Visual-Motor Integration Skills Impact on Handwriting

Amber M. Kapnick
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses
Part of the Occupational Therapy Commons

Recommended Citation
https://scholarworks.wmich.edu/masters_theses/4677
VISUAL-MOTOR INTEGRATION SKILLS IMPACT ON HANDWRITING

by

Amber M. Kapnick

A Thesis
Submitted to the
Faculty of the Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Science
Department of Occupational Therapy

Western Michigan University
Kalamazoo, Michigan
August 2004
ACKNOWLEDGEMENTS

I would like to begin by acknowledging Onsted Community Schools for allowing me to conduct my research at the Primary building. Susan Nash, Primary principal was instrumental in helping me coordinate the research. Thank you to the first grade teachers, parents of first grade students, and the first grade students. Without the involvement and enthusiasm of any of these people this research would not have been possible. I would also like to thank the members of my graduate committee, Dr. Cindie Quake-Rapp, Dr. Ben Atchison, and Dr. Paula Jamison. A special thanks goes to Dr. Quake-Rapp for helping me to run the statistics and to compile the information into tables. A special thanks also goes to the occupational therapy undergraduate students at Western Michigan University for scoring the assessments from the study in order to eliminate any subject bias that may have occurred if I would have scored the assessments.

Finally, I would like to thank all of my family who have been so supportive through this process, particularly my husband Nathan, my mother Cindy, and my grandmother Pat. I would also like to thank my colleagues who have offered input and support during the writing of my thesis.

Amber M. Kapnick
The purpose of this study was to evaluate if a visual-motor integration intervention improved handwriting legibility and visual-motor integration in first grade students as measured by the Minnesota Handwriting Test (MHT) and the Developmental Test of Visual-Motor Integration (VMI). Intervention was based on sensory-motor learning theories. Sixty-six children from four first grade classrooms in a suburban elementary school were randomly assigned to an intervention or a control condition. The intervention group received eight weeks of visual-motor integration training twice a week for 30 minute sessions. The control group received regular academic instruction. All children were tested on the Minnesota Handwriting Test (MHT) and the Beery Test of Visual Motor Integration (VMI) and two supplemental Perception and Motor tests before and after the intervention phase of the study. The MHT measures reproduction skills necessary for accurate printing. The VMI measures visual motor integration skills that are a foundation for handwriting. Raters were not aware of group placement. Univariate analysis of variance confirmed that there were no significant gain scores in the intervention group compared to the control on the MHT. There were significant gain scores for the intervention group on the VMI and the Motor coordination supplemental test of the VMI when compared to the control. The results of this study indicate that a visual motor intervention was effective in improving visual motor integration scores necessary for handwriting.
TABLE OF CONTENTS

ACKNOWLEDGEMENTS ........................................................................................................ ii

LIST OF TABLES ..................................................................................................................... v

CHAPTER

I. INTRODUCTION .................................................................................................................. 1

Need for the Study .................................................................................................................. 4

Purpose .................................................................................................................................. 4

II. LITERATURE REVIEW .................................................................................................... 6

Prior Research on Handwriting Outcomes ........................................................................... 6

The Relationship of Perceptual Motor Functioning on Handwriting .................................. 7

Prior Research on Visual-Motor Integration and Handwriting ......................................... 10

Occupational Therapy and Visual-Motor Skills In Children ............................................. 15

III. METHOD .......................................................................................................................... 18

Research Questions and Hypotheses ................................................................................. 18

Subjects .................................................................................................................................. 18

Measures ............................................................................................................................... 18

Procedure ............................................................................................................................... 20

Intervention Protocol ........................................................................................................... 20

Data Analysis ....................................................................................................................... 27

IV. RESULTS ......................................................................................................................... 28
Table of Contents – continued

CHAPTER

V. DISCUSSION ................................................................................ 30

Limitations ................................................................................. 32

Implications for Further Research ........................................... 32

Conclusion .................................................................................. 33

APPENDIX .................................................................................... 34

Approval Letter From the Human Subjects Institutional Review Board ........................................................................ 35

BIBLIOGRAPHY ........................................................................... 36
LIST OF TABLES

1. Univariate Analysis of Variance for the Six Handwriting Variables on the MHT ................................................................. 28

2. Univariate Analysis of Variance for the VMI and 2 Supplemental Tests of Perception and Motor .................................................. 29
CHAPTER I

INTRODUCTION

One of the first challenges children face when entering school is learning to print. In April 2004 the Michigan Department of Education determined that entry level expectations of public schools would include printing one's name and all twenty six upper and lower case letters of the alphabet. Maeland (1992, 1207) defined handwriting as, "a complex skill encompassing visual-motor coordination, cognition, perceptual skills, and tactile and kinesthetic sensitivity". Proficient handwriting requires maturation and integration of the above skills.

Research has shown that writing readiness is the outcome of appropriate visual-motor integration skill development. Visual-motor integration skills can be defined as "the degree to which visual perception and finger-hand movements are well coordinated" (Beery, 1997). Visual-motor integration skills have also been aptly defined by Lifetime Eye Care (1999, 5) as "skills that give one the ability to accurately analyze and interpret visually presented information and plan an appropriate motor action." Lifetime Eye Care also states that visual-motor integration skills are needed to copy movement patterns and images of drawing and handwriting.

Visual processing skills are different than eyesight and play a significant role in academic learning. A child may be able to see, but may encounter difficulties in visual discrimination of letters and words, visual memory, or visual closure (Lerner, 2000). The ability to copy shapes has been linked to academic achievement (Kephart, 1971). Visual-motor integration skills are important to legible handwriting because writing requires complex integration of the visual and motor systems.

According to Beery (1999), visual-motor integration skills are necessary prerequisites for success in school. Visual-motor integration skills assist children in understanding our symbolic society and improve academic readiness (Lerner, 2000).
According to Snow (as cited in Smith, Allen, & Pratt, 1996) and Scheiman (2002), children with integrated visual-motor integration skills are able to be a part of a perceptual-motor world that is stable and reliable, which enables them to make accurate observations of objects. According to Schneck (1996), visual-motor integration, kinesthesia, and motor planning are closely related to handwriting. Amundson and Weil (1996) report that letter formation is dependent on integration of the visual, motor, and sensory systems. They also report that children who are able to copy developmentally appropriate shapes are more likely to copy more letters than children who are unable to copy developmentally appropriate shapes.

Handwriting readiness is dependent on integrity of the sensorimotor systems (Kranowitz, 1998). According to Alston and Taylor (as cited in Smith, Allen, & Pratt, 1996), letter formation is dependent on integration of the visual, motor, sensory, and perceptual systems, and adequate fine motor coordination. Denoghue and Lamme (as cited in Smith, Allen, & Pratt, 1996), feel that children who participate in handwriting should have well developed small muscles, eye-hand coordination, ability to hold writing utensils, ability to produce basic strokes, such as circles and lines, letter perception, the ability to notice likes and differences, and have a right-left discrimination to assist with orientation to printed language. Alston, Taylor, Wright and Allen (as cited in Smith, Allen, & Pratt, 1996), stress that children should demonstrate mastery in writing readiness tasks prior to participation in handwriting instruction.

Handwriting and the underlying components are becoming critical issues in school based occupational therapy due to the frequency rates of referrals that are received (Amundson & Weil 1996; Oliver 1990; Reisman 1991). Cermack (1991) found that handwriting and similar fine motor deficits are the number one reason for an occupational therapy referral in the school setting. Even with the high frequency of handwriting difficulties reported, Graham (as cited in Peterson & Nelson 2003) found that
kindergarten through sixth grade teachers’ spend a mere 30 to 60 minutes per week engaged in handwriting instruction. It has also been reported that children on average participate in fine motor tasks between 30% and 60% throughout the day and that handwriting activities occur more often than any other type of fine motor manipulation (McHale & Cermack, 1992). Unfortunately, children who experience excessive handwriting errors have been found to have a higher risk of failure in first and second grade (Simner, 1982).

Motor learning theory principles apply to this study because handwriting is a motor act. Motor learning theory states that learning begins with movement, motor stages occur in a natural developmental sequence, and acquisition of motor skills at each specific stage provides the foundation for learning at the next stage (Lerner, 2000).

Perceptual-motor theory supports this study because handwriting also contains a visual component. Because handwriting contains both motor and visual components, integration of these components is important to efficient handwriting (Kranowitz, 1998; Scheiman, 2002). Visual processing skills, that include visual-motor integration skills, are the last group of visual skills to be mastered (Cratty, 1986). During the pre-school years visual-motor integration skills begin to be used for the purpose of reproducing visual forms (Cratty, 1986; Scheiman, 2002).

Sensory integration theory principles relate to this study because the vestibular and proprioceptive systems are closely related to the visual system, allowing a child to have control of their eye movements (Ayres, 1979). Children who do not experience integration of these systems often have difficulty with visual-motor integration tasks such as coloring, drawing lines, and manipulation of hand tools (Ayres 1979; Henderson, Pehoski, & Murray as cited in Bundy; Lane & Murray, 2002; Kranowitz, 1998). Integration of the visual, motor, and sensorimotor systems is important because when the visual area of the cerebral cortex does not have adequate communication with the
vestibular system, visual discrimination will be poor (Ayres, 1979). According to Parham & Mailloux (as cited in Smith, Allen, & Pratt, 1996), between the ages of three and seven sensorimotor functions become an embedded foundation for future academic abilities.

Need for the Study

There is an extensive body of knowledge on the relationship between handwriting and visual-motor integration skills. However, few outcome studies have been completed that look at the relationship between visual-motor integration skills and handwriting. The literature strongly supports the Beery Developmental Test of Visual-Motor Integration Skills (VMI) as a common assessment used by therapists' when evaluating handwriting. However, it was also found that treating visual-motor integration deficits was not the most commonly used intervention for handwriting problems (Case-Smith, 2002; Cornhill & Case-Smith, 1996; Feder, Majnemer, & Synnes, 2000). Due to the fact that occupational therapists use various strategies and theories for handwriting instruction, determining effective treatment approaches is problematic. The fact that consistent and uniform strategies are not used has also made it difficult to determine appropriate strategies. Thus, it is important that various treatment protocols are researched for impact and effectiveness. Knowing the effectiveness of a visual-motor integration skills protocol on handwriting would not only help therapist shape the way they deliver services, but it could change teachers classroom strategies, and possibly even school wide curriculum.

Purpose

The purpose of this study was to determine the relationship that exists between visual-motor integration skills and handwriting. The study was designed to investigate what impact a visual-motor integration intervention would have on the handwriting of first grade students. The study looked specifically at the effectiveness of the intervention on handwriting legibility and the components as measured by the Minnesota Handwriting
Test (MHT). The study was also completed to determine if the intervention would improve visual-motor integration skills as measured by the Beery Developmental Test of Visual Motor Integration Skills (VMI).
CHAPTER II

LITERATURE REVIEW

Prior Research on Handwriting Outcomes

In 2002, Woodward and Swinth completed a survey to determine what multisensory modalities and activities were used most frequently in remediation of handwriting problems by occupational therapists. The survey was sent to occupational therapists that had reported working in the school system to the American Occupational Therapy Association. Results indicated that a wide variety of multisensory modalities and activities were used. Of the multisensory modalities noted, few were reported as being used often or very often. The study found that school-based therapist’s use multiple multisensory modalities and activities in the treatment of handwriting problems.

Woodward and Swinth (2002) recommended that future research be conducted to determine the effectiveness of the multisensory modalities. The authors suggested that it would also be beneficial to complete qualitative research to determine the clinical reasoning process of how school-based therapists select different modalities and activities.

In 2003, Peterson and Nelson examined whether an occupational therapy treatment group for economically and socially disadvantaged first grade students would result in improved Minnesota Handwriting Test (MHT) scores as an indicator of printing quality. The study also examined what effect the treatment had on specific characteristics of handwriting (legibility, spacing, line usage, size, and form). The authors also wanted to determine what relationships exist between performance on the MHT and age, gender, race, and amount of school days missed.

The study included 59 students, who were randomly placed into either an experimental (receive handwriting intervention) or control (do not receive handwriting
intervention) group. Each child completed the MHT to determine pre and post test gain scores following intervention. Students in the experimental group received 20 sessions of occupational therapy. Students in the control group received regular academic instruction.

Results indicated that the experimental group showed significantly higher increases in MHT post-test scores than did the control group. Spacing, line usage, and size were also significantly impacted by the occupational therapy intervention. Legibility and form were not found to be significantly impacted. It was determined that gender and race were not significantly linked to handwriting. Total number of missed days was found to be inversely related to handwriting improvement. Age was not found to be a contributing factor in handwriting improvement.

Peterson and Nelson (2003) recommended that studies be conducted to determine the individual effects of biomechanical, sensorimotor, and teaching-learning strategies on handwriting. The authors also suggested that studies be conducted that look at the use of multiple strategies to improve handwriting.

The Relationship of Perceptual Motor Functioning on Handwriting

In 2000, Tseng and Chow looked at perceptual-motor function in children with slow handwriting speed. For this study, 69 students were selected to participate based on scores from the Chinese Handwriting Speed Test (CHAST). Of these students, 34 were identified as having slow handwriting speed and 35 students were identified as having typical handwriting speed. Each of the students participated in two perceptual assessments (Test of Visual-Perceptual Skills – Non-Motor (TVPS) and The Developmental Test of Visual-Motor Integration Skills (VMI), one motor assessment (the upper-limb speed and dexterity sub-test of the Bruininks-Oseretsky Test of Motor Proficiency (ULSD), and one vigilance assessment (Vigilance Task of the Gordon Diagnostic System).
A significant difference was found between all test scores for both slow and typical handwriting groups, except for visual closure and visual discrimination. The best predictors of handwriting speed in the slow handwriting group included age (42.4% variance), visual sequential memory (13.1% variance), and visual-motor integration skills (6.5% variance). In the typical handwriting group it was determined that age (64.4% variance) and the ULSD (9.95% variance) scores were the most significant predictors of handwriting speed. It was also determined that age, ULSD, visual memory, and visual sequential memory, were the four areas that had significant correlation for both groups.

Tseng and Chow (2000) determined that intervention for those who write slowly should be different than what is typically done for handwriting difficulties because visual sequential memory and visual-motor integration skills were the second and third significant predictors for speed. The authors suggested that intervention should focus on enhancing visual processing, which includes memory and visual-motor integration skills that differ from typical occupational therapy interventions for handwriting that address fine motor skills. The authors suggested that the two groups may use different mechanisms during handwriting tasks. Children with slow handwriting appeared to need more visual processing skills, particularly sequential memory and visual-motor integration skills. Children with typical handwriting speed appeared to rely more on upper-limb coordination.

In 1994 Tseng and Murray examined differences in perceptual-motor measures in children who demonstrate good and poor handwriting abilities. They investigated this correlation under the assumption that students with poor handwriting would not perform as well as students with good handwriting on perceptual-motor tests. They also measured the extent to which perceptual-motor assessments contribute to the legibility of handwriting. The subjects were Chinese students in grades third through fifth. Students with poor handwriting were randomly selected from the subject pool of a
previously completed study. Students with good handwriting were selected on similar
criteria by their classroom teachers. Each subject participated in a handwriting test
(copying a paragraph from a Chinese textbook). The children also completed the
Developmental Test of Visual-Motor Integration Skills (VMI), the upper-limb speed and
dexterity sub-test (ULSD) of the Bruininks-Oseretsky Test of Motor Proficiency, The Test
of Visual Perceptual Skills (TVPS), the Kinesthesia test of the Sensory Integration and
Praxis Test (KIN), the Motor Accuracy Test of the Sensory Integration and Praxis Test
(MAC), the Imitation of Finger Movement (IFM) sub-test of the PEERAMID, and the
Finger Position Imitation Test (FiPIT).

The study found that students with poor handwriting did not perform as well as
students with good handwriting on the majority of perceptual-motor assessments.
Legibility for the entire group was most affected by results on the VMI and the Mac.
Motor planning tested by using the FiPIT was the strongest predictor of legibility for
students with poor handwriting. Visual perception tested by using the TVPS was the
strongest predictor of legibility for students with good handwriting. The authors did not
feel that kinesthesia is a significant contributor to legible handwriting.

The authors stated that even though relationships between legibility and the above
mentioned factors exist, casual assumptions should not be made between legible
handwriting and perceptual motor assessments. While the article talks about the close
relationships it makes an argument that few studies have been conducted looking
specifically at the relationship. The authors even suggested that future research with an
experimental design needs to be conducted.

In 1993 Tseng and Cermak investigated the role that ergonomic factors and
perceptual-motor abilities have on handwriting performance. The authors completed
their investigation by reviewing current research articles. In evaluation of ergonomic
factors, the authors looked specifically at pencil grip and the pressure that is exerted on
writing utensils and the surface being written on. In evaluation of perceptual-motor abilities the authors looked specifically at kinesthetic perception, visual perception, visual-motor integration, and fine motor and motor planning skills.

Tseng and Cermak (1993) stated that an awkward or unconventional grip did not affect the speed and legibility of a child’s handwriting. The authors stated that due to the fact that handwriting is a motor skill, various grips should be expected. Further research is needed in the area of pressure placed on the writing utensil and surface during writing, particularly the effects of low muscle tone on these components. The authors also felt that further research should be completed to study relaxation training and its effects on handwriting legibility.

Tseng and Cermak (1993) stated that a limited amount of research has been conducted on the relationship between visual perception, visual-motor integration skills, fine motor, and motor planning on handwriting. The research that has been done does not provide convincing evidence that visual perception plays a crucial role in handwriting, due to the fact that the majority of studies have been correlational. The authors stated that teaching handwriting may be most effective when coupled with strategies that capitalize on a child’s strengths, developing foundation performance components, and compensation strategies. While many different treatment strategies have been proposed, the authors felt that strategies need to be studied to determine effectiveness for remediating handwriting difficulties.

Prior Research on Visual-Motor Integration and Handwriting

In 2002 Marr and Cermak examined handwriting performance in early elementary students as predicted by the Developmental Test of Visual-Motor Integration Skills (VMI). The authors also examined the role that gender plays in handwriting and if the ability to copy the first nine forms or the oblique cross on the VMI could be used as a predictor of handwriting.
The participants for this study were selected from a convenience sample of typically developing children. Each of the children participated in the VMI at the beginning of kindergarten and The Scale of Children's Readiness In PrinTing (SCRIPT) in the middle of the first grade year. In addition to completing the assessments the children also participated in weekly group activities that were provided by an occupational therapist.

Analysis results revealed that VMI scores were not significantly correlated to performance on the SCRIPT. Gender was determined to play a role in girl's scores ($r=0.03$), but not boy's scores ($r=0.73$). Children who demonstrated success replicating the first nine figures of the VMI did receive higher SCRIPT scores. Kindergarten boys who did not demonstrate success with the first 9 forms did not have significantly lower SCRIPT scores than did boys who were successful with the first nine forms. However, girls who did not demonstrate success with the first nine forms did have significantly lower SCRIPT scores than did girls who were successful with the first nine forms.

The authors felt that it might be most appropriate to use an evaluation of letter copying skills to identify children who may need assistance in handwriting. The authors make this recommendation based on the assumption that the SCRIPT is a reliable measure of handwriting.

In 1994, Weil and Amundson investigated the relationship between visuomotor and handwriting skills of children in kindergarten. In the study the authors researched three hypotheses. The first hypotheses stated that a significant relationship exists between kindergarten student's performance on the Developmental Test of Visual-Motor Integration Skills (VMI) and the ability to copy 34 letters. The second hypotheses stated that a significant difference in letter copying ability exists between children who can successfully copy the first nine forms of the VMI versus those who are unsuccessful. The third hypotheses stated that a significant difference exists in the ability to copy
letters that contain diagonal lines for children who can copy an oblique cross versus children who cannot.

The 60 male and female subjects attended schools that represented high to low socioeconomic status and various ethnic backgrounds. Each subject was assigned to an age category, resulting in three age categories with ten subjects each. Each subject completed The Scale of Children’s Readiness in PrinTing (SCRIPT) and the VMI.

The first two hypotheses were supported, but the third was not. It was also noted that as VMI scores increased, the ability to copy letters also increased.

Weil and Amundson supported the use of the VMI as an evaluation tool to assess readiness skills needed for successful handwriting. The authors supported the belief that kindergarten children are not ready to begin formal handwriting instruction until the second half of the school year. The authors stated that when first teaching children handwriting that they should be taught on unlined paper, to help reduce confusion. The authors stated that it would be of great benefit for efficacy studies to be completed that look at the effectiveness of occupational therapy treatment directed toward improving perceptual motor skills.

In 2003, Daly, Kelley, and Krauss investigated the relationship between visual-motor integration and handwriting skills of children in kindergarten. This was a modified replication study completed by Weil and Cunningham (1994). The authors specifically investigated the relationship between kindergarten visual-motor integration scores and their ability to copy letters legibly, the relationship between legible handwriting and the ability to copy the first nine forms of the Developmental Test of Visual-Motor Integration Skills (VMI), and the effects of using lined and unlined paper on legibility.

The study included 54 typically developing kindergarten students. Each student completed a VMI, 30 students completed a Modified Scale of Children’s Readiness in
PrinTing (SCRIPT) with unlined paper, and 24 students completed a Modified SCRIPT with lined paper.

Daly, Kelley, and Krauss supported the idea that a strong relationship existed between visual-motor skills and the ability to copy legible letters. The second research question was also supported; students who were able to copy the first nine forms of the VMI did demonstrate higher scores on the Modified SCRIPT. The third research question was not supported; no significant performance difference was noted on lined versus unlined paper. The authors stated that using the VMI as an assessment to determine handwriting abilities was appropriate, based on the assumption that visual-motor integration skills are a necessary pre-requisite skill for legible handwriting.

In 2000, Daly investigated the relationship between visuomotor and handwriting skills in kindergarten children. Specifically Daly looked at the use of assessments to predict handwriting ability and the effect occupational therapy had on facilitating fine motor skills in kindergarten children. A modified replication study of Weil, Cunningham-Amundson (1994) was conducted to investigate legibility factors when using lined and unlined paper.

The subjects included 54 typically developing kindergarten children, who were divided into two experimental and two control groups. Each subject participated twice in pre and post testing on the following assessments: Developmental Test of Visual-Motor Integration Skills (VMI), Developmental Test of Visual Perception, Developmental Test of Motor Coordination, Wide Range Assessment of Visual Motor Abilities Pegboard Sub-test, the Scale of Children’s Readiness In Printing (SCRIPT). Children in the experimental groups had an occupational therapy student present in their classroom ½ day per week to facilitate fine motor skills.

Daly determined that a strong relationship existed between kindergartener's performance on the VMI and their ability to copy letter forms, and students who could
copy the first nine VMI forms performed better on the Modified SCRIPT. Daly found that visual-motor integration, visual perception, motor coordination, in-hand manipulation skills, and age were all significant predictors to handwriting success. Daly suggested that strategies that are proven to be effective in treating fine motor and visual-motor deficits need to be developed.

In 2000, Weintraub and Graham examined whether or not orthographic, finger function, visual-motor integration, and gender could be used as significant contributions to the labeling of fifth grade students handwriting as good or poor.

The study included 56 fifth grade students from 12 different schools. All subjects participated in screening tests of the Test of Legible Handwriting (TOLH), the written expression sub-test of the Wechsler Individual Achievement Test (WIAT), and the Otis-Lennon School Ability Test (OLSAT) to assure that cognition was within normal limits and to place the subjects into good and poor handwriting groups. Each subject then participated in assessments to look at orthographic (Alphabet writing task, Colorado Perceptual Speed Test, Expressive Orthographic Coding), finger function (Finger Succession, Finger Lifting, Finger Recognition), and visual-motor integration skills (The developmental Test of Visual-Motor Integration Skills).

Analysis revealed that finger function and visual-motor integration significantly contributed to the prediction of handwriting categories. Orthographic and gender did not significantly contribute to the prediction of handwriting categories. Knowledge of a child's gender, finger function, and visual-motor integration skills lead to the correct categorization of 77% of the subjects as either good or poor handwriters.

Weintrub and Graham (2000) identified that further research is needed to recognize other variables that might add to the accuracy in predicting children's handwriting skills and to determine if therapy targeted at working on motor or visual-motor processes results in positive changes in handwriting performance. Handwriting assessments
should be comprehensive and should include assessment of finger function and visual-motor integration skills.

In 1997, Nielsen examined the following questions: (1). Does a relationship exist between handwriting ability and visual motor skills when measured by the Minnesota Handwriting Test (MHT) and the Developmental Test of Visual Motor Integration Skills (VMI), and (2). Does a relationship exist between age, gender, preschool experience, kindergarten experience, disability, and handwriting skills of first grade students.

The subjects included 62 first grade students from general education classrooms. Each of the subjects participated in the two above mentioned tests.

Nielsen found a moderate relationship between raw scores obtained on the VMI and MHT in answering the question of whether or not a relationship existed between handwriting success and visual motor skills. Nielsen found that kindergarten experience accounted for 8% of the variance and the demographic variables accounted for 16% of the variance.

Nielsen stated that the results of this study indicate that early identification of visual motor deficits may lead to early treatment to help ease handwriting difficulties. Further research needs to be conducted to determine what treatments can be used to effectively treat visual motor deficits. Once these treatments are identified the author stated that research should then be conducted to see how they impact handwriting.

Occupational Therapy and Visual-Motor Skills in Children

In 2003, Dankert, Davies, and Gavin examined whether or not preschool children with developmental delays and preschool children with no delays would experience gains in visual-motor skills after receiving occupational therapy. More specifically, the study examined whether or not preschool children with developmental delays would experience significant gains in visual-motor skills, demonstrated through the ability to copy a higher quantity of shapes on the Developmental Test of Visual-Motor Integration.
Skills (VMI) after one school year of therapy. The authors also wanted to determine if developmentally delayed preschoolers would show a rate of gain that was consistent with typically developing preschoolers after occupational therapy services.

Two treatment groups (one group consisted of children with developmental delays and one group consisted of children with no delays) and one control group (this group consisted of children with no delays) were included in the study. Each of the children completed the VMI, The Developmental Test of Visual Perception (TVP), and The Developmental Test of Motor Coordination (TMC) in September, December, and May. Children with developmental delays in treatment group one received 30-minute individual and one 30-minute group session per week. The individual therapy sessions met the needs of the child's Individualized Education Plan and the visual-motor skills deficits were only addressed during the group session. Children with no delays in treatment group two received one 30-minute group session per week. Treatment activities consisted of fine motor tasks of small manipulatives and finger plays, gross motor tasks of obstacle courses and music, visual-motor and visual-perception tasks of cutting and assembly. Children with no delays in control group three did not receive direct occupational therapy services.

The results of analysis revealed that group one made significant performance gains on the VMI and TVP, but not on the TMC. Group two and group three experienced significant performance gains on the VMI and TVP as well, but they had smaller effect sizes than group one. Group two and group three also experienced significant performance gains on the TMC and these gains were significantly higher than group one. Looking at whether or not group one would demonstrate a rate of gain consistent with group two and group three showed that group one experienced a positive gain. However this gain was not found to be significant. It was determined that group two and
group three made only small positive gains on the VMI. Group two and group three did experience greater gains on the TVP and TMC, but the gains were not significant.

Dankert, Davis, and Gavin (2003) found that pre-school children may benefit from occupational therapy directed at improving visual-motor deficits. The authors supported the use of multiple intervention strategies in pre-school which include movement patterns without tool use. The authors felt that these movement patterns lay the foundation for later tool use during drawing and writing. Conducting this study also led the authors to supporting the use of the VMI in the preschool setting.
CHAPTER III

METHOD

Research Questions and Hypotheses

This study investigated two separate questions. The first question was does visual-motor integration intervention increase posttest scores on the Minnesota Handwriting Test (MHT) and the Developmental Test of Visual-Motor Integration (VMI) in the intervention group when compared to the control group? The second question was what effect does the intervention have on specific variables of handwriting as measured by the MHT and the VMI?

Subjects

Sixty-five subjects were recruited from four first grade classrooms of a rural elementary school in Lenawee County. Inclusionary criteria included, enrollment in a first grade classroom, parental permission, and the child was not currently receiving any special education support and had no identified educational, physical or mental deficits. The treatment group included 16 girls and 18 boys. The control group included 19 girls and 12 boys.

Measures

Data was collected using four different assessments. Visual-Motor integration skills were tested by using the Beery Developmental Test of Visual-Motor Integration Skills (VMI) (Beery, 1997). The VMI was selected because it has been found to be a reliable measure of visual-motor integration skills in relationship to handwriting (Beery, 1997; Cornhill & Case-Smith, 1996; Dankert, Davies, & Gavin, 2003; Feder, Majnemer, & Synnes, 2000; Tseng & Murray, 1994). The most recent version of the VMI includes two supplemental tests, Visual Perception and Motor Coordination. The supplemental tests were given to aide in separating the components of visual perception and motor coordination that are tested in conjunction with one another on the VMI. The VMI
consists of 24 geometric shapes which are presented in a developmental sequence. Visual-motor integration skills are measured by rating the child's ability to replicate the presented shapes. The Beery manual states that it is a reliable measure due to having .92 reliability score on the VMI, .91 reliability score on the visual supplemental test, and .89 reliability score on the motor supplemental test. The reliability scores were determined by calculating interscorer, internal consistency, and test-retest errors. Validity, as determined by the Rasch-Wright analysis of the VMI, was found to be between .80 and .90.

The Minnesota Handwriting Test (MHT) was also used in this study (Reisman, 1999). In 1996, Cornhill & Case-Smith conducted research supporting the use of the MHT as a valid measure of handwriting skills. The MHT was developed to quantify specific characteristics of children's handwriting. The MHT assess six characteristics: rate, legibility, form, alignment, size, and spacing. The MHT was standardized with a sample of 1,100 first and 926 second grade students living in 9 different states (Reisman, 1999). Interrater reliability was found to be between .77 and .88 (Pearson correlation) for inexperienced scorers. Intrarater reliability scores were figured for each of the six handwriting characteristics that the test assess the scores are as follows: rate 1.00, legibility .96, form .97, alignment .99, size .99, and spacing .97. Test-retest stability was calculated for each of the six handwriting characteristics the scores are as follows: rate 71%, legibility 64%, form 75%, alignment 86%, size 82%, and spacing 76%. In 2003 Peterson and Nelson conducted test-retest reliability and interrater reliability studies. Test-retest reliability was found to be between .60 and .89. Interrater reliability was found to be between .73 and .99 for all handwriting characteristics except for speed that was found to be .65.
Procedure

This study was approved by Western Michigan’s Human Subjects Institutional Review Board, see Appendix A. The subjects were randomly assigned to either a treatment (visual-motor integration intervention) or a control (no visual-motor integration intervention) group, according to the first grade classroom they were in. All testing was completed by each of the classroom teachers who were trained by the primary investigator who is an occupational therapist. To eliminate bias, occupational therapy students from an undergraduate program trained in scoring the VMI, its supplemental tests, and the MHT scored all pre and post measures. The occupational therapy students were blind as to what group (treatment or control) the children were assigned to. To ensure the privacy of the students who participated in the study, each was assigned a random number to use in place of their name. All measures were completed according to the standardized instructions and procedures during the second week of October and the third week of December. Each student completed the testing in a group format in their own classroom. Each testing session was approximately one hour in length. The entire study was a total of ten weeks. During weeks one and ten testing was completed. During weeks two through eight intervention sessions were completed.

Intervention Protocol

Intervention sessions were provided by the student investigator, classroom teachers, and three parent volunteers. Prior to the actual beginning of the intervention sessions the student investigator, teachers, and volunteers met to determine what activities would be assigned to each person for the duration of the study. Each person assisting with the intervention groups was given copies of their assigned activities ahead of time so that they were familiar with what they would complete with the children.

Intervention sessions took place during the regular hours of the school day and occurred on Tuesdays and Thursdays. Each intervention session lasted 30 minutes.
The first classroom participated in intervention activities from 12:10 pm to 12:40 pm. The second classroom participated in intervention activities from 2:00 pm to 2:30 pm. Intervention sessions were completed in a group format, with four to five kids in each group. Children rotated through five stations, each of which lasted six minutes.

Intervention session activities consisted of vision skills including, laterality and directionality, focusing, visual localization, peripheral awareness, and visualization. The children also completed specific visual-motor integration activities consisting of balance beam, balance board, trampoline, cross crawl and figure eight work. The visual skill activity ideas were replicated from an improving vision skills manual developed by Anne Roby (1997). The visual-motor integration activities were replicated from a Visual Motor Integration packet developed by Nancy Sornson (2003). Week one of intervention consisted of balance beam activities, bilateral circles, image movements, move the target, and pegboard patterns. The child was asked to walk forward and backward on the balance beam heel to toe, walk forward with bean bags on their hands, and walk forward while keeping their eyes focused on a specified target. During bilateral circles, the child stood facing the chalkboard while keeping their eyes focused on an X, and then they made circles with each hand at the same time. When making the circles the children were asked to draw one circle at a time, making sure to stop at the top before making a new circle. During image movements, the volunteer faced the same direction as the children and moved a body part. The children were asked to move the same body part that they saw the volunteer moving. After the children completed that task the volunteer faced the children requiring them to move the correct right or left body part. During move the target, the children were asked to focus on a popsicle stick that had a sticker on it. They held the popsicle stick and were instructed to move it horizontally, vertically, and diagonally. While moving the popsicle stick the child was instructed to keep their head still and to only move their eyes. During pegboard patters, the children
were given pegboards, golf tees, and a pattern made on a four by four inch paper was placed approximately six feet from the children. They were then asked to make the pattern they saw on their pegboards.

Week two of intervention consisted of balance boards, size emergence, mapping, follow the target, and focusing flexibility. Balance board activities consisted of tossing a bean bag to the child and they tossed it back, the child tossing the bean bag straight up in the air to themselves and catching it, and the child tossing the bean bag to themselves in an arch from one hand to the other and catching it. During balance board activities, the child was asked to always keep their eyes on the bean bag. During size emergence, the child was asked to focus on a dot that was placed in the middle of a half sheet of paper held approximately 14 inches from their nose. Surrounding the dot were squares of different sizes. The child was asked to put the squares in order according to size by placing numbers 1-9 in them, number one corresponded to the smallest square and number nine corresponded to the largest square. During mapping, the child was asked to walk through a map on the floor that was made of masking tape. While walking through the map the child had to verbally call out what direction they were turning. During follow the target, the child was asked to focus on a popsicle stick that had a sticker on it. The popsicle stick was then moved horizontally, vertically, and diagonally by the volunteer. The child was asked to keep their head still and to only move their eyes. During focusing flexibility, the child held a two by two inch letter chart that had a window on it so that only one row of letters was exposed at a time. An eight and a half by eleven word chart was placed on the wall approximately five feet away. The children took turns reading one letter from their letter chart and then looking up and reading one word from the word chart.

Week three of intervention included trampoline activities, form emergence, walk and count, roll the ball, and symbol reproduction. The trampoline activities consisted of
having the child jump in a steady pattern. Then the child was instructed to mimic arm movements that the volunteer did while standing in front of the child. Then while the child jumped they were asked to look at a piece of paper that had a different color circle in each corner. The volunteer would call out what color to look at and the child was asked to only move their eyes and to keep their head still. Then the child was asked to look at four different targets that were placed on the upper and lower left and right corners of a wall. The volunteer would call out what target to look at and asked the child to only move their eyes and to keep their head still. During form emergence, the child focused on the number one which was in the center of a half sheet of paper and numbers two through nine were arranged in a circle around number one. The child was asked to draw lines starting at number one to each consecutive number. After each line the child was asked to bring their marker back to number one. During walk and count, each child was asked to follow verbal direction commands given by the volunteer. For example the child was told to walk forward three steps, turn left and walk five steps, or turn right and walk one step. Directions were given one at a time. During roll the ball, two children were seated across from each other and two children were standing across from each other at a square table. The children who were standing would gently roll the ball to each other and the seated children were to follow the ball with their eyes while keeping their head still. During symbol reproduction, the children were asked to reproduce a series of designs which were placed on the chalkboard in front of them (none of the designs used during the intervention sessions matched any of the shapes from the Developmental Test of Visual-Motor Integration Skills).

Week four interventions included cross crawl and figure eight activities, thumbs up, hokey poky, bounce the ball, and directional arrows. During the cross crawl, each child was asked to raise their left knee to their right elbow and then their right knee to their left elbow. During the figure eight activities, each child was asked to walk on a figure eight.
pattern with was placed on the floor with masking tape. While walking on the pattern they were asked to focus their eyes on a target. During thumbs up, each child had a different color dot put on each of their thumbs and then they were asked to hold their thumbs up in front of their face and shoulder width apart. The volunteer then called out which color the child was to look at. The child was asked to only move their eyes and to keep their head still. During the hokey poky, the children listened to a tape of the hokey poky and were asked to listen and to follow the song. During bounce the ball, two children were seated across from each other and two children were standing across from each other. The children who were standing gently bounced the ball to each other and the seated children were asked to follow the ball with their eyes and to keep their head still. During directional arrows, each child held onto a small arrow chart and a large arrow chart was placed in front of each child on the chalkboard approximately ten feet away. Each child was asked to read one complete row from the large chart and then one complete row from the small chart.

Week five interventions included balance beam activities, target jumps; connect the symbol, pegboard tracking, and secret message. The balance beam activities were replicated from week one. During target jumps, the child was asked to hold two popsicle sticks which had different stickers on them at eye level and shoulder width apart. The volunteer called out which sticker the child was to focus on, the volunteer changed stickers every ten seconds. During connect the symbols, each child was given a sheet of paper that had arrows, people, and hands which all pointed in different directions. The child was asked to connect all of the arrows, people, and hands which were pointing right. During pegboard tracking, each child was given a pegboard that had a line drawn with chalk that ran horizontally through the middle. The child was asked to focus on the left side of the line and to pretend that there was a slow moving bug that was walking back and forth on the line. During secret message, a letter chart was placed on the wall.
ten feet from the children and in front of them was a blank piece of paper. The volunteer would call out a row and a column for the child to locate on the letter chart. That letter was then written on their paper. This format was followed until all of the letters of the secret message were completed.

Week six of intervention included balance board activities, pegboard maps, string tracking, two object sweep, and pegboard patterns. The balance board activities were replicated from week two. During pegboard maps, each child was given a pegboard which had an X marked in the middle. The children were instructed to make a map with golf tees beginning at the edge of the pegboard and working towards the X. Once the map was completed each child used their finger to point to each golf tee and when they came to a turn they had to verbally specify whether it was a right or left turn. During string tracking, each child sat approximately two feet in front of the volunteer. The volunteer held a 12 inch string horizontally at eye level in front of the child. The child was then instructed to pretend that they were watching a tight rope walker walk across the string. During two object sweep, two separate full pages were presented to the children. The first page had a clock at the top, two one inch circles at the bottom, and a dot between the two circles at the bottom. The child was instructed to point their nose at the dot in the center and to first look at the bottom circle on the right, after ten seconds they were asked to focus on the bottom circle on the left. The second page had a dot in the center and a frog on the left and right sides of the paper placed horizontally in the middle. The child was asked to keep their nose pointed at the dot in the center then to focus on the frog on the right, after ten seconds they were asked to focus on the frog on the left. Pegboard patterns were replicated from week one.

Week seven interventions included trampoline activities, mazes, fly the kite, special sweep, and focusing flexibility. The trampoline activities were replicated from week three. During the mazes, each child was given a laminated copy of a maze on which
they first traced with their finger, then they did the maze with a dry erase marker, and then they went back and stated at each turn whether or not it was a right or left turn. During fly the kite, each child was presented with two separate full sheets. The first sheet was a picture of a boy holding onto a vertical kite string and a dot was in the center. The second sheet was a picture of an airplane and an airplane hanger that had a diagonal line connecting them and a dot was placed in the center. Each child was instructed to keep their nose pointed at the dot in the center and to follow each line from bottom to top and top to bottom as if the object were moving. During special sweep, each child was presented with three sheets. The first sheet had a picture of a motor vehicle in each corner and a dot in the center. The second sheet had a picture of different kinds of baseball players in each corner and a dot in the center. The third sheet had a picture of different kinds of farm animals in each corner and a dot in the center. Each child was instructed to point their nose at the dot and then the volunteer would call out what object the child was to focus on. Focusing flexibility was replicated from week two.

Week eight interventions included cross crawl and figure eight activities, dot to dots, follow the target, thumb jumps, and mapping. Cross crawl and figure eight activities were replicated from week four. During dot to dots, each child was given a laminated dot to dot and a dry erase marker. The children completed the dot to dots and then verbally stated at each turn whether it was a right or left turn. Follow the target was replicated from week two. Thumb jumps were replicated from week four. During mapping, each child was presented with a sheet of paper that had a line drawn on it consisting of many turns. The children were instructed to follow the line with their finger and when they came to a turn they were asked to verbally call out whether they were turning right or left.
Data Analysis

A one-way analysis of variance (ANOVA) on the difference gain scores generated by the six variables of the Minnesota Handwriting Test (legibility, spacing, line, size, form and speed) was planned to compare the gains made by the intervention group with those of the control group. In addition, a one-way analysis of variance was conducted on the Beery Test of Visual Motor Integration (VMI) to compare gain scores between the intervention group and control group, and the difference between the supplemental tests of Perception and Motor skills. In addition, a Brown and Forsythe's Test for homogeneity of variance was completed to determine variance between groups. Alpha was set at .05.
CHAPTER IV

RESULTS

Univariate analysis of variance (ANOVA) on the difference gain scores generated by the six variables of the Minnesota Handwriting Test (MHT) showed no significant difference between the intervention and control groups (see Table 1).

Table 1. Univariate Analysis of Variance for the Six Handwriting Variables on the MHT

<table>
<thead>
<tr>
<th>Variable</th>
<th>df **</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legibility</td>
<td>.1401</td>
<td>.3357</td>
<td></td>
</tr>
<tr>
<td>Spacing</td>
<td>.8178</td>
<td>.7437</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>.8702</td>
<td>.1122</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>.5179</td>
<td>.8607</td>
<td></td>
</tr>
<tr>
<td>Form</td>
<td>.6677</td>
<td>.3719</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>.9195</td>
<td>.9902</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05 alpha level
** Between Group (3) for all six variables
   Within Group (61) for all six variables

There was a significant difference in gain scores in the intervention group when compared to the control group on the Beery Test of Visual Motor Integration (VMI). (see Table 2). In addition, univariate tests showed a significant gain in the intervention group on the supplemental Motor test on the VMI when compared to the control group. The
supplemental Perception test on the VMI showed no significant differences between groups.

Table 2. Univariate Analysis of Variance for the VMI and 2 Supplemental Tests of Perception and Motor

<table>
<thead>
<tr>
<th></th>
<th>df **</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMI</td>
<td>.0010</td>
<td>*</td>
<td>.2946</td>
</tr>
<tr>
<td>Perception</td>
<td>.6341</td>
<td></td>
<td>.9406</td>
</tr>
<tr>
<td>Motor</td>
<td>.0761</td>
<td>*</td>
<td>.9216</td>
</tr>
</tbody>
</table>

* p < .05 alpha level
** Between Group (3) for all three variables
   Within Group (61) for all three variables

The Brown and Forsythe Test for homogeneity of variance demonstrated no significant differences between the children in all four classrooms regarding distribution and variance indicating that the children were similar (Pr > F = .2691).
CHAPTER V
DISCUSSION

The purpose of this study was to determine if a visual motor integration intervention improved handwriting in first grade students. The study examined if the intervention improved handwriting legibility as measured by the Minnesota Handwriting Test (MHT). In addition, subjects were measured on the Developmental Test of Visual Motor Integration (VMI) that is strongly correlated in the literature with developmental components required for handwriting. Results did not support part of the first hypotheses of this study handwriting improvement was not noted in the intervention group based on MHT scores. Results did support a significant difference in gain scores for the intervention group when compared to the control group on the VMI. In addition, the intervention group showed significant gains on the Motor supplement of the VMI when compared to the control group.

Weil and Amundson (1994) found that kindergarten student’s performance on the Developmental Test of Visual Motor-Integration (VMI) was significantly correlated with the ability to copy 34 letters. The authors also found that letter copying ability was directly related to a child’s ability to successfully copy the first nine forms of the VMI. Other authors have supported a significant relationship between copying letter forms and scores on the VMI, (Amundson & Weil, 1996; Beery, 1999; Daly, Kelley, & Krauss, 2003; Daly, 2000; Kephart, 1971; Marr & Cermak, 2002; Schneck, 1996; & Tseng & Murray, 1994).

The improvements noted on the posttest scores of the VMI support the notion that the VMI is a sensitive measure of visual-motor integration skills, that is also supported by many other authors, (Beery, 1999; Daly, 2000; Daly, Kelley, and Krauss, 2003; Dankert,
Neilson (1997), found a moderate relationship between scores on the Minnesota Handwriting Test (MHT) and the VMI when comparing handwriting success with visual-motor skills. Peterson and Nelson (2003) found the MHT a sensitive measure of handwriting skills although visual motor skills were not a variable in their study.

The second hypothesis on the effect of the intervention on specific variables of handwriting as measured by the MHT and the VMI was also both supported and not supported. Analysis revealed that the variables of handwriting as measured by the MHT and the Visual Perception supplemental test of the VMI were not significantly impacted. Results also revealed a significant impact on the variables of handwriting as measured by the VMI and the Motor coordination supplemental test of the VMI. The Visual Perception supplemental test of the VMI most likely did not show significant score gains because this was not the focus of the intervention sessions.

Due to the large body of knowledge that exists regarding the relationship between handwriting and visual-motor integration skills, an assumption can be made that the improvement that the first grade students gained on the VMI indicate an improvement in skills needed for handwriting.

Gains in scores on the Motor coordination supplemental test of the VMI for the intervention may have occurred due to the nature of the test. The test is not merely a measure of motor coordination; it contains a visual-motor integration component. On this test the child is presented with a small picture of a shape (the same shapes that are contained on the VMI and Perception supplemental test). Below each presented shape is a larger version of the shape, so that the child is able to draw a line within the shape. Within each shape dots are placed at various locations, so that once the dots are
connected it will look like the small stimulus picture. The child is asked to make sure that they connect all the dots and to stay inside the lines of the shape. Starting at shape 14 the dots are taken away and the child is asked to draw lines within the shape to make it look like the stimulus picture. This test is very similar to completing a dot to dot, which is considered a visual-motor integration task.

Limitations

There were several limitations to this study. One limitation was the different scoring methods used for the Minnesota Handwriting Test (MHT) and the Developmental Test of Visual Motor Integration Skills (VMI) and its two supplemental tests. The MHT is a much more complex test to score than the VMI; therefore it may not have been a reliable measure for this study. Test-retest and interrater reliability studies completed on the MHT prior to the experiment may have strengthened the MHT scores and determine if it was a reliable measure for this population. The eight weeks of intervention may have been a limitation because a longer period of time between pre and posttests on the MHT may have picked up greater gains.

Implications for Further Research

The results of this study indicate that more research is needed in order to determine if using visual-motor integration interventions with children who have poor handwriting will result in improved handwriting ability. Supportive literature exists regarding the relationship that exists between visual-motor integration skills and handwriting, but most studies are correlational. To assist in determining if treating poor handwriting through visual-motor integration interventions is successful, outcome studies need to be completed. More research is needed to determine whether or not the Minnesota Handwriting Test (MHT) is a valid measure of handwriting skills. Research could also be completed to determine if the MHT can be used to measure pre and posttest gains in visual-motor integration skills. Visual-motor integration skills are not the only skills
needed to be successful with handwriting, so it is critical that other studies be completed that will help differentiate necessary skills from unnecessary skills. Once those skills are determined, outcome studies can determine whether or not the interventions are successful.

Conclusion

The results of this study identified that visual-motor integration skills, as foundations for writing can improve through visual-motor integration intervention. Results did not show improvements on the Minnesota Handwriting Test after completion of the visual-motor integration intervention sessions. More research is needed in this area to determine exactly what relationship exists between handwriting and visual-motor integration skills.
Appendix

Approval Letter From the Human Subjects Institutional Review Board
Date: September 17, 2003

To: Cindee Quake-Rapp, Principal Investigator
    Amber Kapnick, Student Investigator for thesis

From: Mary Lagervey, Chair

Re: HSIRB Project Number 03-08-01

This letter will serve as confirmation that your research project entitled "Visual-Motor Integration Skills Impact on Handwriting" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 20, 2004
BIBLIOGRAPHY


<http://www.lifetimeeyecare.net.documents/process.html>