensory intervention in this study, with its absence of verbal mediation, did not allow for verbal feedback regarding process or product. If anything, therapists may have provided subtle visual feedback by demonstrating the letter formation and saying, "*Watch how I do it.*" Both the cognitive and multisensory interventions in this study fell short in terms of feedback, both during the process of learning proper letter formations and regarding the accuracy of the finished product.

In summary, findings from this study were surprising. Neither the multisensory nor the cognitive interventions emerged as a superior intervention for handwriting difficulties. As a result, the intervention protocols themselves were re-examined to understand the findings. Specifically, I used a theory of self-regulation to consider possible weaknesses in the cognitive intervention. A theory of self-regulated learning may provide a framework from which to guide future interventions.

*Research Implications.*

Given the theoretical implications previously discussed, it would follow that self-regulated learning may be a useful lens from which to study handwriting remediation. Some researchers have begun to explore the use of technology in assessing the *process* of handwriting in poor writers (Rosenblum, Weiss, & Parush, 2003). This same technology could be used in intervention/instruction from a self-regulated learning perspective. In using a digitizing tablet, children could receive ongoing feedback about their letter formation and how much pressure they are applying through the writing implement. The technology may offer intrinsic task value in that it would be novel to the students and would add variety to their learning experiences. With this approach, researchers would be able to glean more information about the process of handwriting in struggling writers, which would be helpful in designing effective interventions for these children.

The heterogeneity of the sample in this study points to the need to identify the characteristics of students who struggle with handwriting. A child may have difficulty with handwriting for a host of reasons, some of which may not be amenable to intervention. More research is needed to determine the qualities and characteristics of children who seemingly improve in handwriting performance without intervention compared to those who do not. Once more is known about students who do not improve with regular handwriting instruction, new ideas for intervention may be forthcoming.

The findings of the study suggest that there may be developmental differences in how children respond to intervention. The majority of previous research has examined the effect of intervention on the handwriting of grade 1 students (Berninger et al., 1997; Graham et al., 2000; Jones & Christensen, 1999; Peterson & Nelson, 2003; Sudsawad et

al., 2002). This study provides preliminary evidence that students in grade 2 benefit from cognitive intervention. Further research is required to replicate and contribute to these findings, particularly by improving the cognitive intervention employed in this study by adding more components of self-regulated learning into the treatment protocols.

*Practical Implications.*

There are several practical implications for these findings, particularly for occupational therapy practitioners, special educators, teachers, and parents. First, it is apparent that some children, mostly in grade 1, improved their handwriting legibility without any specific intervention. It seemed that time and regular classroom instruction were sufficient for these children. The apparent benefit of intervention may be more related to the extra practice the students received. If components of the cognitive and multisensory treatment protocols were added to grade 1 curriculum and home activities, students may improve slightly more than what they would with instruction alone. Specific intervention for handwriting difficulties in grade 1 may not be necessary. The story seems to be different for grade 2.

Students in grade 2 did not improve significantly in their handwriting legibility without intervention. Findings from this study suggest that intervention may be more beneficial for students in grade 2 than in grade 1, but the type of intervention matters. Only the cognitive intervention resulted in gains and may have prevented decline in performance for these students. Although these results are preliminary, the evidence suggests that service may be better directed to grade 2 students, especially in these times of fiscal restraint.

The framework of self-regulated learning (Zimmerman, 2002) offers a theoretical perspective from which to build practice. The implementation of self-regulated learning approaches in regular classroom instruction for handwriting may help to circumvent handwriting difficulties and be of benefit to all children, not just those who struggle to print legibly.

### *Limitations*

There are several limitations to this study. The control group participants did not receive the same amount of attention as the intervention groups. It is conceivable that the one-to-one attention of the therapists contributed to the change in legibility and not the interventions per se. Although the sample size was large enough to obtain adequate power, a larger sample may have led to more robust findings. The heterogeneity of the sample may also lessen the integrity of the findings, but the random assignment of participants controlled for any bias that may have resulted from such a diverse sample. The generalizability of the study is limited due to the single geographical area of the study.

The measurement tool used in the study, the *Evaluation Tool of Children's Handwriting* (ETCH) (Amundson, 1995), may not have been sensitive enough to detect subtle changes in legibility. The ETCH is a global measure of legibility and is not designed to assess other specific aspects of legibility, such as consistency of letter size, alignment, or ability to write on the line (Sudsawad et al., 2002). The assessment was also limited to a “snapshot” of the child’s handwriting on two occasions, which is subject to variability in performance. The study did not include other measures of handwriting, such as the children’s schoolwork or teacher ratings of the children’s written work, which

would have increased the ecological validity of the assessment results (Sudsawad et al., 2001).

This study is limited in that it only addressed the instruction/intervention of handwriting and not any other factors that contribute to handwriting performance. Issues such as pencil grasp, fine-motor skills, postural stability, and eye-hand coordination (to name a few) were not addressed in the treatment protocols. Information about the participants' academic program was also not collected. There was an assumption at the outset that children would continue to receive classroom handwriting instruction during the study. It is not known how much instruction the participants received or what programs or approaches teachers used in their classrooms. The variability in the amount and type of instruction may have influenced the findings of this study.

#### *Future Directions*

Future research in handwriting remediation is required, particularly for students beyond the first grade. The theory of self-regulated learning provides a useful foundation upon which to build further studies. As this study was limited to individual intervention sessions, it is recommended that future studies explore the effectiveness of small group or large-scale intervention. The application of self-regulated learning principles to handwriting instruction in the classroom may be one such large-scale study. It may be that this approach, in combination with occupational therapy to address the biomechanical, fine motor and visual motor aspects affecting handwriting performance, may indeed prove to be the optimal way to target handwriting difficulties.

*Summary of Chapter Five*

Although this study did not find any statistically significant results, the findings contribute important information to theory, research, and practice of handwriting instruction and intervention. This study adds to a growing body of literature that indicates “supplementary handwriting instruction early in the primary grades may be a critical factor in preventing writing difficulties, at least for children who do not master handwriting easily” (Graham et al., 2000, p. 621). Further research is needed to determine which children benefit from intervention and what elements of intervention contribute to improvements in handwriting.

## References

- Abbott, R. D., & Berninger, V. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary- and intermediate-grade writers. *Journal of Educational Psychology, 85*, 478-508.
- Abikoff, H. (1991). Cognitive training in ADHD children: Less to it than meets the eye. *Journal of Learning Disabilities, 24*, 205-209.
- Ajuriaguerra, J. de, & Auzias, M. (1975). Preconditions for the development of writing in the child. In E. H. Lenneberg & E. Lenneberg (Eds.) *Foundations of language development: A multidisciplinary approach: Vol. 2* (pp. 311-328). New York: Academic Press.
- Alston, J. (1983). A legibility index: Can handwriting be measured? *Educational Review, 35*, 237-242.
- Alston, J., & Taylor, J. (1987). *Handwriting: Theory, research, and practice*. New York: Nichols Publishing.
- American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders* (4<sup>th</sup>ed. -text revision). Washington, DC: Author.
- Amundson, S. J., (1995). *Evaluation Tool of Children's Handwriting*. Homer, AK: OT Kids.
- Amundson, S. J., & Weil, M. (2001). Prewriting and handwriting skills. In J. Case-Smith (Ed.) *Occupational therapy for children* (4th ed.). St. Louis, MO: Mosby
- Ayres, A. J. (1972). *Sensory integration and learning disorders*. Los Angeles: Western Psychological Services.

- Bairstow, P. J., & Laszlo, J. I. (1981). Kinaesthetic sensitivity to passive movements and its relationship to motor development and motor control. *Developmental Medicine and Child Neurology*, 23, 606-616.
- Beery, K. E., & Beery, N. A. (2004). *The Beery-Buktenica Developmental Test of Visual-Motor Integration: Beery VMI Administration, Scoring, and Teaching Manual* (5<sup>th</sup> ed.). Minneapolis, MN: NCS Pearson.
- Benbow, M. (1990). *Loops and other groups: A kinesthetic writing system*. Tucson, AZ: Therapy Skill Builders.
- Bergman, K. E., & McLaughlin, T. F. (1988). Remediating handwriting difficulties with learning disabled students: A review. *B. C. Journal of Special Education*, 12, 101-120.
- Berninger, V., & Rutberg, J. (1992). Relationship of finger function to beginning writing: Application to diagnosis of writing disabilities. *Developmental Medicine and Child Neurology*, 34, 198-215.
- Berninger, V., Vaughan, K. B., Abbott, R. D., Abbott, S. P., Woodruff Rogan, L., Brooks, A., et al., (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology*, 89, 652-666.
- Briggs, D. (1970). Influence of handwriting on assessment. *Educational Research*, 13, 50-55.
- Bruinsma, C., & Nieuwenhuis, C. (1991). A new method for the evaluation of handwritten material. In J. Wann, A. M. Wing, & N. Sovik (Eds.). *Development*

- of graphic skills: Research perspectives and educational implications*. London: Academic Press.
- Bundy, A. C. & Murray, E. A. (2002). Sensory integration: A. Jean Ayres' theory revisited. In A. C. Bundy, S. J. Lane, & E. A. Murray (Eds.), *Sensory integration: Theory and practice* (2nd ed., pp. 3-33). Philadelphia: F. A. Davis.
- Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research*, 65, 245-281.
- Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally.
- Canadian Association of Occupational Therapists (1990). *Position paper on occupational therapy in schools*. Toronto, ON: CAOT Publications.
- Case-Smith, J. (2002). Effectiveness of school-based occupational therapy intervention on handwriting. *American Journal of Occupational Therapy*, 56, 17-25.
- Chu, S. (1997). Occupational therapy for children with handwriting difficulties: A framework for evaluation and treatment. *British Journal of Occupational Therapy*, 60, 514-520.
- College of Occupational Therapists of British Columbia (2003). *What is an occupational therapist?* Retrieved March 27, 2003 from [http://www.cotbc.org/what\\_is.php](http://www.cotbc.org/what_is.php)
- Conners, C. K. (2000). *Conners' Rating Scales – Revised: Technical manual*. New York: Multi-Health Systems.
- Copley, J., & Ziviani, J. (1990). Kinaesthetic sensitivity and handwriting ability in grade one children. *Australian Journal of Occupational Therapy*, 37, 39-43.

- Cornhill, H., & Case-Smith, J. (1996). Factors that relate to good and poor handwriting. *American Journal of Occupational Therapy, 50*, 732-739.
- Daly, C. J., Kelley, G. T., & Krauss, A. (2003). Relationship between visual-motor integration and handwriting skills of children in kindergarten: A modified replication study. *American Journal of Occupational Therapy, 57*, 459-462.
- Diekema, S. M., Deitz, J., & Amundson, S. J. (1998). Test-retest reliability of the *Evaluation Tool of Children's Handwriting* – manuscript. *American Journal of Occupational Therapy, 52*, 248-255.
- Donoghue, M. (1990). *The child and the English language arts* (5th ed.). Dubuque, IA: Wm. C. Brown.
- Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., et al. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp 75-146). San Francisco, CA: W. H. Freeman.
- Edwards, L. (2003). Writing instruction in kindergarten: Examining an emerging area of research for children with writing and reading difficulties. *Journal of Learning Disabilities, 36*, 136-148.
- Feder, K. P. & Majnemer, A. (2003). Children's handwriting evaluation tools and their psychometric properties. *Physical and Occupational Therapy in Pediatrics, 23*(3), 65-84.
- Feder, K., Majnemer, A., & Synnes, A. (2000). Handwriting: Current trends in occupational therapy practice. *Canadian Journal of Occupational Therapy, 67*, 197-204.

- Fish, M. C., & Pervan, R. (1985). Self-instruction training: A potential tool for school psychologists. *Psychology in the Schools*, 22, 83-92.
- Furner, B. (1969a). The perceptual-motor nature of learning in handwriting. *Elementary English*, 46, 886-894.
- Furner, B. (1969b). Recommended instructional procedures in a method emphasizing the perceptual-motor nature of learning in handwriting. *Elementary English*, 46, 1021-1030.
- Furner, B. (1970). An analysis of the effectiveness of a program of instruction emphasizing the perceptual-motor nature of learning in handwriting. *Elementary English*, 47, 61-69.
- Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th ed.). New York: Longman
- Goldberg, E. R., & Simner, M. L. (1999). A comparison of children's handwriting under traditional vs. whole language instruction. *Canadian Journal of School Psychology*, 14, 11-30.
- Graham, S. (1983). The effects of self-instructional procedures on LD students' handwriting performance. *Learning Disability Quarterly*, 6, 231-234.
- Graham, S. (1992). Issues in handwriting instruction. *Focus on Exceptional Children*, 25(2), 1-14.
- Graham, S. (1999). Handwriting and spelling instruction for students with learning disabilities: A review. *Learning Disability Quarterly*, 22, 78-98.

- Graham, S., Harris, K. R., & Fink, B. (2000). Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. *Journal of Educational Psychology, 92*, 620-633.
- Graham, S., & Miller, L. (1980). Handwriting research and practice: A unified approach. *Focus on Exceptional Children, 13*(2), 1-16.
- Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. *Educational Psychology Review, 8*, 7-87.
- Hamestra-Bletz, E., & Blöte, A. W. (1993). A longitudinal study on dysgraphic handwriting in primary school. *Journal of Learning Disabilities, 26*, 689-699.
- Harris, S. J., & Livesey, D. J. (1992). Improving handwriting through kinaesthetic sensitivity practice. *Australian Journal of Occupational Therapy, 39*, 23-27.
- Jones, D., & Christensen, C. A. (1999). Relationship between automaticity in handwriting and students' ability to generate written text. *Journal of Educational Psychology, 91*, 44-49.
- Jongmans, M. J., Linthorst-Bakker, E., Westenberg, Y., & Smits-Engelsman, B. C. M. (2003). Use of a task-oriented self-instruction method to support children in primary school with poor handwriting quality and speed. *Human Movement Science, 22*, 549-566.
- Kosiewicz, M. M., Hallahan, D. P., Lloyd, J., & Graves, A. W. (1982). Effects of self-instruction and self-correction procedures on handwriting performance. *Learning Disability Quarterly, 5*, 71-78.
- Lamme, L. L. (1979). Handwriting in an early childhood curriculum. *Young Children, 35*, 20-27.

- Laszlo, J. I., & Bairstow, P. J. (1983). Kinaesthesia: Its measurement, training, and relationship to motor control. *Quarterly Journal of Experimental Psychology*, 35A, 411-421.
- Laszlo, J. I., & Bairstow, P. J. (1984). Handwriting: Difficulties and possible solutions. *School Psychology International*, 5, 207-213.
- Lockhart, J., & Law, M. (1994). The effectiveness of a multisensory writing programme for improving cursive writing ability in children with sensorimotor difficulties. *Canadian Journal of Occupational Therapy*, 61, 206-214.
- Lord, R., & Hulme, C. (1987). Kinaesthetic sensitivity of normal and clumsy children, *Developmental Medicine and Child Neurology*, 29, 720-725.
- Maeland, A. F. (1992). Handwriting and perceptual-motor skills in clumsy, dysgraphic, and 'normal' children. *Perceptual and Motor Skills*, 75, 1207-1217.
- Mandich, A. D., Polatajko, H. J., Macnab, J. J., & Miller, L. T. (2001). Treatment of children with developmental coordination disorder: What is the evidence? *Physical and Occupational Therapy in Pediatrics*, 20, 51-68.
- Markham, L. (1976). Influence of handwriting quality on teacher evaluation of written work. *American Educational Research Journal*, 13, 277-283.
- Meichenbaum, D. (1977). *Cognitive-behavior modification: An integrative approach*. New York: Plenum Press.
- Miller, L. T., Polatajko, H. J., Missiuna, C., Mandich, A., & Macnab, J. J. (2001). A pilot trial of a cognitive treatment for children with developmental coordination disorder. *Human Movement Science*, 20, 183-210.

- Missuina, C., Mandich, A. D., Polatajko, H. J., & Malloy-Miller, T. (2001). Cognitive orientation to daily occupational performance (CO-OP): Part 1 – theoretical foundations. *Physical and Occupational Therapy in Pediatrics*, 20, 69-81.
- Oliver, C. E. (1990). A sensorimotor program for improving writing readiness skills in elementary-age children. *American Journal of Occupational Therapy*, 44, 111-116.
- Peterson, C. Q., & Nelson, D. L. (2003). Effect of an occupational intervention on printing in children with economic disadvantages. *American Journal of Occupational Therapy*, 57, 152-160.
- Robin, A. L., Armel, S., & O’Leary, K. D. (1975). The effects of self-instruction on writing deficiencies. *Behavior Therapy*, 6, 178-197.
- Rosenblum, S., Weiss, P. L., & Parush, S. (2003). Product and process evaluation of handwriting difficulties. *Educational Psychology Review*, 15, 41-81.
- Rubin, N. & Henderson, S. E. (1982). Two sides of the same coin: Variations in teaching methods and failure to learn to write. *Special Education: Forward Trends*, 9 (4), 17-24.
- Sassoon, R. (1983). *The practical guide to children’s handwriting*. London: Thames & Hudson.
- Schunk, D. H., & Zimmerman, B. J. (1994). *Self-regulation of learning and performance: Issues and educational implications*. Hillsdale, NJ: Lawrence Erlbaum.
- Simner, M. L. (2003). *Promoting skilled handwriting: The kindergarten path to meaningful written communication*. Ottawa, ON: Canadian Psychological Association.

- Simner, M. L., & Eidlitz, M. R. (2000). Towards an empirical definition of developmental Dysgraphia: Preliminary findings. *Canadian Journal of School Psychology, 16*, 103-110.
- Smits-Engelsman, B. C. M., & van Galen, G. P. (1997). Dysgraphia in children: Lasting psychomotor deficiency or transient developmental delay? *Journal of Experimental Child Psychology, 67*, 164-184.
- Stipek, D. J. (1996). Motivation and instruction. In D. C. Berliner and R. C. Calfee (Eds.), *Handbook of Educational Psychology*. NY: Simon & Schuster Macmillan.
- Sovik, N. (1975). *Developmental cybernetics of handwriting and graphic behaviour*. Boston: Universitetsforlaget.
- Sudsawad, P., Trombly, C. A., Henderson, A., & Tickle-Degnen, L. (2001). The relationship between the *Evaluation Tool of Children's Handwriting* and teachers' perceptions of handwriting legibility. *American Journal of Occupational Therapy, 55*, 518-523.
- Sudsawad, P., Trombly, C. A., Henderson, A., & Tickle-Degnen, L. (2002). Testing the effect of kinesthetic training on handwriting performance in first-grade students. *American Journal of Occupational Therapy, 56*, 26-33.
- Taylor, J. (2001). *Handwriting: A teacher's guide. Multisensory approaches to assessing and improving handwriting skills*. London: David Fulton.
- Tseng, M. H., & Cermak, S. A. (1993). The influence of ergonomic factors and perceptual-motor abilities on handwriting performance. *American Journal of Occupational Therapy, 47*, 919-926.

- Tseng, M. H., & Chow, S. M. K. (2000). Perceptual-motor function of school-age children with slow handwriting speed. *American Journal of Occupational Therapy*, 54, 83-88.
- Tseng, M. H., & Murray, E. (1994). Differences in perceptual-motor measures in children with good and poor handwriting. *Occupational Therapy Journal of Research*, 14, 19-36.
- Weil, M. J., & Cunningham Amundson, S. J. (1994). Relationship between visuomotor and handwriting skills of children in kindergarten. *American Journal of Occupational Therapy*, 48, 982-988.
- Weintraub, N., & Graham, S. (2000). The contribution of gender, orthographic, finger function, and visual-motor processes to the prediction of handwriting status. *Occupational Therapy Journal of Research*, 20, 121-140.
- Woodward, S., & Swinth, Y. (2002). Multisensory approach to handwriting remediation: Perceptions of school-based occupational therapists. *American Journal of Occupational Therapy*, 56, 305-312.
- Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 3-21). Hillsdale, NJ: Lawrence Erlbaum.
- Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 1-37). Mahwah, NJ: Lawrence Erlbaum.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64-70.

Ziviani, J. (1987). Pencil grasp and manipulation. In J. Alston & J. Taylor (Eds.), *Handwriting: Theory, research, and practice*. New York: Nichols Publishing.

## Appendix A

## Sample Treatment Protocol for Cognitive Intervention

Child's Research ID: \_\_\_\_\_

Date: \_\_\_\_\_

**Cognitive Intervention Protocol**

Please check each item as you complete it during each treatment session to serve as a record of what occurred during each session. Return completed forms to principal investigator once all treatment sessions have been conducted. Thank you!

**Session 1: Crazy C letters *c, a, d****Warm-Up*

- therapist and/or child sing the Alphabet Song
- therapist points to letter *c* on letter strip and asks child to name letter
- therapist names letter *c* and asks child which letter comes before and after it
- therapist points to letter *a* on letter strip and asks child to name letter
- therapist names letter *a* and asks child which letter comes before and after it
- therapist points to letter *d* on letter strip and asks child to name letter
- therapist names letter *d* and asks child which letter comes before and after it

*Modeling*

- therapist demonstrates (by tracing with index finger) and describes how to form each letter using cards with numbered arrows that show the order and direction of strokes for each letter (in order of *c, a, d*)

*Imitation*

- child traces each letter on the numbered arrow cards with index finger (in order of *c, a, d*)
- child describes how to form each letter while tracing it

*Discussion*

- therapist and child discuss how the letters in the group are similar and different

*Practice*

- on the cognitive worksheet supplied, ask child to trace the letter *c* with the numbered arrows and have him/her describe how to form it
- child traces the three letter *c*'s on the worksheet
- child copies the letter *c* three times
- give the child the lined paper supplied and ask him/her to write the letter *c* three times from memory

- ❑ return to the cognitive worksheet and ask the child to trace the letter *a* with the numbered arrows while describing how to form it
- ❑ child traces the three letter *a*'s on the worksheet
- ❑ child copies the letter *a* three times
- ❑ give the child the lined paper supplied and ask him/her to write the letter *a* three times from memory
- ❑ return to the cognitive worksheet and ask the child to trace the letter *d* with the numbered arrows while describing how to form it
- ❑ child traces the three letter *d*'s on the worksheet
- ❑ child copies the letter *d* three times
- ❑ give the child the lined paper supplied and ask him/her to write the letter *d* three times from memory

*Evaluation*

- ❑ child circles best-formed letter for each target letter

## Appendix B

## Sample Treatment Protocol for Multisensory Intervention

Child's Research ID: \_\_\_\_\_

Date: \_\_\_\_\_

**Multisensory Intervention Protocol**

Please check each item as you complete it during each treatment session to serve as a record of what occurred during each session. Return completed forms to principal investigator once all treatment sessions have been conducted. Thank you!

**Session 1: Crazy C letters *c*, *a*, *d****Chalk and chalkboard*

- therapist introduces letter group and demonstrates formation of each letter, one at a time, on the chalkboard using chalk
- child copies the letter *c* three times on the chalkboard using chalk
- child copies the letter *a* three times on the chalkboard using chalk
- child copies the letter *d* three times on the chalkboard using chalk

*Sky Writing*

- therapist demonstrates "sky-writing" of letter *c* (starting with upper limb fully extended at 90 degrees of shoulder flexion with index finger pointed)
- child imitates sky-writing of letter *c* three times
- therapist demonstrates "sky-writing" of letter *a*
- child imitates sky-writing of letter *a* three times
- therapist demonstrates "sky-writing" of letter *d*
- child imitates sky-writing of letter *d* three times

*Cornmeal Tray*

- therapist demonstrates formation of letter *c* in cornmeal tray
- child traces letter *c* in cornmeal three times
- therapist demonstrates formation of letter *a* in cornmeal tray
- child traces letter *a* in cornmeal three times
- therapist demonstrates formation of letter *d* in cornmeal tray
- child traces letter *d* in cornmeal three times

*Bumpy Glue Letters*

- child traces over letter *c* three times
- child traces over letter *a* three times
- child traces over letter *d* three times

*Worksheet and Markers*

- ❑ there are three markers supplied: one colour for each letter
- ❑ child traces letter *c* three times
- ❑ child copies letter *c* three times
- ❑ child traces letter *a* three times
- ❑ child copies letter *a* three times
- ❑ child traces letter *d* three times
- ❑ child copies letter *d* three times

*Pencil and Paper*

- ❑ using a pencil, child copies letter *c* (from bumpy letter *c* card) three times on supplied lined paper
- ❑ child copies letter *a* three times
- ❑ child copies letter *d* three times

Appendix C

Parent Consent Letter

***Parent Consent Form***

---

**Effectiveness of Occupational Therapy in Remediating Handwriting Difficulties:  
Cognitive versus Multisensory Interventions**

You are being invited to participate in a study entitled Effectiveness of Occupational Therapy in Remediating Handwriting Difficulties: Cognitive versus Multisensory Interventions that is being conducted by Jill Zwicker. Jill Zwicker is a graduate student in the department of Educational Psychology at the University of Victoria as well as an occupational therapist at Queen Alexandra Centre for Children's Health. You may contact her if you have further questions by calling 477-1826 ext. 6336.

As a graduate student, I am required to conduct research as part of the requirements for the degree of Master of Arts in Learning and Development. It is being conducted under the supervision of Dr. Allyson Hadwin. You may contact my supervisor at 721-6347.

This research is being funded by the Research Advisory Committee of the Child, Youth, and Maternal Health Program, Vancouver Island Health Authority, British Columbia Society of Occupational Therapists, Michael Smith Foundation for Health Research, and the University of Victoria.

The purpose of this research project is: (1) to determine if children with handwriting difficulties who receive intervention show greater improvement in handwriting legibility compared to children with handwriting difficulties who do not receive intervention; and (2) to determine the effectiveness of multisensory interventions (learning through the senses) and cognitive (thinking) interventions in improving handwriting legibility.

Research of this type is important because handwriting is a complex skill to learn. Many children have difficulty learning how to form letters and to print legibly. If children have to put excessive effort into concentrating on proper letter formation, their ability to put thoughts on paper and to complete written assignments can be affected. Poor handwriting legibility can affect students' academic performance and self-esteem. This research will help to determine the impact of two different handwriting interventions on improving handwriting legibility in primary students. It is important to determine effective interventions for handwriting problems so that the far-reaching effects of these difficulties can be prevented.

You are being asked to participate in this study because your child meets the inclusion criteria based on his/her occupational therapy assessment. The occupational therapist has indicated that your child may benefit from the intervention under investigation.

If you agree to voluntarily participate in this research, your child's participation will include completing a pretest of handwriting legibility. If he/she scores below 85% legibility, your child will be randomly assigned to one of three groups: cognitive intervention, multisensory

intervention, or a control group. You, as well as your child's classroom teacher, will also be asked to fill out a short questionnaire regarding your child's behaviour. This information is collected in order to monitor the potential effects of behaviour on the outcomes of the intervention.

Intervention will involve 10 weekly sessions with the occupational therapist of 30 minutes duration. Each intervention will focus on correct letter formation for two or three letters each session. The cognitive intervention focuses on thinking and talking about the letters as well as paper/pencil practice. The emphasis of the multisensory intervention is on learning the feel of the letter in different sensory modalities, including paper/pencil practice. Children in either of the intervention groups may be observed one or two times by the principal investigator to ensure that the therapist is following prescribed treatment protocols.

All participants will complete a posttest of handwriting legibility following 10 weeks of intervention or no intervention. Participants in the control group will receive 10 weeks of therapy following the posttest. Parent/guardian may choose either the cognitive or multisensory treatment protocol.

Participation in this study may cause some inconvenience to your child as he/she will be taken out of regular classroom instruction to complete the assessment and treatment outlined in the study. In order to minimize disruption to the child's school day, a mutually agreeable time for each session will be determined by the therapist and your child's teacher. If your child is assigned to the control group, he/she will not receive intervention during the study, but will be offered treatment of the same duration and intensity after completion of the posttest.

There are no known or anticipated risks to your child by participating in this research.

The potential benefits of your child's participation in this research is that he/she will receive more intensive intervention than what is currently provided through school-based occupational therapy services. The information obtained through this research will contribute to knowledge regarding effective handwriting interventions and may influence future practice in occupational therapy practice and special education.

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your child's data will not be used in the study.

The researcher may have a relationship to potential participants as a therapist. To help prevent this relationship from influencing your decision to participate, the following steps to prevent coercion have been taken: your child will receive occupational therapy intervention regardless of your decision to participate in the study.

To make sure that your child continues to consent to participate in this research, the occupational therapist will ask your child at the beginning of each treatment session if he/she is willing to continue with the study. Your child will also indicate consent by signing a letter that states that he/she can stop participating in the study at any time without consequences. You will be contacted by telephone part way through the study by Audrey Gibson (Coordinator of the School Age Program at Queen Alexandra Centre) or Hilary LeRoy (Senior Occupational Therapist) to ensure ongoing consent for your child to participate in the study. You may withdraw your child from the study at any time.

In terms of protecting your child's anonymity, all data used for research purposes will be coded and entered with no identifying information. As the data collected in this study also serves therapeutic purposes, the assessments will be kept on your child's medical file for future use in guiding treatment recommendations or monitoring progress.

Your child's confidentiality and the confidentiality of the data will be protected by keeping the information on your child's medical file in a secure location as per Vancouver Island Health Authority policy. For research purposes, assessment results will be coded and entered into a database with no personal identification.

The data collected for this study serves two purposes: clinical assessment and outcome measurement for research. The assessment data may be used to guide future therapeutic interventions and/or monitor progress beyond the timeline of the study. Occupational therapists may share the assessment results with parents and school as per consent in referral process.

The assessments administered will remain on the child's medical file as per Vancouver Island Health Authority policy. Data coded and entered for research purposes will be destroyed after five years.

It is anticipated that the results of this study will be shared with others in the following ways: (1) directly with participants; (2) published thesis; (3) presentation at universities or professional conferences; (4) published journal article; (5) on the internet; and (6) presentation to Queen Alexandra Centre and local school districts.

In addition to being able to contact the researcher and her supervisors at the above phone numbers, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President of Research at the University of Victoria (250-472-4362) or Dr. Peter Kirk, Director of Research and Evaluation at the Vancouver Island Health Authority (250-370-8261).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

\_\_\_\_\_  
*Name of Participant*

\_\_\_\_\_  
*Signature*

\_\_\_\_\_  
*Date*

***A copy of this consent will be left with you, and a copy will be taken by the researcher.***

## Appendix D

## Child Consent Form

**Effectiveness of Occupational Therapy in Remediating Handwriting Difficulties:  
Cognitive versus Multisensory Interventions**

My occupational therapist has asked me to be in a project looking at ways to help children learn how to print better. If I choose to help with this project, I would be asked to print letters and words on a special paper so my therapist can see how I print (pretest). I would then see my occupational therapist one day a week for 10 sessions. I would miss 30 minutes of school each week to have this therapy. In the therapy, I would be learning how to print letters in different ways. Another occupational therapist working on the project, Jill Zwicker, may come and watch my therapy session one or two times. At the end of the therapy, my therapist will ask me to print letters and words again like I did at the beginning (posttest).

I may be asked to help with the project in a different way. I may be asked to show my therapist how I print letters and words (pretest) and then not see my therapist for 10 weeks. My therapist will ask me to print letters and words again (posttest). After that, I would then see my occupational therapist one day a week for 10 sessions. I would miss 30 minutes of school each week to have this therapy. In the therapy, I would be learning how to print letters in different ways.

If I choose not to help with this project, my occupational therapist will still help me try to print better.

If I decide at any time that I do not want to be in the project anymore, I just have to tell my therapist or my parent(s).

I understand that no one except the people working on the project will see the work that I do and they will not use my name when they talk or write about the project. Information about how I print will be put together with information about how other children print; this information may be published but no one will be able to tell what information is mine.

I have had a chance to ask questions. I would like to be in this project. If I have any more questions, I can ask my parent(s). My mom and/or dad have been given telephone numbers of people to contact to find out more about the project.

Child Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Therapist Signature: \_\_\_\_\_

Date: \_\_\_\_\_