GRIP PATTERN DEVELOPMENT IN EARLY WRITERS:

A STUDY OF FLIP CRAYONS

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To the Dean of the Graduate School:

I am submitting herewith a thesis written by Aimee Michelle Sidhu entitled "Grip Pattern Development in Early Writers: A Study of Flip Crayons." I have examined this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts with a major in Occupational Therapy.

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ABSTRACT

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GRIP PATTERN DEVELOPMENT IN EARLY WRITERS:
A STUDY OF FLIP CRAYONS

MAY 2010

The purpose of this study was to examine the effects of Flip Crayons, developed by *Handwriting Without Tears*, on grip pattern development, variability of grip and tracing accuracy within 4-year-olds. Thirty-nine participants from California and Colorado, with and without identified disabilities, were tested in an pre-test/post-test format over an 8-week trial. Data were analyzed for grip development, variability of grip and tracing accuracy. Statistically significant differences between the treatment and control groups were noted at pre-test for grip selection. Variability of grip increased over the eight-week trial period for both groups. There was no statistically significant change in tracing accuracy. Based on the results, Flip Crayons do not make an impact on student grip development, variability of grip or tracing accuracy when provided within the classroom as the only writing implement. Further testing is appropriate to determine the use of Flip Crayons within the classroom.

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CHAPTER I

INTRODUCTION

Within the public schools, kindergarten students are expected to begin Journal Writing and to provide written output within the classroom beginning the first day of school. Some researchers estimate that students spend up to 85% of the school day performing fine motor tasks, of which at least 65% is writing (Amundson & Weil, 2002). These 4-, 5-, and 6-year-olds present with a variety of grip patterns when holding and utilizing writing utensils, such as crayons, pencils and markers. Researchers have spent the last twenty years providing operational definitions for grip patterns of young children and their impact on developing writers (Erhardt, Beatty & Hertsgaard, 1981; Rosenbloom & Horton, 1971; Schneck & Henderson, 1990). Most researchers agree there are a variety of mature, dynamic grip patterns that promote overall legibility and efficiency (Dennis & Swinth, 2001), in addition to some inefficient and maladaptive grip patterns (Schneck, 1991; Selin, 2003). Within the research, little has been studied related to the early development of hand skills to promote functional grip patterns with standardized protocols regarding length and diameter of writing utensils placed in hands. Tseng and Cermak (1993) refer to changes in diameter as an ergonomic approach that bypasses a maladaptive (typically fisted) grip pattern and encourage further research in this area.

Handwriting Without Tears® has developed the Flip Crayon (patent pending), with the assumption that use of these small crayons (2-3/8" length with two colors, one

on each end, 3/8" diameter) will promote foundational grip patterns for young beginning writers. The purpose of this research is to examine the use of small 'flip crayons,' by Handwriting Without Tears® to determine their effectiveness on grip pattern development within the classroom setting.

CHAPTER II

REVIEW OF THE LITERATURE

Grip Development

Expectations of Early Writers

Currently within the public school system, kindergarten students are expected to begin handwriting as part of the literacy curriculum from day one. According to the California Department of Education (1997) English-Language Arts State Standards, Kindergarten students are expected to legibly write words and brief sentences (p.7; Writing Standard 1.0), including writing all 52 letters of the alphabet in upper and lowercase without prompts, utilizing age-appropriate size and spacing (p.7; Writing Standard 1.4). Within the general education classroom, this often is accomplished by using strategies promoted through language arts curricula, such as journal writing and invented/phonetic spelling. These curricula are often not paired with direct handwriting instruction or development of pre-writing requisites, including fine motor readiness skills necessary to begin writing activities. Some researchers estimate that students spend up to 85% of the school day performing fine motor tasks, of which at least 65% is writing (Amundson & Weil, 2002), while others place it closer to 31-60% of the school day (Feder & Majnemer, 2007). Knowing this high level of expectation within the public schools, it is important to understand the developmental readiness skills required to be able to successfully write.

Long standing research in the area of visual motor development suggests that students are not ready to begin the writing process until they are able to copy the first nine basic shapes of the Developmental Scale of Visual Motor Integration (Beery, 1997). Additional research supports the development of necessary fine motor and in-hand manipulation skills in a developmental, chronological sequence, as necessary to demonstrate appropriate handwriting readiness (Amundson & Weil, 1996; Benbow, 1995; Case-Smith, 1994; Goodgold, 1983; Selin, 2003). Many occupational therapists have looked specifically at the development of grip patterns as it relates to an early writer's ability to manipulate a writing utensil to imitate, copy and independently form meaningful shapes within a variety of contexts.

Researchers agree that a wide a variety of components make up the process of handwriting and should always be considered in their entirety when looking at students with handwriting problems (Dennis & Swinth, 2001; Feder & Majnemer, 2007). Estimates of handwriting problems in children within the school system range from 10 to 30% (Karlsdottir & Stefansson, 2002) and can cause later academic difficulty. For example, Summers (2001) studied kindergarten students and found that form errors (additions, deletions, or misalignments) predicted later academic abilities in reading and handwriting. Sandler et al. (1992) found that children with handwriting problems had a tendency towards lower mathematics achievement, low verbal intelligence, and increased difficulty with attention.

Development of Grip Patterns

Early writers, four-to-six years old, present with a variety of grip patterns when holding and utilizing writing utensils, such as crayons, pencils and markers. Researchers have spent the last thirty years providing operational definitions for grip patterns of young children and their impact on developing writers (Erhardt, 1974; Rosenbloom & Horton, 1971; Schneck & Henderson, 1990). The development of grip has been studied as an important fine motor milestone for children. According to Mary Benbow (1995) any grip pattern developed over time forms a motor map, whether it is efficient or inefficient, which cannot be readily changed. This belief has led occupational therapists and teachers to focus their energy on developing efficient and functional grip patterns at an earlier age. Amundson & Weil (2002) suggest that by the beginning of the second grade, it may become too stressful on the student to attempt changing a grip pattern.

According to Rosenbloom and Horton (1971), grip often is expected to develop in the following way, beginning at 12 weeks of life. The ulnar (power) side of the hand, including the pinky and ring finger, develop first, and then attention shifts to the radial side of the hand, where precision is developed. Specifically, infants begin with a primitive squeeze at 20 weeks and begin to adduct the thumb at approximately 28 weeks old. As grip continues to develop, the neat pincer with slight wrist extension emerges at 44 weeks, allowing the child to begin to pick up small objects as they are exploring their environment. A true opposed grip emerges at 52 weeks, with the beginning stages of a static tripod grip often emerging between 3 and 4 years old.

Current literature suggests, based on early grip pattern development, one should consider and evaluate the differences between coloring (requiring a 'power grip') and drawing (requiring a 'precision grip') (Schneck & Henderson, 1990). The original idea of power and precision grips came in 1956 with Napier's research on the functional outcomes of the purpose of the grip. Practitioners have long understood that mobility builds on stability, thus making the power grip a predecessor to the precision grip (Vainio, Tucker & Ellis, 2007). Even within a coloring task, we may need to consider that the edges require more precision and the middle more power, depending on the picture. Selin (2003) in her book *Pencil Grip: A Descriptive Model and Four Empirical Studies* discusses the development of power and precision grips. The power grip is often defined as stabilizing the utensil, often utilizing more of the palm of the hand. In a precision grip, the dynamic intrinsic muscles are required to move the utensil small distances, often utilizing more thumb to finger opposition. These prehensile skills are key elements in the development of handwriting accuracy and fluidity.

In an initial research study from the Netherlands looking at the underlying mechanisms of handwriting difficulties in primary school children, Volman, van Schendel and Jongmans (2006), studied a small sample size (29 children with handwriting problems and 20 control) with initial look at fine motor skill development, as it relates to handwriting quality. The study results indicate that both unimanual dexterity, as tested on the Movement ABC (Henderson & Sugden, 1992) and motor coordination, as tested on the Motor Coordination subtest of the Developmental Test of Visual Motor

Integration (Beery, 1997), provide the primary explanation for handwriting problems. Despite the small sample size, this research reiterates the underlying assumption that deficits in handwriting quality are directly affected by underlying deficits in fine manual coordination.

Development of in-hand manipulation skills plays an important role in the development of grip patterns. According to Charlotte Exner (1990), in-hand manipulation skills also follow a typical progression, with target skills occurring during development of other fine motor skills. Specifically, palm-to-finger translation typically occurs between 2 and 2-1/2 years old, utilizing the precision side of the hand. However, when stabilization is required in palm-to-finger translation, utilizing both sides of the hand together, requiring a more sophisticated separation of the sides of the hand, this skill often does not develop until a child is 6-7 years old. In other in-hand manipulation skills however, such as vertical shift and rotation, development occurs more simultaneously between 3 and 3-1/2 years old.

When compared to grip pattern development, these skills can be matched to coincide with dynamic patterns of intrinsic muscle development. In a study conducted in Israel with 35 - 3rd and 4th grade students, analysis was done of proximal and distal muscle use during handwriting tasks utilizing surface electromyography at the upper trapezius and the intrinsic muscles of the thenar eminence (thumb muscles) (Naider-Steinhart & Katz-Leurer, 2007). The results indicated that muscle use is significantly less variable within the upper trapezius (shoulder) when compared to the thumb muscles. This

study increases the research pointing towards necessary development of intrinsic muscles within the hand to promote efficient handwriting.

In further study on the functional development of grip patterns, Schneck and Henderson (1990) looked at 320 children ages 3-0 to 6-11 without underlying disabilities to help operationally define the development of grip through childhood. This study included both coloring and drawing tasks as part of the measurement criteria and specifically identified the dynamic and lateral tripod as the most common mature grip patterns of older children within the study (90%). Continued study of children without underlying disabilities with and without handwriting problems was conducted by Schneck in 1991. Grip patterns within this study were scored utilizing a 5-point scale, developed by Schneck and utilized for comparison purposes in later studies specifically targeting developmental grip patterns.

Most researchers agree there are a variety of mature, dynamic grip patterns that promote overall legibility and efficiency (Dennis & Swinth, 2001), in addition to some inefficient and maladaptive grip patterns (Benbow, 1995; Schneck, 1991; Selin, 2003). In subsequent research, Mary Benbow (1995) also identified types of grip patterns seen in emerging writers and added to the grips discussed by Schneck and Henderson (1990) by specifically identifying efficient and inefficient grips. Within her definitions, Benbow (1995) reiterated that there is more than one functional grip, adding the quadropod to the dynamic tripod and the adapted (lateral) tripod. In looking at maladaptive or inefficient grip patterns, Benbow (1995) discussed the lack of intrinsic muscle skill development

during use of the thumb wrap, the thumb tuck, the transpalmar grip, the transpalmar interdigital brace, the supinated grip and the index grip. However, as identified in Burton and Dancisak (2000), the use of the Schneck 5-point scale has been studied for good inter-rater reliability between therapists within the field. The 10-point descriptors were considered less reliable in this study of 60 preschool students between multiple raters. This ongoing discussion regarding efficient versus inefficient grip patterns have emerged in the past two decades. Primary consistencies within the literature do indicate that grip patterns based on stability, rather than dynamic use of intrinsic hand muscles produce inefficient, fatiguing and sometimes painful grip patterns that may cause students difficulty within the school setting.

External Factors Affecting Grip Development

In addition to discussion regarding grip patterns, some current research has begun to suggest the relationship between early development of hand skills and environmental factors, such as length and diameter of writing utensils (Readdick, 1994; Schneck & Henderson, 1990; Tseng & Cermak, 1993; Weinraub, 2006). Tseng and Cermak (1993) refer to changes in diameter as an ergonomic approach that bypasses a maladaptive (typically fisted) grip pattern and encourage further research in this area. Weinraub (2006), as part of her un-published master's thesis, explored the use of broken crayons as a practical adaptive strategy to promote the development of a mature tripod grip utilizing Schneck & Henderson's (1990) 10-developmental stages of grip pattern. This study included 44, 4- and 5-year-olds observed over the course of 6-weeks, with the

experimental group being given broken crayons and the control group utilizing whole crayons during coloring activities. The results indicate a stronger benefit (higher scores obtained on the grip developmental scale) in 4-year-olds, as compared to 5-year-olds, of a mature tripod grip when utilizing a broken crayon. This suggests that intervention at a younger age may be more beneficial, when motor maps have not yet begun to solidify in the developing writer.

As suggested earlier, the nature of the task, coloring, drawing or writing, may also impact the grip pattern and performance of the child (Schneck & Henderson, 1990; Selin, 2003). Use of the power or the precision grips impacts the type of grip chosen (Napier, 1956; Schneck & Henderson, 1990; Selin, 2003). Contextually, preschool students are provided with a variety of coloring and pre-writing tasks within the classroom to explore use of writing implements. A variety of utensils is often presented, including crayons, markers, and markers, of varying lengths and diameters (Amundson & Weil, 2002). Initial research has begun looking specifically at diameter of writing utensils as it relates to grip development (Readdick, 1994). Within Readdick's (1994) study, a small sample of children (20 toddlers and preschoolers) were found to utilize identical grips on varying sizes of writing utensils, regardless of age. There was some correlation, however, to exposure and use of specific writing implements within the home that promoted overall grip development (Readdick, 1994), further indicating a need for both adult demonstration and exploration to develop mature grip patterns.

Flip Crayons by Handwriting Without Tears®

The Handwriting Without Tears® (HWT) program was developed by an occupational therapist, Jan Z. Olsen, beginning in the late 1970's as a response to concerns her son's 1st grade teacher was having with his handwriting development (Olsen, 2008). As part of the development of the HWT developmental curriculum, the Get Set for School Pre-K curriculum was developed in 2002 to support the multisensory development of handwriting readiness from a young age. This developmental approach provides teachers, parents and therapists with specific tools and strategies to implement that directly promote pre-writing readiness. The Flip Crayons (patent pending), were specifically developed to promote and develop grip fine motor skills (HWT, 2008). The crayon itself is a two-sided crayon measuring 3/8" in diameter and 2-3/8" in length, with two different colors on each end. HWT provides this specific statement within the Flip Crayon box upon purchase:

> "Flipping the crayon develops hand coordination and fine motor skills. It is our belief that pencil grip habits start at an early age and are affected by the tool provided to the child and the amount of adult demonstration. Many children have been given big, fat crayons to use. As a result, awkward "whole-hand" fisted grips developed. Big crayons and "whole-handed" grips are fine for two-year-olds. That's it! As children mature, so must their grip and so must the tools they use. With proper tools and adult

demonstration we can break the trend of 'poor grips' and make coloring and writing easier for children!" (HWT, 2008)

The purpose of this research was to examine the use of small Flip Crayons,' by HWT to determine their effectiveness on grip pattern development within the classroom setting.

Statement of the Problem

According to current research, the development of grip and grip patterns is important to the overall development of handwriting accuracy and efficiency. A lack of research continues to exist regarding the impact of specific interventions on the overall development of grip patterns specifically for early writers, with and without disabilities, within the preschool setting.

Purpose of the Study

The purpose of this research was to examine the use of small Flip Crayons by HWT to determine their effect on the type of grip pattern development, variability of the grip, and handwriting accuracy of 4 to 4½ year olds within the preschool setting. The research question is do Flip Crayons have an effect on type of grip pattern used, variability of grip, and tracing accuracy?

Definitions of Terms

Schneck & Henderson's (1990) 5-point rating scale (Appendix A) terminology will be utilized to specifically identify individual grip patterns.

Flip Crayons (HWT, 2008): A two-sided crayon measuring 3/8" in diameter and 2-3/8" in length, with two different colors on each end.

Map wheel: A small, compass-like device that is used to measure length of a drawn line.

BOT-2 Overlay: A transparency developed by the test publishers for the Bruininks-Oseretsky Test of Motor Proficieny-2nd Edition (Bruininks & Bruininks, 2005) indicating 1/16" from the line both to the inside and the outside.

Primitive grips: Five grips which make up the first group of grips in the Schneck and Henderson (1990) scale; usually observed from three to five years of age.

Transitional grips: Three grips making up the second group of grips in the Schneck and Henderson (1990) scale. All three grips have the forearm resting on the table.

Mature grips: Two grips identified in the 5-pt grip rating scale as tripod grip patterns.

Primary researcher: Refers to the on-site researcher providing direct instruction to the child.

Secondary researcher: Refers to the distance researcher interpreting grip pattern pictures for reliability utilizing the 5-pt grip rating scale (Appendix A).

Limitations and Assumptions

Within this research study, the researchers assume, given a sampling of an average preschool day, students will be exposed to at least fifteen minutes of handwriting activities (where pencil or crayon is utilized) during their school day. Due to the nature of preschool services across districts and service areas, students may or may not have exposure to other writing implements during the course of their typical week, including Flip Crayons. Handedness will be noted, but changes in handedness will not be part of exclusion criteria and may affect grip patterns. The population is drawn from three to

seven classrooms at each school site and may not be representative of the greater preschool population, thus the study is limited by a convenience sampling. All participants in California within the preschool setting are designated with developmental delays, which may or may not include delays in fine motor development. It is assumed that the data collected is representative of each child's best effort.

CHAPTER III

METHODOLOGY

This study was conducted in two settings by two principle investigators. The method and results outlined in this document is replicated in the thesis by May (2010). A quasi-experimental, repeat measures design was used in this study. Participants were assigned to one of two groups, a control group, and an experimental group consisting of both general and special education children based on demographic and convenience samples. Institutional Review Board at Texas Women's University reviewed and gave approval for the study as well as consent from the Colorado and California school districts where the students attend preschool.

Participants

Thirty-nine children ages four to four and a half participated fully within the study from April to June 2009. The children were recruited from two school districts, one in California and one in Colorado. Twenty children (sixteen boys and four girls) attended school in Irvine, California. All California participants were identified with developmental delays, receiving specially designed instruction through the enrollment in special day classes. Nineteen preschool students, (four girls and fifteen boys) attended school in Cherry Creek, Colorado and were drawn from three separate blended classrooms that included children with and without disabilities. All the Colorado

preschoolers received intervention from both general and special education teams. Table 1 provides more detailed demographic information regarding the participants.

Table 1

Participant Demographic Information

	Colorado	California	Combined
Male	15	16	31
Female	4	4	8
With disabilities	5	20	25
Without disabilities	14	0	14
Treatment group	11	12	23
Control group	8	8	16
Treatment with disabilities	2	12	14
Control with disabilities	3	8	11

Inclusion criteria were that children be between the ages of four and four years six months participating in half-day (two-and-a-half to three hours per day) preschool settings. Children with and without identified disabilities were included within the study. The number of participants with identified disabilities was twenty-five or 64% of the total number. Of these, 100% of the participants with disabilities were from California and 26% from Colorado. Types of disabilities identified were based on California and Colorado educational eligibility categories, including developmentally delayed and preschooler with a disability. Fourteen of the participants had no identified disability and

represented 36% of the total number and constituted 74% of the participants from Colorado.

Exclusion criteria were the presence of musculoskeletal impairments, including children with Downs' syndrome and cerebral palsy. In addition, no children with recent hand trauma were included.

Instruments

Flip Crayons (a two-sided crayon measuring 3/8" in diameter and 2-3/8" in length, with two different colors on each end) were utilized in the experimental classrooms as the primary writing utensil. Schneck and Henderson's (1990) 5-point grip scale (Appendix A) was utilized for definition of grip development stages. This rating scale identifies grip patterns, assigning numbers one through five to ten different commonly observed grips in developmental sequence. For the purposes of tracing, six, 2" circles on an 8½"x11" piece of white paper were printed on a piece of paper. According to the Beery Test of Visual Motor Integration - 4th Edition (Beery, 1997), the circle is a developmentally-appropriate shape for students age 3 and up, allowing shape formation to not be a confounding variable in the child's overall accuracy. The Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) (Bruininks & Bruininks, 2005) overlay guide was utilized to judge deviation from a 1/16" line for the 2" circle traced in each trial. A map wheel was used to measure the child's accuracy along the line. Digital cameras (Sony Cybershot) provided pictures of each child's grip over 6 trials at start and end of research. Standard number 2 pencils (Papermate) were utilized within the testing procedure.

Procedure

Informed, signed parental consent was obtained to begin this study. Children meeting study criteria were invited to participate in the study by both written and verbal invitation. The primary researcher offered to meet with the parents, as necessary, to review the purpose of the research and provide an opportunity to have their questions answered. Prior to data collection, the researchers exchanged pictures of grips with ratings to increase reliability and validity of data collection and interpretation. The same procedural safeguards were used for the map wheel instrument.

Classrooms were divided into treatment or control. Before data collection, teachers were asked to state their preference in participation, whether as a treatment or control classroom. In California, four classrooms were identified as control and three as treatment classrooms. In Colorado, one classroom was the control classroom and two were treatment classrooms. Teachers in the control group were instructed to continue providing ongoing handwriting and fine motor instruction to their students at least fifteen minutes per day, with no changes made to the typical writing utensils provided to their students. Teachers in the treatment classrooms were instructed to specifically present Flip crayons during fifteen-minute writing lessons as the only writing implement, in addition to replacing other writing implements in the Writing Center (an environment within the classroom for students to explore writing without guided teacher instruction). Craft utensils, such as paintbrushes and markers specific to art projects, were not removed from the treatment classrooms.

Each child met individually with the primary researcher in a quiet corner of the classroom. The child was given a piece of white, 8-1/2"x11" paper (Appendix B) with six 2" circles printed on it. Each child was presented with a #2 standard pencil at midline with the tip pointing toward them and asked to trace over the top of the circle. A digital photograph was taken of the child's grip as they held the writing utensil and was tracing the circle. The photograph was assigned a random number to ensure anonymity and recorded on the Observation Schedule (Appendix C). The child was then be asked to put down the pencil and was presented with another standard #2 pencil at midline with the point facing toward them. Six photographs in total were taken of the child's grip pattern as the child traced each circle on the page. This concluded the pre-test portion of the research.

For the subsequent eight-weeks, children within the control group continued to utilize a variety of writing implements, as typically occurs within their classroom setting. Classrooms with children in the experimental group were given only Flip Crayons to replace other writing implements within their classroom. At the end of the eight weeks, each child completed identical testing as described above with the primary researcher individually within their typical classroom setting.

Data Analysis

Data were collected at two sites by each primary researcher. For inter-rater reliability in identifying grip patterns prior to data collection, the researchers exchanged and scored a sample set of pictures of grip patterns to practice utilizing the 5-pt grip

scale. Agreement was 100% with 5 sample pictures. After data collection, to create blind scoring conditions, digital pictures collected by the primary researcher were electronically mailed to the secondary researcher for scoring and vice versa. Accuracy was measured by deviation from the line by the primary researcher using the BOT-2 overlay in combination with the map wheel.

The researchers used Microsoft Excel 2007 and SPSS 8.0 Guide to Data Analysis computer software. Descriptive statistics, binomials, chi squares, Mann-Whitney U tests, and on Wilcox Signed Rank Tests were used to compare data with a .05 level of confidence. Data analysis sought to answer the following research questions:

Research Questions: Were the groups different at pretest in grip type, grip variability, and tracing accuracy? Were there changes within each group from pretest to posttest in grip type, grip variability, and tracing accuracy? Were the groups different at posttest in grip type, grip variability, and tracing accuracy?

CHAPTER IV

RESULTS

Grip

Frequency distribution data show type of grip selected, among the children in the control group and the treatment group (Table 2).

Table 2

Frequency Distribution for Grip Selection in Treatment and Control Groups

Grip Choice	1	2	3	4	5
Control Group					
Pre-test	0	40	25	20	11
Post-test	0	6	19	47	24
Treatment Group					
Pre-test	0	21	48	56	13
Post-test	1	16	48	52	20

Statistical comparison of frequency distributions between the treatment and control groups at pre-test indicate a discrepancy between the groups ($\chi^2(3, N = 39) = 57.88$ (3), $p < .01$). Due to this difference, further analysis for grip type comparing the treatment and control groups was not made.

Analyzing the groups independently between pre- and post- test, the treatment group showed no significant changes in frequency distribution ($\chi^2(3, n = 23) = 6.126, p = 1.06$). Within the control group further analysis does indicate statistical significance ($\chi^2(3, n = 16) = 88.76, p < .01$). Grip development of participants in the control group reveals a shift in grip choice to more mature grip selections based on Schneck and Henderson's 5-point scale (Appendix A). Children in the control group were primarily utilizing primitive grips at pre-test and more mature transitional grips at post-test.

Variability of Grip

Grip patterns were designated consistent if the same pattern was used for all six circles. Grip patterns were designated as variable if more than one pattern was used within the six circles. At pre-test, the control group participants demonstrated 75% consistency of grip choice and the treatment group participants demonstrated 74% consistency of grip choice. Both groups were similar at pretest in their grip consistency.

Between pre-test and post-test, the control group demonstrated a change from 75% of the participants remaining consistent to 62% of the participants remaining consistent in their grip choice. When analyzed with a binomial test, this represents a statistically significant difference between pre- and post-testing ($p = .002$). Likewise, in the treatment group, 74% of the participants demonstrated consistency of grip at pre-test and 48% demonstrated consistency at post-test. Using a binomial test demonstrates a statistical significance ($p = .015$). However, when comparing the control and treatment groups with consistency of grip choice at post-test, no statistical difference was noted

using a binomial test ($p = .577$). Participants in both groups increased the overall variability of their grip selection over the course of the eight-week trial period.

Accuracy

Accuracy was determined by utilizing the map wheel for deviation from the circle line. The number of inches drawn within 1/16" of the line was measured. Table 3 shows mean and standard deviation in number of inches for each group.

Table 3

Accuracy: Mean and Standard Deviation at Pre- and Post-test

	Pre-test	Post-test
Treatment group		
Mean	2.51	2.52
Standard deviation	1.64	1.65
Control group		
Mean	1.80	1.66
Standard deviation	1.53	1.49

Statistical analysis, using the Mann-Whitney U test, indicated no statistical significance between both groups at pre-test ($z = -.47, p = .638$). Within the treatment group, no statistical significance was noted between pre and post-test accuracy, utilizing the on Wilcox signed ranks test ($z = -.47, p = .638$). Additionally, no statistical significance was noted in the control group ($z = -1.57, p = .116$). In determining whether

there was a difference between the treatment and control groups at post-test, the Mann-Whitney U test ($z = -1.61, p = .107$) indicates there was no statistical significance noted. Overall, participants in both the control and treatment groups made little or no change in tracing accuracy over the course of the eight-week trial period.

CHAPTER V

DISCUSSION

Based on the results and data analysis, Flip Crayons do not appear to make a direct impact on student grip development, variability of grip or tracing accuracy when provided within the classroom as the only writing implement. However, flaws within the research design appear to have directly impacted the overall study. The original design of this study included four groups, rather than two, dividing both the treatment and control groups into children with and without disabilities. However, due to the convenience sampling of the study in the Colorado and California school districts, in addition to the narrow age span chosen by the researchers based on review of current literature, the group sizes were unable to be generated practically. This impacted the overall results and analysis of the study, as further determination regarding disability as a contributing factor was not able to be ascertained. The following discussion will attempt to answer questions raised by the results and to identify the strengths and limitations of the study, specific to grip development, variability of grip and tracing accuracy.

When considering use of tools (specifically Flip Crayons) for grip development, there was no direct intervention by the researchers or occupational therapists related to use of the Flip Crayons or general grip development patterns. Teachers were instructed, if in the experimental groups, to utilize only Flip Crayons during this time, however it was impossible to prevent use of other typical classroom utensils, such as markers, paint

brushes, and colored pencils during other classroom times. Likewise, within the control group classrooms and in the homes of all children, it was unknown whether Flip Crayons were being utilized and with what consistency. In both school districts, the Handwriting Without Tears has been introduced and utilized by teachers as an approved curriculum, allowing teachers flexibility in use of the *Get Set for School* (HWT, 2008) preschool program for early writers, which includes the potential use of Flip Crayons as part of the typical curriculum. This lack of control over use of Flip Crayons within the classroom, including a lack of direct intervention by occupational therapists or specific training regarding the use of Flip Crayons may have contributed to uncontrollable variables within this study.

In addition the researchers made the assumption that instruction was provided by classroom teachers at a minimum of fifteen minutes each school day. Due to IRB approval and timeframes within the school districts, the experimental trial took place primarily between Spring Break and the end of the traditional school year. Therefore, much of the post-testing was completed near the end of the school year, possibly contributing to the decreased handwriting accuracy scores noted in both groups. This time frame may have also included an increase in field trips and class parties, thus reducing the potential time for writing during the course of the school day. Further contributing factors may have been related to the Colorado system being on a year-round calendar, with children attending school for nine-weeks with three weeks off between sessions.

Upon analysis of both groups, it was evident that the two groups were not comparable, based on statistically significant differences at pre-test specifically related to grip development. At pre-test, the treatment group demonstrated more transitional grip patterns, according to Schneck and Henderson's 5-point grip scale (Appendix A), while the control group demonstrated more primitive grip patterns. If we consider the scale to provide ranked data, with each increased number representing a more mature grip pattern (one through five), the treatment group at pre-test had a mean of 3.45, where the control group had a mean of 3.01. Accordingly, only the control group made statistically significant gains in maturity of grip development over the course of the eight-week trial period. Post-test mean data suggests that the groups both reached the transitional grip stage identified by Schneck and Henderson (1990) at the end of the eight-week trial period. The difference in the number of participants with disabilities within the treatment group, as compared to the control group (14/23 or 61% and 11/16 or 69%) may have contributed to this discrepancy. In addition, the researchers also allowed teachers to decide which group they would be willing to participate in, treatment or control, prior to receiving informed consent and knowing which participants would be in each classroom. This caused the overall numbers within the control group (16) to be less than the total number within the treatment group (23) based on consent and participation. Literature review also suggests that this age range (four to four years and six months) is a time of significant growth and development for grip patterns from primitive to transitional grips

(Amundson & Weil, 2002; Benbow, 1995; Case-Smith, 1994; Goodgold, 1983; Selin, 2003).

Statistical analysis suggests that overall students increased the variability of their grip (choosing more than one grip) over the course of the trial period, equally between the treatment and control groups. This suggests that four to four-and-a-half year olds have variable grip patterns within an eight-week time frame. It appears to be a time of experimentation for children as they learn to adopt a more mature grip. While teachers and clinicians may encourage and model transitional and mature grip patterns, each child may need to experiment and develop ongoing underlying dynamic dexterity within the fingers in order to demonstrate consistency in their grip pattern selection.

Within this study, accuracy was determined utilizing the developmentally-appropriate circle taken from the Beery Visual Motor Integration Test (Beery, 1997). In addition, the map wheel was used in conjunction with the BOT-2 overlay in order to determine a child's accuracy in relationship to the line. Following pre-test completion, both researchers noted that many participants demonstrated accuracy over less than half the circumference of the circle. When selecting this tool, the researchers considered a variety of options, including coloring, a maze (similar to that used in the Beery VMI Motor Coordination subtest) and a line, however felt a circle would provide adequate data for the purposes of this study. There was not a significant difference between the treatment and control groups at pre-test or post-test, nor were there any differences between groups over the course of the trial. This suggests that accuracy was not a factor

to be considered within this study, as students did not make significant gains over the course of eight-weeks, either in the control or the treatment group. It may also lead to further consideration of the power versus precision grip development as part of the typical development of grip patterns.

For occupational therapists and teachers working with early writers, the implications of this study suggest that Flip Crayons did not have any effect on grip patterns, variability of grip or tracing accuracy. This may be a result of the significant limitations of this study, such as convenience sampling and age range of participants, lack of direct intervention in the use of Flip Crayons, and the length of the study. However, this does not preclude the possibility of the use of Flip Crayons as one of many treatment strategies to utilize with individuals and small groups to promote appropriate grip pattern development. More specifically, direct instruction within the classroom and with parents regarding the typical developmental sequence of grip patterns is a key component to successful use of any tool. Clinicians should also consider the ongoing variability of grip patterns which ultimately leads to more mature patterns at an older age, allowing flexibility and growth of patterns to emerge over time. Current research regarding handwriting suggests that children learn best through first imitation, then copying, and finally independent writing (Olsen, 2008). Imitation of mature grip patterns, possibly through the use of small writing implements such as Flip Crayons, may benefit students with and without disabilities, but further research is needed to ascertain this association.

Ongoing research in the area of grip development and handwriting accuracy appears to be warranted based on this research. Specifically, a randomized control trial utilizing direct instruction within the classroom setting may provide more information regarding use of small implements, such as Flip Crayons, and their impact on grip development, variability of grip and tracing accuracy. No conclusive evidence can be drawn. The results do however suggest that access to a variety of writing implements within the classroom supports overall grip pattern development.

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APPENDIX A

Operational Definitions of Grip Positions

Operational Definitions of Grip Posture and Score on the Pencil-Grip Assessment

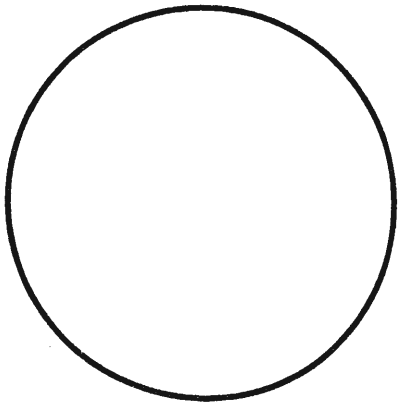
Score	Definition
1	*Radial cross palmar grip* Pencil positioned across palm projecting radially, held with fisted hand, forearm fully pronated, full arm movement (Morrison, 1978).
2	*Palmar supinale grip* Pencil positioned across palm projecting ulnarly, held with fisted hand, wrist slightly flexed and supinated away from midposition, full arm movement (Erhardt, 1974).
2	*Digital pronate grip, only index finger extended* -Pencil held in palmar grip with index finger extended along pencil toward tip, arm not supported on table, full arm movement (Morrison, 1978).
3	*Brush grip* Pencil held with fingers with eraser end of pencil positioned against palm, hand pronated with wrist movement present, whole arm movement, forearm positioned in air.
3	*Grip with extended fingers*-Pencil held with fingers, wrist straight and pronated with slight ulnar deviation, forearm moves as a unit.
4	*Static tripod grip* Pencil stabilized against radial side of third digit by thumb pulp with index pulp on top of shaft. thumb stabilized in full opposition, wrist slightly extended and hand moves as a unit, pencil rests in open web space, forearm resting on table (Rosenbloom & Horton, 1971).
4	*Cross thumb grip* Fingers fisted loosely into palm, pencil held against index finger with thumb crossed over pencil toward index finger, finger and wrist movement, forearm positioned on table (Gesell, 1940).
4	*Four fingers grip* Pencil held with four fingers in opposition, wrist and finger movement, forearm positioned on table.
5	*Dynamic Tripod grip* Pencil stabilized against radial side of third digit by thumb pulp with index pulp on top of shaft of pencil, thumb stabilized in full opposition, wrist slightly extended fourth and fifth digits flexed to stabilize the metacarpophalangeal arch and third digit, Localized movement of digits of tripod and wrist movements on tall and horizontal strokes, forearm resting on the table (Rosenbloom & Horton, 1971).
5	*Lateral tripod Grip* -Pencil stabilized against radial side of third digit with index pulp on 101' of shaft of pencil, thumb adducted and braced over or under anywhere along the lateral border of index finger, wrist slightly extended, fourth and fifth digits flexed to stabilize metacarpophalangeal arch and third digit. Localized movement of digits of tripod and wrist movements on tall and horizontal strokes, forearm resting on table (Schneck, 1989).

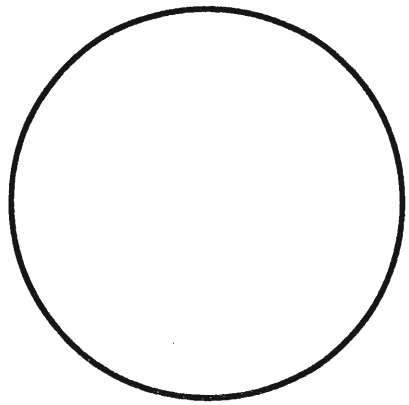
* A score of 1 is the lowest score obtainable; a score of 5, the highest. Schneck (1991)

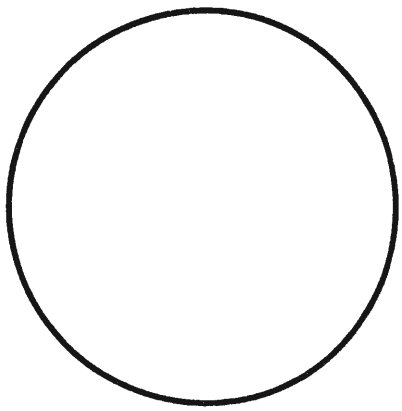
APPENDIX B

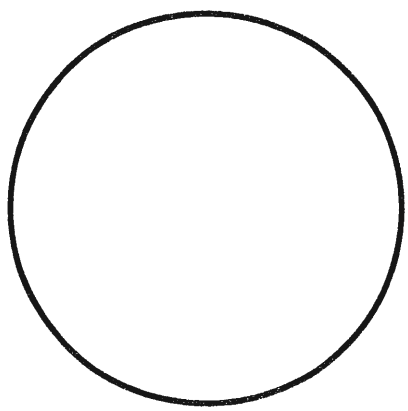
Tracing Circles

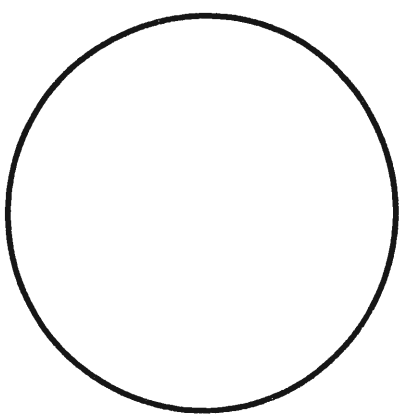
Tracing Circles

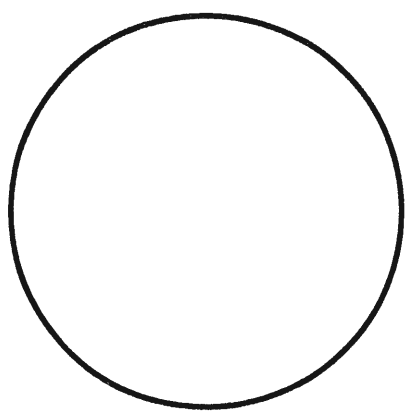












APPENDIX C

Pre- and Post-Observation Data Chart

Pre- and Post-data Observation Chart

TRIAL 1						
Student #	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6
010						
045						
076						
024						
073						
013						
054						
134						
089						
022						
035						
029						
097						
044						
103						

TRIAL 2						
Student #	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6
010						
045						
076						
024						
073						
013						
054						
134						
089						
022						
035						
029						
097						
044						
103						