2022

THE EFFECTIVENESS OF HANDWRITING INTERVENTION ON HANDWRITING AND SPELLING OUTCOMES DELIVERED VIA TELEHEALTH

Laura Bray
University of Kentucky, lmbr252@uky.edu
Author ORCID Identifier:
https://orcid.org/0000-0003-1795-0208
Digital Object Identifier: https://doi.org/10.13023/etd.2022.290

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's thesis including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Laura Bray, Student

Dr. Camille Skubik-Peplaski, Major Professor

Dr. Patrick Kitzman, Director of Graduate Studies

THE EFFECTIVENESS OF HANDWRITING INTERVENTION ON HANDWRITING AND SPELLING OUTCOMES DELIVERED VIA TELEHEALTH

DISSERTATION

A dissertation submitted in partial fulfillment of the

requirements for the degree of Doctor of Philosophy in the

College of Heath Sciences

at the University of Kentucky

By

Laura P. Bray

Lexington, Kentucky

Co- Directors: Dr. Camille Skubik-Peplaski, Professor of Occupational Therapy

and. Dr. Patrick Kitzman, Professor of Physical Therapy

Lexington, Kentucky

2022

https://orcid.org/0000-0003-1795-0208

ABSTRACT OF DISSERTATION

THE EFFECTIVENESS OF HANDWRITING INTERVENTIONS ON HANDWRITING AND SPELLING OUTCOMES DELIVERED VIA TELEHEALTH.

Across the United States, there has been a push to improve the literacy of our population, especially in the school systems. This has resulted in emphasizing reading skill development; however, literacy encompasses more than just reading. Literacy is the internal processes needed to create and understand contextualized visual, written, and verbal information. According to the Common Core State Standards, foundational literacy skills include reading, but also writing, listening, and speaking abilities. Handwriting is an area of literacy that is often forgotten, but has significant positive correlations to writing composition, spelling, and early reading skills. In fact, the Simple View of Writing developed by Berninger et al. affirm handwriting as a low level writing skill needed to be mastered in order to excel in the higher compositional writing skills.

In recent years as the dependency on technology increases, explicit instruction of handwriting is frequently overlooked in curricula. Accordingly, the percentage of children struggling with handwriting is on the rise. Associations with handwriting difficulties can include pain with writing; decreased written content; anxiety; low self-efficacy; and avoidance of handwriting. The most common referral for a school-based occupational therapist remains handwriting issues. Currently, there is no standard of care for addressing handwriting goals, but evidence suggests that practice and instruction of handwriting is imperative.

Concurrently, the use of telehealth service delivery in pediatric occupational therapy has significantly increased in utilization since the COVID-19 pandemic. The research into the effectiveness of pediatric occupational therapy interventions delivered via telehealth is still emerging. Thus, the overarching purpose of this dissertation is to determine the effectiveness of handwriting interventions on handwriting and spelling outcomes delivered via telehealth. Through this investigation, further insight will be provided into the feasibility of handwriting interventions via telehealth as well as the relationship between handwriting and spelling.

This two-part dissertation began with a pilot case study to gain insight into the feasibility and effectiveness of delivering the Handwriting Without Tears® curriculum, a frequently used multi-sensory handwriting program, via telehealth. The case study was conducted with a first grader who was typically developing to gain understanding into the relationship between handwriting and spelling. The results of this pilot study informed and streamlined the subsequent case series study. This investigation was conducted with children with literacy issues of handwriting and/or spelling delays, who would be more representative of a pediatric occupational therapy caseload. This dissertation project aims to build on the handwriting-focused literacy research as well as grow the evidence for pediatric occupational therapy telehealth interventions.

KEYWORDS: Handwriting, Spelling, Telehealth, Literacy, Handwriting Without Tears

Laura P. Bray

07/19/2022

Date

THE EFFECTIVENESS OF HANDWRITING INTERVENTION ON HANDWRITING AND SPELLING OUTCOMES DELIVERED VIA TELEHEALTH

By

Laura P. Bray

Camille Skubik-Peplaski, Ph.D., OTR/L, FAOTA

Co-Director of Dissertation

Patrick Kitzman, PT, Ph.D.

Co-Director of Dissertation

Esther Dupont-Versteegden, Ph.D.

Director of Graduate Studies

07/19/2022

Date

DEDICATION

To my mom. I recently lost my mother after a quick and sudden illness. As my family is grappling with this new void, there is a universal experience for us that evokes a simultaneous intense sense of connection and loss--seeing her handwriting. Her handwriting is a lasting way in which she is able to communicate using her own voice. The loops and scribbles that she wrote will be artifacts for us to hold tightly that represent her words, thoughts, ideas, and heart to pass to the next generation. In an age where handwriting is seemingly lost, it still holds great power and value.

To Zack and our children, for always encouraging and supporting me to dream bigger.

ACKNOWLEDGMENTS

Thank you to all who contributed to this dissertation project and supported my growth as a researcher. I am so appreciative of my entire Committee as they have provided professional and personal support as well as taught me more than they will ever know throughout this process. I am incredibly grateful to Dr. Camille Skubik-Peplaski, my advisor and Committee Chair. I was lucky enough to sit next to her at a KOTA meeting in the fall of 2017 after moving back to Kentucky. It was here that she provided the final spark of encouragement I needed to finally pursue my PhD. She has continued to guide, encourage, teach, and support me throughout the years and I suspect she will continue to do so throughout my career. I admire her tireless devotion to the continued development of rehabilitation sciences, especially occupational therapy. Additionally, I would like to thank Dr. Patrick Kitzman, my Committee Co-Chair. He gave me an even greater appreciation for interdisciplinary research as he always had a collaborative and complementary approach, providing a different and robust perspective. Thank you to Dr. Colleen Schneck who spent her last years at EKU to continue to foster and progress my research as well as my career. I have learned so much from her humble, yet prolific approach to research and occupational therapy. I am grateful to Dr. Matthew Hoch agreeing to be on this handwriting research Committee. I learned so much from his approach to research design and statistics, which furthered my growth throughout this project, and will continue to do so throughout my research career. Lastly, I want to thank Dr. Susan Cantrell. Her perspective throughout this research was invaluable. She furthered my thinking about literacy, handwriting, and the cultural influences impacting these realms.

I am also indebted to Dr. Gilson Capilouto who fostered my professional writing and confidence; Dr. Esther Dupont-Versteegden who supported me personally and professionally throughout my time in the program; Dr. Kristen Perry who I learned so much about literacy and how expansive it truly is; Dr. Janice Almasi who is a cheerleader of reading and literacy and taught me about assessment in context; and Dr. Kera Ackerman who helped to expand my systematic review.

My EKU colleagues have provided mentorship, support, and encouragement at every turn in this process. They have bent over backwards to welcome me, teach me, and provide a helping hand whenever needed. I am especially thankful to Dr. Dana Howell who had provided guidance and encouragement since I met her as my professor and now as our Department Head.

I am thankful to my family for their support and encouragement throughout my studies and dissertation. My husband, Zack, has encouraged me to strive for this dream long before I actually did. Our children, June and Doug, have been patient cheerleaders. My parents, siblings, and in-laws have provided support, wisdom, and childcare over the years to help me be able to pursue this degree. I am also thankful to my friends and family who have had to endure a lot of conversations about research and handwriting. It 'takes a village" and my whole village provided enthusiasm and support to keep me going.

Lastly, I want to thank all the participants and families. They provided collaboration and support for this project and my research. I am truly indebted to them and their enthusiasm and curiosity. Their energy fueled this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

1.1 Introduction

The purposes of this introduction were to: 1) provide a brief overview of literacy; 2) discuss the relationship of handwriting with literacy; 3) review occupational therapy practices with handwriting; 4) delve into the use of telehealth as a service delivery option for pediatric occupational therapy; 5) establish the purpose and aims of this project; and 6) provide a theoretical approach for the project.

1.2 Background

The United States has ascribed immense value to literacy and literacy education. However, literacy continues to be an area in which we struggle to educate our citizens. The average reading score for a fourth grader declined from 2017 to 2019.[3] The average evidenced-based writing and reading SAT scores for college-bound seniors steadily decreased from 2018 to 2020.[3] Only 12.8% of adults in the United States are classified as proficient in literacy as of 2017.[4] The increase in online learning during COVID-19 has negatively impacted literacy, as research found that first graders' writing abilities have significantly declined since the start of the pandemic.[5]

The United Nations Educational, Scientific, and Cultural Organization defines literacy as "the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts."[6] Literacy is a vastly broad concept that allows a person to engage with the written and pictorial world. The immense nature of literacy thus translates in being interwoven into *all* domains of occupation.[7] Literacy is highly influenced by the context in which it is practiced, such as social patterns, cultural practices, and historical events, especially

apparent in written language.[8,9] The importance of literacy is emphasized at a national level, but as this translates down to the personal and community level, the worth attributed to literacy is highly influenced by institutional, community, familial, and individual values and beliefs.[9] This variance can further be seen in the national, statewide, and local levels of educational delivery.

In response to slow national literacy progress, the Common Core State Standards[10] were developed in 2009 to account for the lack of consistency of educational expectations. The Common Core Standards[10] promote an average level of achievement for students across the country, creating evidenced-based national learning goals, and have been adopted by 41 states. The Standards[11] view literacy as emergent from the foundational skills of reading, writing, utilization of language, speaking, and listening, which has shaped how literacy is approached in the academic context.

Reading has received the majority of the attention in the literacy arena.[12,13] However, writing is an equally important foundational literacy skill, but lagging in evidence-based interventions as compared to reading.[13,14] The Common Core State Standards[10] describe writing as a multi-faceted process, including the functional use of grammar, spelling, writing conventions, vocabulary, organization, and handwriting. In Berninger et al.'s[15] Simple View of Writing, the writing process begins with the acquisition of low level processes, such as transcription skill (e.g., handwriting, keyboarding, and spelling), in order to develop mastery of the higher level processes of conceptualization, organization, grammar, and editing. Thus, the attainment of the lower level transcription processes is imperative in progressing the literacy skills associated with writing.

1.2.1 Handwriting as a Foundational Literacy Skill

As the Simple View of Writing suggests, handwriting has a central role in literacy.[15] Once handwriting becomes automatic, working memory resources can be diverted from the act of handwriting to the act of writing (e.g. planning, organizing, editing).[15] This concept is confirmed by the positive correlation between handwriting legibility and fluency and mastery of writing composition.[16] Handwriting proficiency allows for less "disruption" in the writing process; thus, compositional quality was improved when the handwriting processes increased.[16] For example, children who were more fluent with legible handwriting were able to produce longer and better quality compositions.[17,18] Connelly et al.[19] compared handwriting fluency to keyboarding fluency and found keyboarding did not have the same relationship with composition; classifying typed compositions as compared to handwritten as two years developmentally behind. Handwriting fluency is a significant predictor of progression of composition skills.

The contribution of handwriting to composition development has been found to be unique in comparison to other foundational writing abilities. Alves et al.[17] found a stronger relationship between handwriting fluency and composition quality as compared to spelling and composition. Participants who received a spelling intervention did not improve their compositional abilities whereas the handwriting intervention cohort exhibited increased compositional length and quality. These results concurred with a meta-analysis where length of writing was found to be more strongly correlated to handwriting fluency (r=.48) rather than spelling (r=.25).[20] Puranik and Al Otaiba[21] also determined handwriting was the variable that accounted for the most unique variance

with compositional abilities at 4.1% as compared to spelling at 2.3% and socioeconomic status at 2%. A child's ability to complete handwriting automatically had a positive correlation with the quality of their writing, including planning and organizing ideas, vocabulary, and fluidity of the text.[14] Handwriting fluency was found to have a slight, but statistically significant correlation with compositional ability, such as ideas, words, and sentence production, in kindergarten as compared to other transcription and oral language abilities.[22] Development of handwriting is a key writing foundational ability.

Handwriting not only has an impact on the higher level of writing processes, but on other lower level processes as well, such as spelling. Handwriting quality is positively correlated with spelling skills.[23] This was found to be true especially for children in elementary school.[24] Pritchard et al.[23] hypothesized that handwriting reinforced orthographic representations of words and improved spelling memory. Conversely, eight to nine year old students who tested with poor to very poor handwriting performed significantly lower on spelling tasks.[25] Thus, when handwriting is not mastered, it can negatively impact other literacy skills.

Handwriting proficiency also influences early reading skills. Research suggests a neurological overlap between reading, writing, and spelling contributes to the positive correlation between handwriting and the other aspects of literacy.[26-28] Suggate et al.[29] postulated that due to these shared neural pathways, by enhancing handwriting, one could actually strengthen the pathways involved in other literacy areas, such as reading. The positive relationship between handwriting and early reading skills has been confirmed in research. Children with very good to good handwriting scored significantly higher on word reading and pseudo-word reading.[25] Kindergarteners who exhibited improved letter

writing fluency also showed increased letter naming fluency, which may be attributed to the shared perception, cognition, and application of critical features of letters.[27] James and Engelhardt[26] performed a functional magnetic resonance imaging (fMRI) on fifteen pre-literate four- to five-year-old children. They asked participants to write letters, trace letters, and type letters prior to the fMRI. Once in the fMRI, the participants were shown these letters and shapes. It was found that there was a significant difference in the neural pathways after the printed stimulus was shown as compared the tracing and typed stimuli. Viewing the handwritten material, children recruited neural pathways involved in the reading system, which were not fired when shown the other stimuli. Research has shown greater employment of visual and motor neural networks while completing handwriting[30] or even just reading a handwritten versus a typed letter[31]; thus, solidifying the shared pathways between these two literacy skills.

The influence of handwriting and early reading skills can also be seen in the adult research. In a case study of a man with acquired dyslexia, the participant was able to achieve greater success with naming handwritten letters as compared to typed letters, which is a key foundational skill in reading.[28] Adults who learned Arabic exhibited greater ability to comprehend the written language when they practiced handwriting in Arabic as compared to typing.[32] By writing the characters, it was postulated the participants solidified their connection with the orthographic and phonetic languages. The sensorimotor act of completing handwriting helps to strengthen development of not only handwriting itself, but composition, spelling, and early reading skills as well.

1.2.1.1 Handwriting Instruction

Handwriting instruction, as a foundational skill in literacy, has been included in the Common Core State Standards[10] for kindergarten and first grade. However, as a child progresses through school, the demands for handwriting become greater.[33] Handwriting has receded in curricular importance in recent times[34]; even though the literature supports handwriting instruction to improve legibility and fluency.[35] Instruction of handwriting is inconsistent among teachers and schools.[36,37] A survey study found the duration and modality of handwriting instruction for kindergarteners to second graders wide-ranging, with the direct teaching of handwriting averaging between 30 to 45 minutes per week.[37] These findings replicate the results of a survey study conducted by Asher[36] with kindergarten to fifth grade teachers. Respondents in this study also demonstrated high variability among explicit instruction methods and frequency.

As the presence of handwriting has diminished in the curriculum,[34] 84.9% of teachers felt their students' handwriting, as well as prerequisite fine and gross motor skills, had also declined recently.[38] In a survey study, teachers felt confined in their abilities to explicitly teach handwriting due to other academic requirements, but 99.3% of the teachers deemed learning handwriting as "very important" to "important." Accordingly, Roessingh et al.[18] determined that 56% of fourth grade students were experiencing difficulty with handwriting, which has increased from previous research, which found 10 to 34% of typically developing fourth and fifth students struggling with handwriting.[39] These studies were conducted pre-pandemic, and online instruction during the pandemic was found to further negatively impact the amount of explicit handwriting instruction that was able to be incorporated into the curricula.[40]

1.2.1.2 Occupational Therapy and Handwriting

Difficulty with handwriting is the most frequent reason for referral for school-based occupational therapists.[41] Children who struggle with handwriting may experience concurrent issues. Children who exhibit poor handwriting frequently were awarded lower grades than students with superior handwriting, even in the face of comparable content.[42] Also, children who have handwriting delays often have decreased speed and are not able to generate as much content[43]; have pain and difficulty with handwriting; avoid handwriting; and can have associated anxiety and low self-efficacy.[44] Although explicit teaching of handwriting has declined,[45] it continues to impact a child's academic success and confidence.[46,47]

School-based occupational therapists report addressing handwriting outcomes in up to 75% of their caseload.[48] Although occupational therapists are frequently consulted for handwriting delays, there is no gold standard in how improve the handwriting performance. Occupational therapists utilize a variety of approaches when addressing handwriting with clients. A survey with 198 school-based therapists found over 130 different modalities were identified as used in handwriting treatment.[49] A multisensory approach was the most common with 92% of the occupational therapists indicating they used this modality with clients. Multisensory interventions included adaptation of writing tools and surface; commercially available handwriting programs, such as Handwriting Without Tears®, Callirobics; or use of a play-based approach to target foundational skills, such as visual-motor integration, visual perception, fine motor development.[49] Federer et al.[50] also found a varied approach used for handwriting by pediatric occupational therapists, with 90% using a sensorimotor approach. However, in a systematic review of the handwriting research, treatment approaches that focus on

improvement of isolated component-level sensorimotor skills (e.g., visual motor integration, visual perception, kinesthesis, fine motor manipulation) were not effective in improving legibility.[51] The systematic review also found the handwriting research to encapsulate a range of different handwriting modalities, including therapeutic practice, self-evaluation, and remediation of skills with therapeutic practice and self-evaluation to be the most effective.[51] It has been found that use of handwriting as the treatment intervention to be the most successful approach,[51,52] which is considered an occupation-as-means approach as the intervention itself is practicing the targeted goal of therapy.[53]

1.2.1.3 Telehealth in Occupation Therapy

Handwriting goals are not only targeted in the school-based setting, but in outpatient pediatric settings as well. Accordingly, the majority of the research on handwriting has been conducted face-to-face in the school or outpatient settings. However, telehealth in pediatric occupational therapy is increasing in use. The American Occupational Therapy Association[54] (AOTA) defines telehealth as the delivery of occupational therapy services, including evaluations, consultations, preventative sessions, and/or therapeutic visits, delivered virtually through information and communication technology. The COVID-19 pandemic served as a catalyst to promote the use of telehealth in the occupational therapy. In a global survey by Ganesan et al.,[55] 60.7% of responding occupational therapists used telehealth during the pandemic versus 36.1% before the pandemic. Of the respondents, only 2% were from the United States. In a subsequent survey, an even more dramatic increase in adoption of telehealth was noted with 92% of occupational therapists had not used telehealth pre-pandemic whereas 99% reported having used it during the pandemic.[56] The differences in adoption of telehealth

could be due to variability in respondents between the two studies, as 97% of the respondents were American in the second study[56]; which aligns with previous findings of practitioners in the United States reporting higher use of telehealth services.[57] Seventy eight percent of occupational therapists relayed they will continue to use telehealth as the pandemic contact restrictions lessen[58]; thus, telehealth is a service delivery method that is poised to sustain.

Research into the effectiveness of telehealth as a service delivery method is continuing to grow. Associated advantages with telehealth have been reported with pediatric occupational therapy from both the client and clinician perspectives. Caregivers relayed many perceived benefits associated with telehealth, such as it is family-centered and increased caregiver involvement in the session; more accessible and flexible to the family needs; easier to fit with the child's routines and natural setting[59]; and children felt more relaxed being able to complete therapy in their own homes.[60] Occupational therapists reported both advantages and disadvantages with telehealth as a service delivery method. Telehealth benefits included increased access to clients in rural or low-income areas; decreased time between referral for services and evaluation[61]; and improved attendance and adherence to home exercise programs.[62] Barriers associated with telehealth included lack of technology support[57]; difficulty evaluating and monitoring client progress[63]; and the need for physical facilitation of occupations.[60] The AOTA[64] has called for further research on telehealth effectiveness for occupational therapists. Since the pandemic sparked a sharp increase in telehealth utilization in pediatric occupational therapy, the research is lagging behind on the effectiveness of telehealth interventions.

1.3 Stating the Problem

Handwriting is a foundational skill in writing literacy. Research has found handwriting to have positive correlations with spelling,[23,25] compositional abilities,[16,18] and early reading skills.[26,65-67] However, handwriting has progressively declined in its incorporation into elementary school curricula.[45] Accordingly, referrals for occupational therapists to address handwriting delays remain consistent.[41] Sensorimotor and multisensory activities have been found to be the most common intervention techniques employed by occupational therapists[49,50]; however, focus on improvement of isolated sensorimotor component skills does not translate into improvements in handwriting legibility.[51,52] The most effective intervention approaches are where handwriting itself is the targeted activity,[51,52] thus occupation-as-means.[53] There has been evidence that multisensory, manualized curricula where handwriting is explicitly instructed and practiced, such as Handwriting Without Tears® (HWT), are effective interventions to improve handwriting outcomes.[68-70] HWT and other manualized curricula have yet to be researched via a telehealth delivery format, which is increasingly being used by occupational therapists.[55,63] Additionally, literacy benefits associated with the manualized handwriting curricula, such as HWT, have yet to be researched. Thus, there is a critical need to understand if manualized handwriting curricula, specifically HWT, has positive correlations with other areas of literacy and determine the effectiveness and feasibility of delivering a handwriting curriculum via telehealth.

1.4 Research Purpose & Approach

The overall goal of this research is to further understand the role of handwriting as a foundational literacy skill. We plan to determine the effectiveness of the Handwriting

Without Tears® (HWT) curriculum via telehealth delivery on the literacy outcomes of handwriting speed, handwriting legibility, and spelling. Additionally, this research will contribute to the understanding of the effectiveness and feasibility of handwriting interventions via telehealth delivery. The Specific Aims for this research are as follows.

Specific Aim 1: Investigate the feasibility and effectiveness of the HWT curriculum via telehealth for lower elementary aged children who are typically developing.

A pilot study (Chapter 3) was conducted with a first grade female with no identified difficulties with literacy. The participant attended 18 total synchronous telehealth visits with the primary investigator, an occupational therapist, including evaluation and posttest. The primary investigator delivered 16 HWT lessons via synchronous telehealth using HWT associated physical manipulatives, three times weekly for five weeks. We hypothesized the participant would exhibit improvements in handwriting speed, legibility, and spelling. Additionally, we postulated a telehealth delivery would be a feasible and effective service delivery method to ascertain these results.

Specific Aim 2: Determine the effectiveness of the HWT via telehealth on handwriting and spelling outcomes for lower elementary children with handwriting and/or spelling difficulties.

Twelve second and third grade participants with handwriting and/or spelling difficulties were recruited for this repeated baseline case series design (Chapter 4). As children are highly variable in their development, each participant served as their own control to account for this variability. It was hypothesized that children with handwriting

and/or spelling difficulties would improve in handwriting speed, handwriting legibility, and spelling abilities after attending seven synchronous HWT lessons via telehealth and 14 asynchronous virtual HWT lessons.

1.5 Theoretical Approach

The Occupational Therapy Practice Framework 4th edition, neuroplasticity principles, and the Self-Determined Occupational Performance Model will serve as the theoretical perspectives used to address handwriting in occupational therapy. They will be briefly introduced below and discussed in detail in Chapter 2.

1.5.1 Occupational Therapy Practice Framework and Neuroplasticity

The Occupational Therapy Practice Framework[1] (OTPF) guides occupational therapists to approach therapy in a holistic manner in order to capture the complexity of occupational performance. This is especially important with handwriting as it is a highly variable occupation dependent on the child, their abilities, and the context in which it is being performed. The OTPF guides the clinician to consider the domains of performance

skills, client factors, performance patterns, contexts, and occupations as to how clients' participation and engagement is supported.[1] See Figure 1.1.

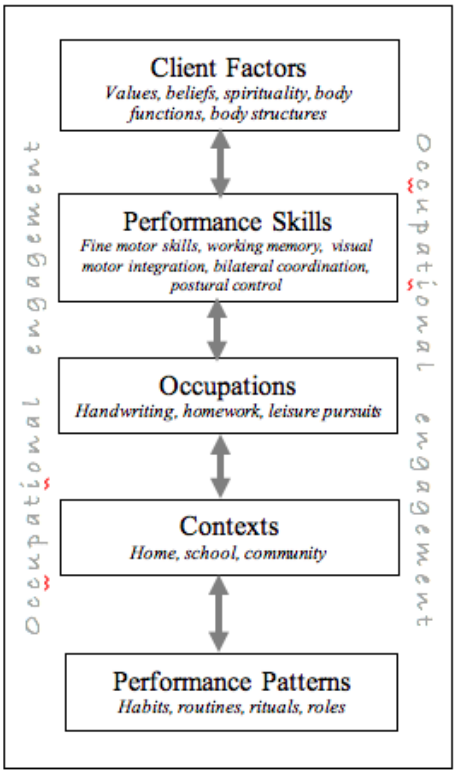


Figure 1.1: Overview of the OTPF[1]

1.5.1.1 Performance Skills

Occupational therapists work with clients to improve their performance skills, which are the abilities required to participate and engage in occupation, including motor, process, and social interaction skills.[1] At a neurological level, these performance skills can be enhanced using principles of neuroplasticity. Neuroplasticity is the "brain's ability to encode experience and learn new behaviors."[71] Research has shown children exhibited neuroplastic changes in response to sensorimotor and/or cognitive-based interventions.[72] Thus, children are able to learn new occupations with sustained neurological change in response to occupational therapy treatment.

Neuroplasticity principles should be incorporated into interventions to strengthen outcomes.[72] There are ten neuroplasticity principles listed in Table 1.1.[71] As determined in the handwriting research, specificity and repetition are intervention factors that predict improved results. In multiple systematic reviews, specificity, or focus on handwriting itself during the intervention, using occupation-as-means,[53] generates progress in handwriting outcomes.[51,52] When therapy is focused on increasing component level skills (e.g., fine motor manipulation, visual motor integration, visual perception) without incorporating handwriting into treatment, legibility was not improved. This corresponds to the research in neuroplasticity as neural changes were

Table 1.1. Neuroplasticity Principles[71]

Neuroplasticity Principles
Use it or lose it
Use it and improve it
Specificity
Repetition
Intensity
Timing
Salience
Age
Transference
Interference

associated with practice of the actual skill, or occupation, the person is learning.[71]

Additionally, Hoy et al.[52] found repetition to be the key predictor in handwriting advances; which again correlates to the neuroplasticity principle of repetition and intensity are required for sustained results.[71] An additional neuroplasticity principle is "use it and improve it," where skill have to be used in order to improve.[71] This aligns with the use of repetition and specificity in treatment; however, handwriting is often

overlooked in explicit curricular instruction diminishing opportunities for repetition and solidification of skills.[45]

Neuroplasticity principles indicate when neurons are activated together, the synapses are strengthened and preserved,[73] supporting the use of handwriting as a piece in the larger puzzle of literacy. There is a neurological overlap of handwriting with reading, writing, and spelling pathways, supporting the direct relationship between handwriting and other areas of literacy.[26-28] Suggate et al.[29] postulated by enhancing handwriting, one could actually strengthen the pathways involved in other literacy areas and promote neurological change.

1.5.1.2 Client Factors

The OTPF directs occupational therapists to also consider client factors. When occupational therapists successfully incorporate subjective client factors, such as interests, values, and motivation, into literacy occupations, engagement has been shown to improve.[74] The neuroplasticity principle of salience supports the integration of client factors in treatment as well. An experience needs to be meaningful to a client to gain their motivation and attention. The client factor of autonomy, or the need for occupational choice and independence, is also found to be highly important to literacy engagement.[75] When a child is asserting occupational choice, they perceive the selected occupations as meaningful, gratifying, and achievable.[76] As a child's autonomy is supported, motivation and subsequent progress towards outcomes are improved.[74,77]

1.5.1.3 Performance Patterns

Performance patterns, including habits, routines, rituals, and roles, need to be considered by the occupational therapist when addressing handwriting and literacy according to the OTPF. Occupational therapists found telehealth to be more adaptable to families' routines and thus, clients were more comfortable.[58,60,78] Additionally, caregivers reported due to the decrease in travel time, therapy via telehealth was more accessible and less of a disruption to their schedules than in-person therapy.[59]

1.5.1.4 Context

Context is another key domain to be contemplated when working towards literacy engagement.[1] Utilizing a sensory-rich environment has been found to improve neuroplastic changes in treatment.[72,79] Additionally, therapy in a home setting can promote practice of occupation in a natural environment. In a survey by Wallisch et al.,[59] caregivers preferred that telehealth was delivered in their typical environment, as it was within the rhythms of the client's day as well as in their chosen context. Occupational therapists echoed the same sentiment.[58] Occupational therapists found by delivering services at home via telehealth, there was increased recruitment for members of the client's social context, such as caregivers and other family members, to participants. The client and family members also exhibited more security and relaxation by engaging in therapy in their preferred environment.[58] By reducing stress, a client is more open to neuroplastic changes.[79]

Kleim and Jones[71] include timing, or the temporal context, as a principle in neuroplasticity. They explain that learning and subsequent plasticity appears to precede and can be dependent on one another. As handwriting is a foundational skill, it needs to

be taught and solidified prior to other higher-level skills as supported in the Simple View of Writing.[15]

1.5.2 The Self-Determined Occupational Performance Model

The Self-Determined Occupational Performance Model (SDOP) blends principles of Self-Determination theory[74] and the Person-Environment-Occupation Performance Model[80] to target handwriting outcomes when working with children.[2] This model reinforces the transactional relationship described above in the OTPF between the person, context, and occupation in achieving occupational performance. In the person domain, autonomy, is emphasized where the child should have occupational choice in order to improve motivation and engagement in handwriting.[76] The environment domain not only encompasses the social, cultural, temporal, and physical concepts of concepts from the OTPF, but stresses the importance of relatedness for children. When a person feels a sense of belonging, or relatedness, their intrinsic motivation to participate in occupational pursuits, such as handwriting and writing, will be improved.[76,81] Lastly, the occupation domain highlights the Self-Determination concept of the feeling of competency.[2] Competency can occur when a child feels knowledgeable about occupational expectations as well as confident in their ability to meet these expectations.[82] Please see Figure 1.2. The SDOP model was used for this project as it complements the OTPF and

neuroplasticity principles as well as provides a direct application for handwriting interventions.

1.6 Operational Definitions

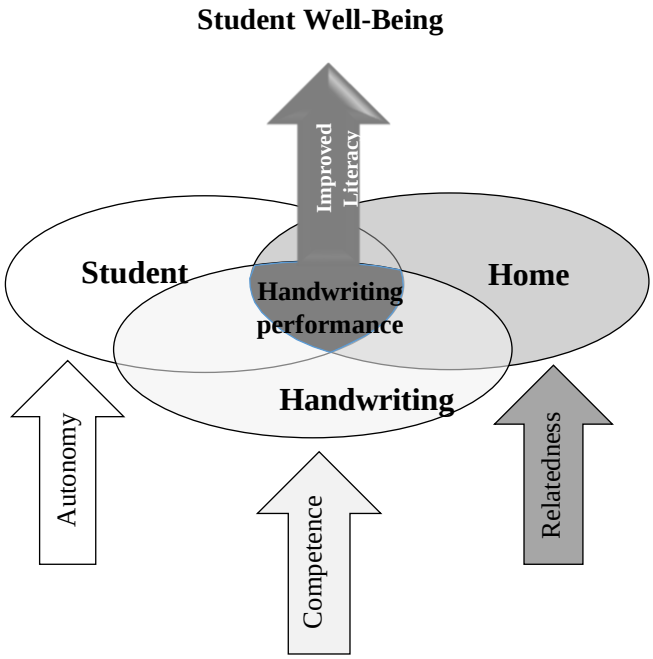


Figure 1.2: SDOP Model[2]

Context: the physical, temporal, technological, social, attitudinal, institutional environments.[1]

Literacy: the internal processes needed to create and understand contextualized visual, written, and verbal information, including "reading, writing, listening, and speaking" foundational abilities.[83]

Neuroplasticity: the ability of the nervous system to undergo change and learning in response to experience.[72]

Occupation: activities that a person needs to do, wants to do, has to do that provoke meaning and purpose within the person.[1]

Occupation-as-Means: when occupation is used at the treatment intervention itself.[1]

Salience: the meaning a person ascribes to an experience.[71]

Telehealth: the delivery of health services, including assessment, monitoring, consultation, prevention, and treatment via through information and communication technology.[54]

1.7 Assumptions

It was assumed that:

1. All participants provided an honest and accurate representation of their demographic information.

1.8 Limitations

1. A convenience sample was chosen for the studies for both Aim 1 and Aim 2; thus, the participants were not representative of the larger population of children experiencing difficulty with handwriting and/or spelling.
2. All participants maintained their typical instruction in spelling and handwriting during and outside school to minimize disruption to their normal performance patterns. However, the effects of the intervention cannot be fully isolated from the alternate instructional benefits.

1.9 Delimitations

1. Participants were varied in their difficulty with spelling and/or handwriting and their current instruction during the study. However, it was felt this variability

would be representative of a typical pediatric caseload held by an occupational therapist.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The purposes of this review were to: 1) discuss the literature of handwriting and/or spelling interventions currently used with children with literacy difficulties; 2) discuss the literature on current pediatric telehealth practices; 3) introduce the blending of the Occupational Therapy Practice Framework 4th edition, the Self-Determined Occupational Performance Model and neuroplasticity principles to literacy as the theoretical perspective used to address handwriting in occupational therapy.

2.2 Handwriting and/or Spelling Interventions for Children with Literacy Difficulties

The following was a systematic review conducted by Bray, Skubik-Peplaski, and Ackerman[84] that discussed the effectiveness of handwriting and/or spelling interventions for children with literacy difficulties.[84] This is an 'Accepted/Original Manuscript' of an article published by Taylor & Francis Group in the Journal of Occupational Therapy, Schools, & Early Intervention on June 4, 2021, available online: https://www.tandfonline.com/doi/abs/10.1080/19411243.2021.1934227?journalCode=wjot20

2.2.1 Introduction

Literacy is deeply embedded across occupations throughout the lifespan.[7] It is a difficult concept to define because it is dependent on an individual's context and occupation,[85] but hinges on a person's receptive and expressive language abilities, including reading, oral and written expression, listening, and viewing.[86] Literacy mastery is entrenched throughout the occupational roles of peoples' lives, contributing

significantly to their overall occupational success. This is never more evident than in a child's occupational role as a student.

Historically, occupational therapists have been known for their niche in addressing handwriting, especially in school systems.[87] In recent years, occupational therapists have begun to expand their role past handwriting into other aspects of literacy, especially engagement in literacy activities.[51,87-89] This is a natural progression as educational participation has been an identified occupational category in the Occupational Therapy Practice Framework[1] (OTPF), which includes engagement in reading, math, and academic coursework. Furthermore, as literacy endeavors are highly contextualized and individualized,[85] the contribution of occupational therapists is complementary to the educational team due to the unique emphasis our education and training has on client-centeredness and context. The OTPF specifies that occupations are personally meaningful activities that are used as both the intervention in therapy, the 'means', and also the outcome of therapy or 'end'.[1]

Occupational therapists address the individual's performance patterns and skills to enhance educational occupational performance. Thus, occupational therapists need to recognize their role in literacy and how it impacts the occupational performance of students in order to better assist educators and others on the academic team.[90] Children with specific learning disabilities (SLD) have many occupational performance issues in school, especially in literacy-related activities.[91] SLD are classified as language disorders,[34] which include dyslexia, dysgraphia, developmental aphasia, brain injury, or perceptual disabilities[92] (IDEA). As defined by IDEA, a SLD is when "one or more of the basic psychological processes involved in understanding or in using language, spoken

or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations."[92] Berninger et al.[34] define the SLD of dyslexia as a developmental condition that affects reading and spelling skills; yet is not related to a child's intellect or educational resources. Dysgraphia is a developmental disorder that affects a child's ability to produce legible writing.[34]

Twenty percent of the worldwide population present with dyslexia.[93] The prevalence of concurrent writing and spelling disorders is high with those who have been diagnosed with dyslexia: 94 to 96% of children with dyslexia also present with dysgraphia[12]; and 95% of students with reading delays have diminished spelling.[94]

Transcription skills, or handwriting and spelling abilities, are key components in literacy as they are positively correlated with compositional aptitude.[34] Berninger et al.[95] described handwriting and spelling as low-level processes that contribute significantly to the higher-level processes of planning, composing, and revising. With the rise in technology, the importance of transcription, especially handwriting, is frequently overlooked.[34] Yet, McMaster and Roberts[33] found that children are involved in pencil-to-paper tasks (i.e., mostly handwriting) 20 to 50% of their school day. Handwriting is currently only included in the Common Core Standards for kindergarten and first grades[10]; yet, handwriting is used most frequently in third through fifth grades.[33] Additionally, Collette, Anson, Halabi, Schlierman, and Suriner[37] found minimal consistency in the manner and amount of which handwriting was addressed among kindergartners to second graders, with direct instruction time averaging around 30 to 45 minutes per week through a survey study. Handwriting plays a major role in a child's self-efficacy, outlook, and academic success throughout school.[47,96] It promotes

development of writing skills, such as spelling and composition, both at a sentence and essay level.[97,98] Additionally, it also has been found to improve reading development.[67] Children who were more proficient with writing demonstrated improved early reading abilities, such as with naming letters, phonetics, and reading at a word level.[67,99] Along with handwriting, spelling is a critical piece of composition, hence written expression. Accordingly, the ability to spell is related to the quality of written work.[100] Children who struggle with spelling often are at risk for decreased compositional aptitude and academic success.[34] Improving one's spelling skills is positively correlated with writing and reading abilities.[99-101]

Difficulty with handwriting and spelling can disrupt the compositional skills of children with SLD.[97] It has been estimated that 90 to 98% of children with SLD have fine motor issues and/or struggle with handwriting.[102] In fact, deficits in handwriting can be an indicator of a SLD.[103] Additionally, spelling is one of the most frequent challenges for children with SLD.[104] Often the difficulties that children face with spelling (e.g., frequent in-word pauses) negatively impact handwriting by disrupting the fluency of transcription.[105] Even in copying tasks, 58% of children with dyslexia make spelling mistakes.[105] It has been found that handwriting and spelling deficits can persist unless treated.[102,103,106]

Most existing literature focuses on reading interventions for children with SLD[12]; however, deficits in handwriting and spelling are prevalent. Reading, writing, handwriting, and spelling are interrelated skills with neurological overlap that cannot be fully teased apart.[26-28,107] Suggate et al.[29] found evidence of shared neural pathways between handwriting and reading abilities, and consequently proposed that due to this

neurological overlap, reading abilities could potentially be strengthened with improvements in handwriting. Research has also found that as transcription abilities become automatic, more cognitive resources become available for higher-level writing, such as planning, composing, and revising text.[34,105] As occupational therapists begin to venture into a greater understanding of literacy, it is imperative to recognize the importance of transcriptional abilities and their impact on academic literacy. However, there is currently a lack of a systematic review critically evaluating the research available for handwriting and spelling interventions for children with SLD. With the importance of evidence-based practice, this systematic review investigated the effectiveness of interventions in promoting handwriting and spelling in children with SLD to further inform occupational therapy practice.

2.2.2 Methods

2.2.2.1 Inclusion/Exclusion Criteria

A systematic search of the literature was conducted to determine the effectiveness of handwriting and/or spelling interventions with children with SLD on handwriting and/or spelling outcomes. Prior to the initiation of the systematic review, an informal agreement occurred between the first two authors, indicating scope and focus of review, including search terms, inclusion and exclusion criteria. Both authors were experienced with handwriting; the first author additionally has extensive knowledge of spelling and the second author has 10 years of quantitative and qualitative research experience.

Articles were included if they researched children with an SLD; investigated the effect of an intervention on handwriting and/or spelling outcomes; were written in English; were published in a peer-reviewed academic journal; and published in 2008 or

later. Articles were excluded if handwriting and/or spelling were not the primary outcomes, such as articles about writing composition or reading only interventions; investigated children where SLD was not the primary diagnosis, such as children with developmental disabilities; and articles that only had an abstract. Articles were also excluded if spelling interventions were not conducted in English because of the unique nature of spelling in the English language (i.e., specific rules, phonetic components). For this systematic review, the definition by the IDEA[92] described above was used to define SLD.

2.2.2.2 Literature Search

The literature search was completed using EBSCOhost with the search databases of Academic Search Complete, CINAHL with full text, ERIC, MEDLINE, Psychology and Behavioral Sciences Collection, APA PsychINFO, and the Teacher Reference Center. This systematic review began in 2018, thus literature was searched from January 1, 2008 with March 30, 2020 as the day of the last search. Two separate searches were conducted to locate interventions targeting handwriting and those targeting spelling. The search terms indicated the person or a child with a learning disability, intervention, and outcome of handwriting or spelling with synonyms to maximize results. The search terms and Boolean operators are displayed in Table 2.1 below.

Table 2.1. Search Terms and Boolean Operators

Population				Intervention		Handwriting Outcome	Spelling Outcome
Child OR; Children OR; Pediatric	AND	Dysgraphia OR; Dyslexia OR; Learning Disability	AND	Treatment OR; Intervention	AND	Handwriting OR; Writing	Spelling

2.2.2.3 Study Selection

The titles and abstracts were screened to determine if the article warranted independent further review by the first author. If the title and abstract indicated that the research investigated the use of a therapeutic intervention to improve the handwriting and/or spelling outcomes for children with SLD, it underwent a full read. Once an article was read and determined that it met the inclusion and exclusion criteria, further synthesis of the results was completed as described below. A hand search of the reference lists from the included articles was conducted as well as a review of the research on handwriting websites, such as Learning Without Tears, Zaner-Bloser, and D'Nealean, and Loops and Other Groups. Systematic reviews and meta-analyses for literacy interventions were also hand searched for potential relevant studies to be included.

2.2.2.4 Data Collection

After the literature search was complete, the first author independently extracted relevant data. This data, which included authors' name; publication year; research design; participant characteristics, such as sample size, age, diagnosis, and gender; intervention information for all participant groups, such as type, frequency, who performed intervention, and format (i.e., individual, group); handwriting and/or spelling outcome measurement used; language of outcome measure; when outcomes were measured; and the results were entered into a table. Additional comments and relevant information were placed in a separate document.

2.2.2.5 Study Quality

The methodological quality and risk of bias were assessed using the questions from the Downs and Black[108] checklist. The checklist is a 26-item tool that examines the internal validity (bias and confounding), external validity, and quality of reporting for randomized and non-randomized studies. Each metric was scored as to whether it was present, not present, unable to be determined, or not applicable for the individual study, with the highest score allowed at 27 points. For the purposes of this systematic review, articles were found to be of high quality if scored at 60% or above, moderate quality if 40–59%, and limited quality if below 40%. High quality indicated the study was well designed, minimizing bias and confounding, while maintaining a high degree of external validity and reporting.

2.2.2.6 Analysis of Results

Due to the variability in assessment tools used, effect sizes were determined to provide an unitless measure to directly compare outcomes between studies. The effect sizes were calculated using Hedge's g and 95% confidence intervals. Hedge's g effect sizes use the difference between the pre/posttest means, which are then divided by pooled standard deviations for all intervention groups who had a SLD. Control groups were excluded if the participants did not have a SLD and/or did not participate in a specified intervention. The effect size was found to be small if between 0.2 and 0.49, medium if between 0.5 and 0.79, large if between 0.8 and 1.29, and very large if over 1.3.

The Strength of Recommendation Taxonomy[109] was also used to categorize the evidence supporting the handwriting and/or spelling interventions for children with learning disability. Research is found to be of grade A quality if there is consistent, high

quality, patient-centered evidence; grade B if there is varying, limited quality, patient-centered evidence; and grade C if there is consensus, disease-centered evidence.

2.2.3 Results

2.2.3.1 Study Selection

The literature search for handwriting produced 599 articles, which narrowed to 365 after duplicates were removed. After screening abstracts against the inclusion criteria, 10 articles were read in full and four were eliminated as they did not meet the inclusion criteria upon further reading. A hand search of the reference lists from the included articles was conducted, but no novel research was found. Finally, research on handwriting websites was reviewed, but did not yield studies that met the inclusion criteria. One of the studies found was a pilot study conducted by Baldi and Nunzi[103] with three participants, one of which did not have a SLD. The first and second authors decided to include the study and to analyze the results of the remaining two participants with diagnosed SLDs.

The literature search for spelling produced 549 articles, which narrowed to 251 after duplicates were removed. After screening the abstracts against the inclusion criteria, eleven articles were found. From this process, two articles were read further and found to be conducted in non-English formats.[110,111] Nine articles were read in full and four were eliminated as they did not meet the inclusion criteria. A hand search was done on systematic reviews for spelling interventions with children with SLD and one study warranted further review which was subsequently not included as it was not an intervention study Please refer to Figure 2.1 for further information on the literature search process.

2.2.3.2 Study Characteristics

Of the eleven studies included in the final review, two were randomized control trials, three were quasi-experimental, and six were single-case design. Eight of the studies were a level 2b of evidence according to the Centre for Evidence-Based Medicine[112] and three were a level 4, all of which had extremely small sample sizes and used non-standardized outcome measures.[103,113,114]

In both the handwriting and spelling literature, there was overlap between research teams and interventions used. For the handwriting results, Chang and Yu[46,115] conducted two studies with similar aims. The spelling results included two studies with overlapping research teams investigating the use of hope stories coupled with different interventions.[116,117] Additionally, two studies evaluated the efficiency of the Cover, Contrast, and Compare intervention[113,114] (CCC). Finally, two studies researched both handwriting and spelling outcomes, conducted by substantially similar research teams, using related interventions centered around the Human Assisted Writing Knowledge program[34,117] (HAWK).

The interventions across studies generally fell into the overarching categories of tablet- based, visual perceptual and/or sensorimotor, and self-management. A theme of

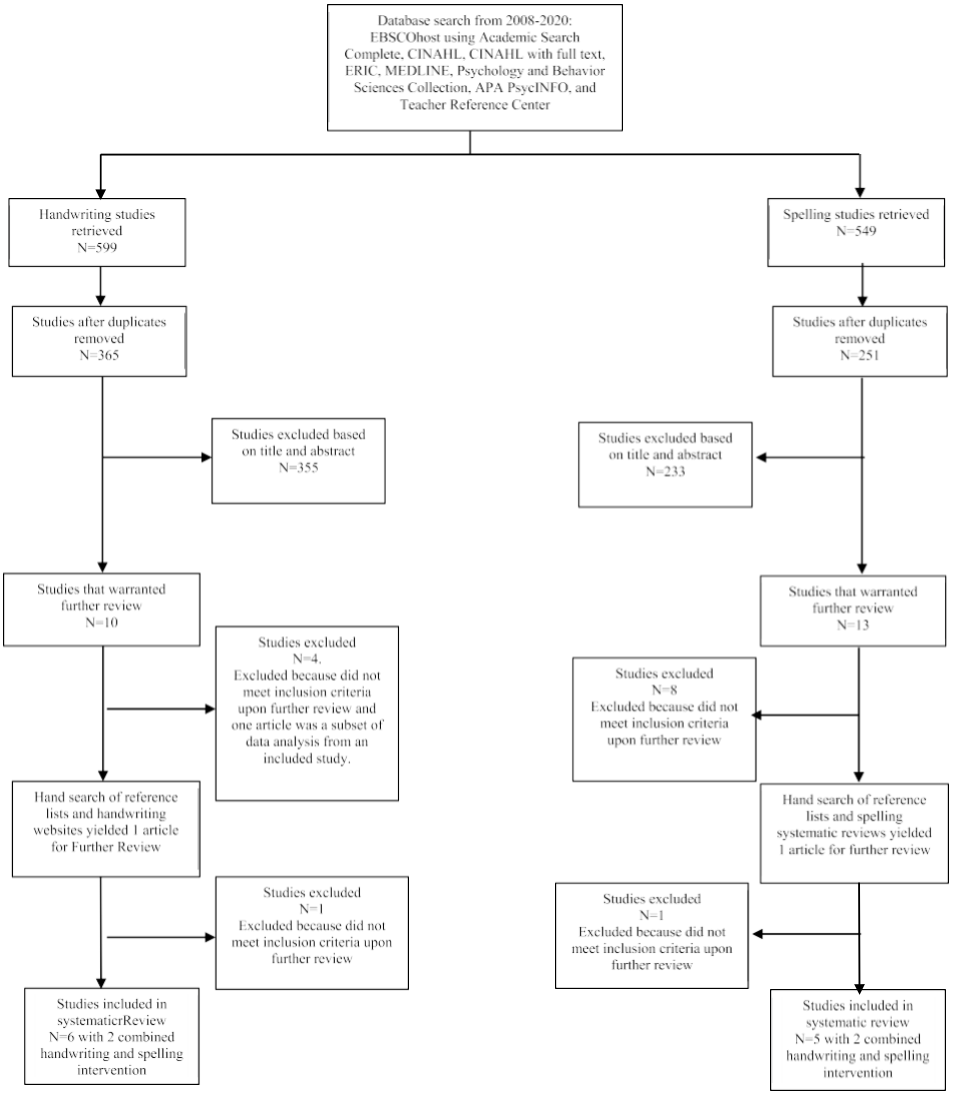


Figure 2.1: Flow Chart of Literature Search

occupation-as means versus occupation-as-ends arose as well, which will be further detailed below. Table 2.2 summarizes the studies, including participant characteristics, interventions investigated, and intervention group results.

2.2.3.3 Study Quality

The first two authors separately completed the Downs & Black checklist[108] and after discussion, reached a strong agreement (0.82 Cohen's kappa) for risk of bias and

critical appraisal. Many possible threats to the validity of the studies were found by both authors.

Only one of the studies utilized blinded assessors[118] and no blinding for participants was found in applicable designs. Compliance of treatment was reported 27% of the time, so it was unclear if participants attended all visits and if they completed home programs if applicable. Attrition rates were also inconsistently reported across studies. It was unable to be determined if participants, both in the intervention and control groups, were recruited simultaneously or staggered across studies. Confounding was not addressed in all the studies, except one where it was only partially alluded,[118] and concealed allocation was not completed throughout the research. The majority of the studies (73%) were found to be of moderate strength using the Downs and Black[108] checklist with two of high quality and one of limited quality. Table 2.3 summarizes the results for risk of bias across studies and critical appraisal scores. The. results from only 12 of the metrics were displayed, including those that investigated specifically performance, reporting, detection, selection, and attrition biases.

2.2.3.4 Effect Sizes

Hedge's g effect sizes and 95% confidence intervals were calculated for nine of eleven of the studies. Effect sizes were not calculated for two studies: Verma, Begum, and Kapoor[119] results were differences in pre/posttest means and standard deviations and it was unclear the standard deviations were pooled; and the Zielinski et al.[114] study because a standardized assessment was not used and the accuracy of spelling was determined based on the performance on the participants' spelling for their individual

classroom weekly assigned vocabulary words, which varied across participants, meaning the effect sizes would not serve as a true comparison to the other studies.

Other considerations about effect sizes were made due to study-specific conditions. The Baldi and Nunzi[103] study had a sample size of three and used descriptive statistics for each of the three participants. Therefore, the mean of each specific outcome for the two participants with a SLD (the third was only found to have poor handwriting) and pooled standard deviation were calculated. Additionally, means and standard deviations were calculated for the results of the Schlesinger and Gray[118] and Zannikos et al.[113] studies to determine the effect size. Finally, the results of the word choice subtest of the Process Assessment of the Learner (see Berninger et al., 2013) were not included in effect sizes as they were not presented as means and standard deviations.

The handwriting outcome measures, because heterogeneous across studies, were separated as those that measured quality and those that measured speed. Spelling was measured in accuracy calculations across studies with certain studies examining total words correct versus phonetic spelling. Not all studies had a control group and if they did, the control group did not always have a comparable baseline, thus the within group effect sizes were calculated only. See Figures 2.2-2.4 for effect size plots.

Table 2.2. Description of Studies

Article	Client Group		Intervention		Comparison	Outcome Measure		Intervention Results
	Intervention Group	Control Group	Treatment	Frequency	Control Group	Assessment(s) Used	Follow-up	
Baldi & Nunzi[103] Single case design 4 Handwriting	N=3; Mean age: 112 months; Grade: 4; Gender: male; Diagnoses: one participant with dyslexia; one with dyslexia and developmental coordination disorder	No control	Handwriting Task Program (performance-oriented program that is a graded, child-specific training activities)	45 min, 2x/week for 13 weeks. Homework for 15-20 min 5-6 days/week. (Individual vs. Group is not indicated)	N/A	Writing analysis of four dysgraphic characteristics; Battery for the assessment of writing skills of children from 7 to 13 years old, which measures speed and accuracy (Italian)	Post-test, 1 month follow-up, 3 month follow-up	All participants had significant reduction in visual-spatial, inadequate motor learning, and motor efficiency errors in handwriting; Improvements in handwriting speed were made from pre- to post-test for all.
Berninger et al.[116]. Quasi-experimental design 2b Spelling	N=12; Age: 9-14; Grade: 4-9; Gender: 2 females, 10 males; Diagnosis: dyslexia	N=12; Age: 9-14; Grade: 4-9; Gender: 3 females, 9 males; Diagnosis: dyslexia	Teacher-led Hope Stories, discussion, journal. Four step treatment program. Step 1: Phonological reading; Step 2: Phonological reading and spelling; Step 3:Phonological reading/spelling, orthographic training; and computerized reading program; Step 4: morphological training and computerized reading program	1 hour, 2x/week for 30 lessons over 5 months. (Group)	Teacher-led Hope Stories, discussion, journal. Four step treatment program. Step 1: Phonological reading; Step 2: phonological reading and awareness; Step 3: Same as step 2; Step 4: orthographic training	Spelling subtest of the WJ III; Spelling subtest of the WIAT 2; Word Choice subtest of the Process Assessment of the Learner (English)	Post-test	Significant gains achieved in spelling by both groups. For intervention group, significant improvement after step 3 as compared to control. Gains levelled out during Step 4 as intervention group plateaued and control group continued to progress.
Berninger et al.[34] Single case design 2b Handwriting and Spelling	N=35; Age: 10 years, 4 months to 14 years; Grade: 4-9; Gender: 80% male; Diagnoses: dysgraphia (n=13), dyslexia (n=17), OWL LD (n=5)	No control	HAWK program on iPad for handwriting, spelling, and composition; stylus and finger used	2 hours, 18 lessons; span of time over which the lessons were provided is not indicated (Individual)	N/A	DASH Best and Fast; Alphabet 15s; Test of Orthographic Competence (TOC) (English)	Post-test	Participants had significant gains in both DASH scores and in the Alphabet 15s score for cursive letters. DASH Copy Best was most significant gain. Twelve of 13 of the students with dysgraphia improved in their handwriting scores. Medium effect size for spelling improvements in all participants.

Table 2.2. Description of Studies (Continued)

Article	Client Group		Intervention		Comparison	Outcome Measure		Intervention Results
	Intervention Group	Control Group	Treatment	Frequency	Control Group	Assessment(s) Used	Follow-up	
Chang & Yu[115] Randomized control trial 2b Handwriting	N=14; Age for total sample: 6 years 8 months to 8 years 7 months; Grade: 2-1; Gender for total sample: 33 males, 9 females; Diagnosis: dysgraphia	N=14 for control group and N=14 for sensorimotor group. The groups were matched by age, gender, and preferred hand to the intervention group.	Computer-assisted handwriting remediation program	45 minutes, 2x/week, 6 weeks; (Individual)	Comparison of sensorimotor intervention (group) and control received handwriting instruction in the classroom	Elementary reading and writing test; Pen movement measurements including, mean pause time, mean peak velocity, and mean exerted force (Chinese)	Post-test	Computer group had significant improvement in speed of near point copy test, handwriting fluency, and exerted force. The sensorimotor group had significant improvement in near point copy test.
Chang & Yu[46] Randomized control trial 2b Handwriting	N=14; Mean Age: 82.14 months (6.84); Grade: 1-2; Gender for total sample: 24 males, 4 females; 3 left-handed; Diagnosis: dysgraphia	N=14; Mean Age: 82.36 months (6.90); Grade: 1-2; 2 left-handed; Diagnosis: dysgraphia;	Sensorimotor with emphasis on visual and haptic perception. Intervention delivered by occupational therapists	45 min 2x/week for 6 weeks (Group)	Handwriting instruction in classroom.	Battery of Chinese Basic Literacy (Chinese)	Post-test	Significant improvement in handwriting speed of far-point copying and handwriting accuracy while copying, with greatest gains in accuracy of far-point copying.
Fusco et al.[120] Quasi-experimental design 2b Handwriting	N=10; Age: 8-11; Grade: 3-5; Gender: not specified; Diagnosis: dyslexia	N=10; Age: 8-10, paired gender and age with control; In good academic standing	Visual motor and visual perceptual exercises	50 min 2x/week for 6 weeks (Individual)	Visual motor and visual perceptual exercises	Dysgraphia Scale (Portuguese)	Post-test	Significant gains in 4 of 10 items on Dysgraphia Scale. Participants improved from 80% of children presenting with dysgraphia to 40% post-intervention.

Table 2.2. Description of Studies (Continued)

Article	Client Group		Intervention		Comparison	Outcome Measure		Intervention Results
	Intervention Group	Control Group	Treatment	Frequency	Control Group	Assessment(s) Used	Follow-up	
Schlesinger & Gray[118] Quasi-experimental design 2b Spelling	N=5; Grade: 2; Gender: 2 females, 3 males; Diagnosis: dyslexia	N=6; Grade; 2; Gender: 4 females, 2 males; Typical development	Multisensory structured language and structured language instruction in same session using two non-English created alphabet grapheme names with associated English phonemes	6 one hour sessions, 1-3x/week, over the course of 6-7 weeks (Individual)	Same as intervention group	Participants were asked to spell words, which were recorded and scored by an interventionist and a trained observer (English)	Post-test (1 and 2 weeks post)	Treatment effect gains in spelling for both multistructured and structured language format for two of three participants with dyslexia, with greater improvements in structured language.
Thompson et al.[117] Single case design 2b Handwriting and Spelling	N=14; Age: 9-12; Grade: 4-6; Gender: 8 males, 6 females; Diagnosis: dyslexia	No control	HAWK program on iPad targeting handwriting, spelling, and composition; stylus and finger used; Combined with Hope Stories with subsequent group instruction and computer coding lessons	2 hours weekly for 12 weeks (Individual and group)	N/A	DASH Best and Fast; Alphabet 15; Spelling subtest of the WIAT 3 (English)	Post-test	Significant gains in both DASH scores, Alphabet 15, and in the spelling subtest of the WIAT 3. Teachers noted improvements in participants motivation and engagement.
Verma et al.[119] Single case design 2b Handwriting	N=40; Age: 6-11, Grade: 1-4; Gender: 31 males, 9 females; Diagnosis: dysgraphia	No control	Occupational Therapy Kit which included HWT materials and workbooks, fine motor activities, and multisensory activities	45 min 3x/week for 12 weeks (Group vs. Individual is not indicated)	N/A	The Print Tool; HWT Screener; (Language not indicated. English assumed with HWT, but location is India.)	Post-test	Significant gains in letter memory, placement, and sentences for participants in grades 1-3 and word and capital cursive for grade 4 using HWT Screener. Significant gains in capitals lowercase, letter and word spacing for all participants using the Print Tool.
Zannikos et al.[113] Single case adapted alternating treatment design 4 Spelling	N=4; Age 10-11; Grade: 5; Gender: male; Diagnosis: specific learning disability	No control	Alternating Cover, Contrast, Compare (CCC), Taped Spelling Intervention (TSI), and control (no lesson, only spelling list probe) interventions	Daily sessions for three weeks with 2 participants receiving 7 intervention sessions and 2 receiving 9 (Group)	Same as intervention group	Correct letter sequence, total words correct, and rate of learning were measured (English)	2+ weeks post-test	Gains in correct letter sequence and total words correct occurred in all participants in both the CCC and TSI interventions with the CCC demonstrating more efficient and greater gains. All participants surveyed relayed a preference for CCC intervention.
Zielinski et al.[114] Multiprobe single case design 4 Spelling	N=3; Age: 14-17; Grade: 9-12; Gender: 1 female, 2 males; Diagnosis: specific learning disability	No control	CCC with spelling words from their weekly vocabulary	2-4x/week over 2 months with 20-22 sessions for each participant; Sessions ~10 minutes (Individual)	N/A	Number of correct spelling and spelling errors recorded by observer and reliability checked by teacher (English)	Post-test	Increased spelling words correct and decreased spelling errors when CCC intervention used. When CCC not employed, accuracy not maintained in participants.

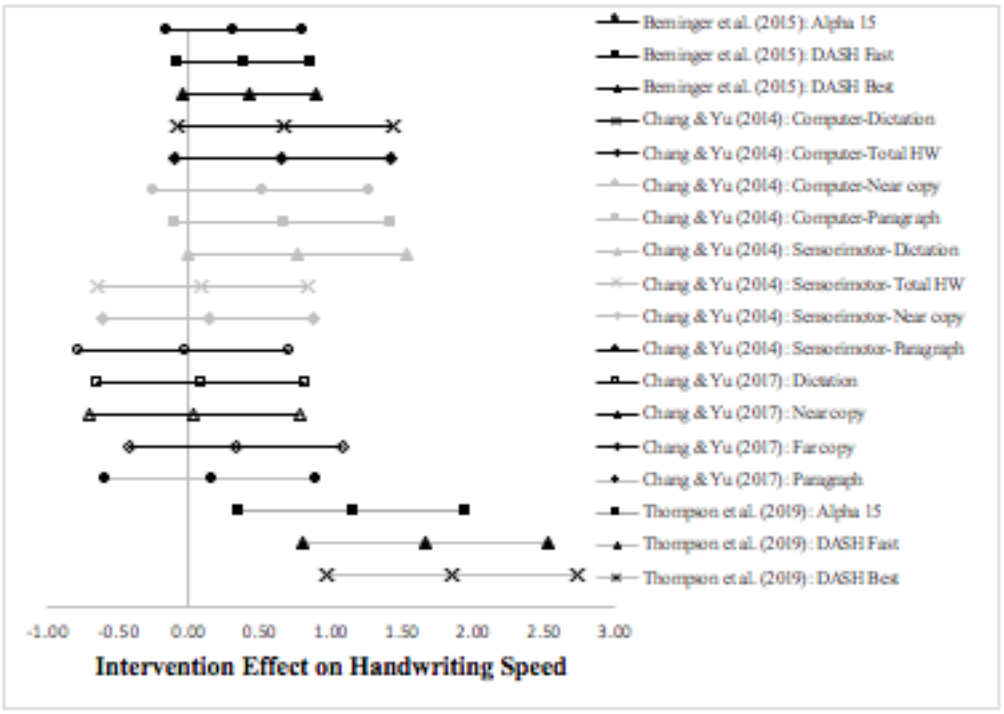
Table 2.3. Results from the Downs and Black Appraisal Checklist[108]

Article		Baldi & Nunzi[103]	Berninger et al.[116]	Berninger et al.[34]	Chang & Yu[115]	Chang & Yu[46]	Fusco et al.[120]	Schlesinger & Gray[118]	Thompson et al.[117]	Verma et al.[119]	Zannikos et al.[113]	Zielinski et al.[114]
Intervention Type		H	S	HS	H	H	H	S	HS	H	S	S
Performance Bias	Participants blinded	N/A	N	N/A	N	N	N/A	N/A	N/A	N/A	N/A	N/A
	Assessors blinded	U	N	U	N	N	N	Y	U	U	N	N
Reporting Bias	Free of selective reporting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Detection Bias	Compliance with treatment	U	U	U	U	Y	U	Y	Y	U	U	N
	Appropriate statistics	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	Accurate outcome measures	Y	Y	Y	Y	Y	Y	N	Y	N	N	N
Selection Bias	Participants recruited from the same population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Recruited over the same timeframe	U	U	U	U	U	U	Y	U	U	Y	U
	Group selection randomized	N/A	N	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A
	Concealed allocation	N/A	N	N/A	N	U	N/A	N/A	N/A	N/A	N/A	N/A
	Adjustment for confounding	N	N	N	N	N	N	N	N	N	N	N
Attrition Bias	Participant loss taken into account	Y	Y	Y	U	U	Y	Y	Y	U	Y	Y
Risk of Bias score		5/9	5/12	5/9	5/12	6/12	5/9	7/9	6/9	3/9	4/9	3/9
Overall Downs and Black score		14/24 (58%)*	14/27 (52%)	13/24 (54%)*	15/27 (56%)**	14/27 (52%)	14/24 (58%)*	15/24 (63%)*	15/24 (63%)*	12/24 (50%)*	9/24 (38%)*	10/24 (42%)*
Interpretation		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	Moderate	Limited	Moderate

** This is scored out of 24 because 3 items were found to be N/A since all cohorts received the same intervention or there was not a control group*

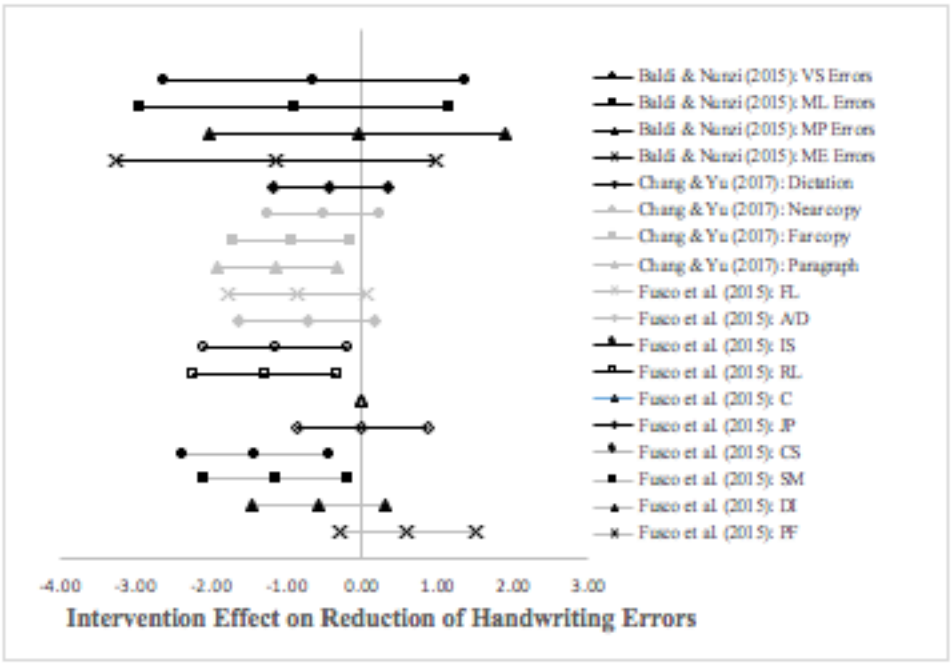
*** Second author scored this article 13/24 (48%).*

Key: H=Handwriting intervention, HS=Combined Handwriting and Spelling intervention, S=Spelling intervention, Y=Yes, N=No, U=Unable to determine, N/A=Not Applicable



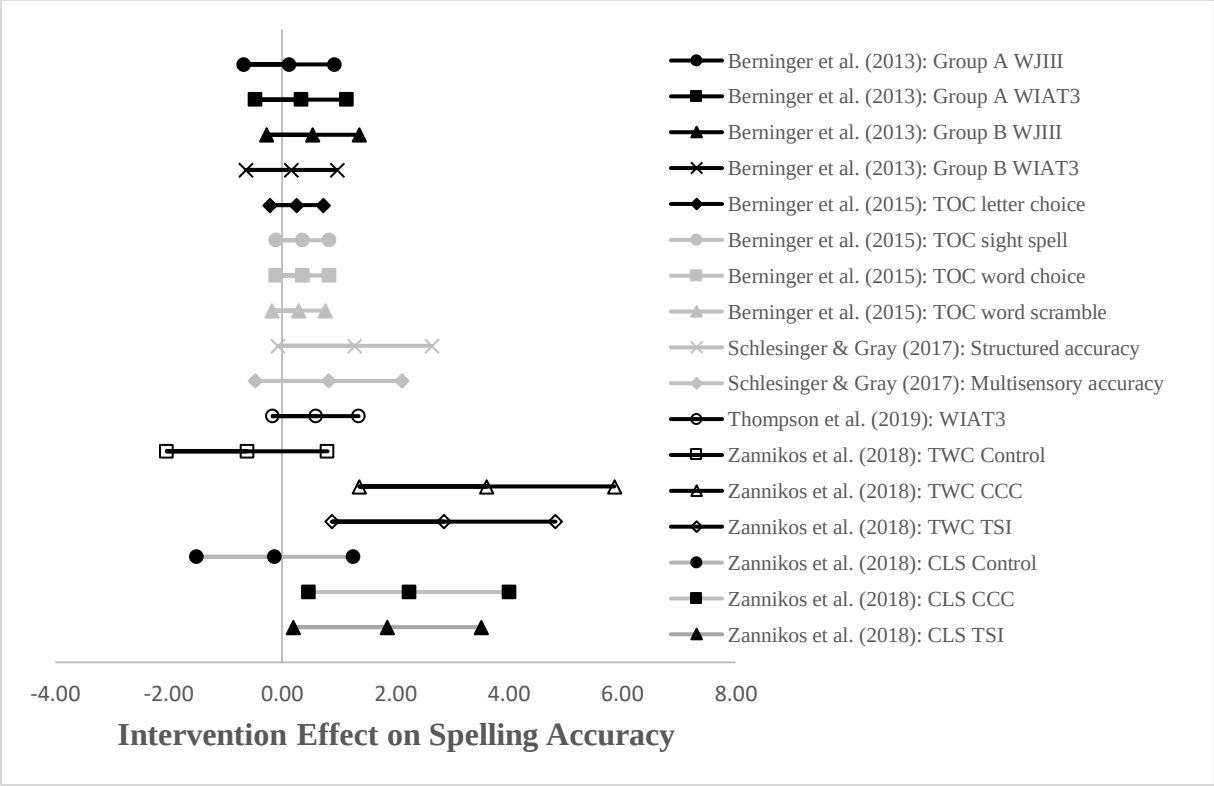
Key: HW=Handwriting

Figure 2.2: Forest Plot of Handwriting Speeds



Key: VS=visual spatial; ML=motor learning; MP=motor planning; ME=motor efficiency; FL=floating lines; A/D=ascending/descending; IS=irregular spacing; RL=retouched letters; C=curvature; JP=junction points; CS=collisions; SM=sudden movements; DI=dimension irregularity; PF=poor form

Figure 2.3: Forest Plot of Handwriting Quality



Key: TWC=Total Words Correct; CLS=Correct Letter Sequence

Figure 2.4: Forest Plot of Spelling Accuracy

2.2.3.5 Individual Studies Results

Themes among the interventions investigated were noted. Three studies utilized tablet- based platforms[34,115,117] with two using the HAWK program specifically to address handwriting and spelling outcomes; four employed sensorimotor and/or visual perceptual techniques[46,115,118,120]; and six emphasized self-management treatments.[34,103,113,114,116,117] Studies were determined to be self-management if the participants were instructed on how to self-evaluate their performance and/or could complete the majority of the intervention independently. These interventions included the HAWK program, the CCC

method for spelling, the Taped Spelling Intervention (TSI) for spelling, and hope stories to improve motivation.

The literature was also examined through a lens of occupation-as-means and occupation-as-ends. Trombly[53] described occupation-as-end as a bottom-up approach to treatment, where client factors are purposefully targeted with occupation as the final goal. Occupation-as-means is a top-down approach with the occupation as the "therapeutic change agent"[53] in which the goal is achieved. Trombly's definitions of these concepts have evolved as occupational therapy addresses both occupation-as-ends as the overarching occupation-based goal and occupation-as-means as the therapeutic approach for treatment[1,121]; thus, using both concepts simultaneously. However, for the purpose of this review, we will define studies that focused on component-level skills (i.e., phonetics activities, visual perceptual exercises) with occupation as the goal (i.e., improvement of spelling or handwriting) as occupation-as-end treatments. Those studies that used occupation as the therapeutic medium will be referred to as occupation-as-means studies.

2.2.3.6 Tablet-based Interventions

Tablet-based interventions were found in the literature for both handwriting and spelling interventions as technology has become more prevalent in our culture. Berninger et al.[34] and Thompson et al.[117] investigated the use of the HAWK program, which is an iPad response-to-instruction program that teaches handwriting, spelling, and composition. It incorporates multisensory components, as it uses verbal instructions, provides written text, requires participants to write using a stylus and their finger, and encourages the students to imitate sounds. Additionally, each student is then responsible for recording their performance to raise self-awareness of areas where improvement is

needed. The Berninger et al.[34] study, which focused on the effectiveness of the HAWK program without a control, found that students with dyslexia, dysgraphia, and/or oral written language learning disability had significant improvements in the targeted outcomes. In this study handwriting speed was measured by the Alphabet 15, Detailed Assessment of Speed of Handwriting (DASH) Fast, and DASH Best and spelling was measured by the Test of Orthographic Competence (TOC). All outcomes had small effect sizes with wide confidence intervals (Alphabet 15s: 0.32 ± 0.47; DASH Fast: 0.38 ± 0.48; DASH Best 0.42 ± 0.48, TOC letter choice: 0.25 ± 0.47; TOC sight spell: 0.36 ± 0.47; TOC word choice: 0.37 ± 0.47; TOC word scramble: 0.29 ± 0.47). Twelve of the 13 participants with dysgraphia demonstrated improvements in their handwriting speed; while 13 of 17 participants with dyslexia improved in one or more areas of spelling.

Thompson et al.[117] also investigated the use of the HAWK program with participants with dyslexia, but in combination with hope stories and computer programming instruction. They found significant gains in handwriting speed as measured by the Alphabet 15, DASH Best and Fast, and spelling as measured by the spelling subtest in the Wechsler Individual Achievement Test, Third Edition (WIAT 3). The results were more convincing than the previous study as the effect sizes were larger with narrower confidence intervals, specifically for the handwriting outcomes where all effect sizes were classified as very large (Alphabet 15s: 1.15 ± 0.8; DASH Fast: 1.67 ± 0.86; DASH Best 1.86 ± 0.89; WIAT 3: 0.59 ± 0.76).

Chang and Yu[115] also studied the use of a tablet-based program in improving handwriting outcomes with children with dysgraphia. They integrated multisensory components into their platform through the addition of visual and verbal input as well as

provided immediate feedback of the user's performance in an effort for the student to self- correct in future attempts. The intervention tablet-based group was found to have significant improvements in fluency of writing as well as speed, specifically with the speed of writing from dictation (0.68 ± 0.76), copying near point (0.51 ± 0.76), copying paragraph (0.67 ± 0.76), and total handwriting (0.66 ± 0.76) as measured by the Elementary Reading and Writing Test, a standardized test used in China. There were medium effect sizes for all of these measures with wide confidence intervals.

The tablet-based interventions were all considered occupation-as-means approaches as these interventions used the occupational goal as the medium through the use of a tablet. For example, Chang and Yu[115] targeted handwriting goals through practicing hand- writing on the tablet. The HAWK program[34,117] incorporated both handwriting and spelling in isolation and then applied these skills to larger compositional practice. Thompson et al.[117] supplemented the HAWK program with instruction on the occupation of computer coding as well as opportunities for social occupations through hope stories.

Overall, the evidence for the use of computer-based interventions for handwriting and spelling outcomes were varied with effect sizes ranging from small to very large. Thompson et al.[117] demonstrated the strongest outcomes, especially with regard to handwriting. As their participants had similar demographics to interventions to the Berninger et al.[34] study, this may suggest opportunities for further occupational exploration through hope stories for motivation and computer coding is a stronger treatment option.

2.2.3.7 Sensorimotor Interventions

Five studies investigated the use of sensorimotor/visual perceptual interventions to target handwriting or spelling outcomes. Chang and Yu[46,96,115] researched the use of a sensorimotor intervention that emphasized visual perception, visual motor integration, and haptic perception with children with dysgraphia. This intervention was considered occupation-as-ends as the sensorimotor component level skills were targeted while handwriting was not addressed; however, there were minimal details provided in how the intervention was executed. In 2014, Chang and Yu[115] compared the sensorimotor intervention as a control to another control group of traditional classroom instruction and the tablet- based intervention previously outlined in the above section. In 2017, the authors researched the effectiveness of this intervention exclusively.[46] In 2014, Chang and Yu[115] found that there were no significant improvements in the sensorimotor group, as compared to a control of in-class instruction, except in the speed of writing from dictation (0.77 ± 0.77). The remaining results had small to no effect size associated with it (total handwriting: 0.10 ± 0.74; near point copy: 0.14 ± 0.74; paragraph copy: −0.03 ± 0.74). In Chang and Yu,[46] the intervention group had significant improvements in handwriting speed with the far point copy test as well as an overall reduction in incorrect characters. There were large effect sizes associated with the reduction of errors in the far point (−0.92 ± 0.78) and paragraph copy subtests (−1.14 ± 0.8), medium effect size with near point copy (−0.51 ± 0.75), and small effect size with dictation (−0.42 ± 0.75). Small effect sizes were associated with all speed improvements (dictation copy: 0.09 ± 0.74; near point copy: 0.03 ± 0.74; far point copy: 0.33 ± 0.75; paragraph copy: 0.16 ± 0.74).

Fusco et al.[120] also studied the effectiveness of targeting visual perception and visual motor integration in order to improve handwriting quality through the use of visual

perception exercises with children with dyslexia as compared to children without dyslexia. This intervention was also considered occupation-as-ends as the intervention targeted the component skill of visual perception and visual motor integration to address occupation of handwriting. Using the Dysgraphia Scale, it was found that the children with dyslexia improved significantly in handwriting quality, including a reduction in errors of floating lines (−0.86 ± 0.91), retouched letter (−1.28 ± 0.96), collusions (−1.41 ± 0.98), irregular spacing (−1.14 ± 0.95), and sudden movement (−1.15 ± 0.94). All had large to very large associated effect sizes with only one metric with a confidence interval that crossed zero. Medium effect sizes were found for the reduction of ascending and descending lines (−0.73 ± 0.90) as well as dimension irregularity (−0.57 ± 0.90), while the remaining three had very small to no effect size (curvature: 0 ± 0; junction points: 0 ± 0.88; poor form: 0.06 ± 0.8).

Verma et al.[119] studied the effectiveness of multisensory techniques to improve handwriting outcomes. They investigated the use of Occupational Therapy Kits for therapists with children with dysgraphia. The Occupational Therapy Kits were based on the Handwriting Without Tears® (HWT) program, which incorporates multisensory techniques to reinforce letter recall and formation through the use of song, gross motor activities, and fine motor tactile tools.[122] The Occupational Therapy Kits Verma et al.[119] utilized for the study included HWT workbooks and HWT manipulatives, in addition to other multisensory fine motor activities. This intervention was categorized as occupation-as-means because it used game, play, and handwriting to reach the overall goal of handwriting improvement. The Print Tool® and the HWT screener were used as measurement tools to determine handwriting outcomes. Significant to highly significant

improvements in all areas of handwriting as measured by both The Print Tool® and the HWT screener were found. As mentioned previously, the effect sizes were unable to be calculated due to the manner in which the statistical results were presented; thus, direct comparisons to the results from the other studies should be made with caution.

Schlesinger and Gray[118] compared the effectiveness of a multisensory structured language program to a sequential structured language program for participants with dyslexia and a control group of typically developing children. The different intervention strategies were introduced to each child separately within each intervention session, using a created alphabet to instruct on phonemes and graphemes. The interventions were adapted from the Orton Gillingham approach with multisensory techniques incorporated for half the structured language instruction and omitted for the second half. Orton Gillingham instruction incorporates the use of multisensory strategies, language-based direction, structured instruction, and flexibility to the individual to target reading outcomes.[123] The study intervention was classified as occupation-as- ends with the final target to improve spelling abilities through addressing component-level skills of phonemes and graphemes. Outcome measurements were determined by spelling accuracy on dictated words; however, the word list or how the words used were determined was not provided. The researchers found large effect size changes with wide confidence intervals for spelling accuracy for both interventions for the participants with dyslexia (structured group: 1.29 ± 1.36; multisensory group: 0.82 ± 1.36).

Overall, the effect sizes for multisensory literacy interventions were varied, but found to be most effective in the results for handwriting quality as half the effect sizes were large to very large with six of seven of those having confidence intervals that did

not cross zero,[120] indicating a higher level of accuracy with the results. The Verma et al.[119] study also contributed preliminary evidence to support the use of multisensory, occupation-based, techniques to promote handwriting outcomes.

2.2.3.8 Self-management Interventions

Promotion of autonomy was a theme that was seen in the tablet-based interventions as well as in the following four studies where having an active role of self-revision and/or self- management were emphasized. These interventions were self-led by participants, and in some instances, were tools that could be utilized independently after the study. Two studies investigated the use of the CCC method, where the participants were initially taught this strategy to assist in learning spelling words. Both of these studies were thought of as occupation-as-means as they adapted spelling education to improve spelling outcomes. The CCC method has the student cover the word, write the word, reveal the word, contrast with the spelling word stimulus, and revise as needed.[113,114] Zielinski et al.[114] investigated the effectiveness of CCC with three individuals with SLD. The spelling words used for both assessment and intervention were taken from the individual students' weekly vocabulary lists. Spelling accuracy was assessed at each intervention; however, no standardized test was utilized. During the CCC condition, participants demonstrated improvements in spelling accuracy; contrastingly, when the CCC program was suspended, the students did not continue to have spelling gains.

Zannikos et al.[113] compared the effectiveness of CCC versus another self-managed technique of the TSI program. The TSI is an audio program where the student is given the word, writes the word, and then is provided the correct spelling of the word, revising

spelling as needed. Four participants used both programs during each intervention session and demonstrated greater improvements in spelling, as well as more satisfaction, with the CCC program as compared to the TSI; however, improvements were associated with both techniques. Again, informal measurements were used to assess total words correct (TWC) and correct letter sequence (CLS) on intervention-specific assigned spelling lists with a control probe. The spelling words associated with CCC and TSI were administered daily whereas the control probe was administered every three days. The effect sizes were very large for both the CCC and TSI interventions with stronger results for the CCC strategy (TWC CCC: 3.61 ± 2.25; CLS CCC: 2.24 ± 1.17; TWC TSI: 2.85 ± 1.97; CLS TSI: 1.85 ± 1.66). Even though the results for this study are strong, they should be interpreted with caution due to the small sample size. Additionally, the participants were introduced daily with the associated spelling words with the CCC and TSI interventions, and every few days with the control probe spelling list. Thus, familiarity with the words may contribute to the participants' progress as well.

A pilot study performed by Baldi and Nunzi[103] investigated the effectiveness of the use of an intervention that promoted both individual and familial self-management of treatment. The research team introduced the Handwriting Task Program to their participants, a task-based program that relied on scaffolded feedback of performance through the use of prompts, both verbal, visual, and if necessary, physical. It reinforced the behavior of revision and repair and incorporated the role of family with frequent homework. Although this method was less independent than the two introduced previously, it encouraged the participants' active role in checking their work. The Handwriting Task Program also targeted client factors of visual perceptual, visual motor,

and eye-hand coordination through activities and exercises. The Handwriting Task Program was considered an occupation-as-ends approach because it focused on exercises for eye-hand, copying, pre-writing, and movement-based rather than addressing handwriting as a whole occupation. The study had three participants, one with dyslexia; one with dyslexia and developmental coordination disorder; and one with poor handwriting. The two participants with diagnosed SLDs improved in the quality of their writing as they had a reduction of errors in three of four areas of handwriting assessed. There were large effect sizes for a reduction in motor efficiency (-1.14 ± 2.11) and motor learning errors (-0.90 ± 2.06), a medium effect size associated with the decrease in visual spatial errors (-0.63 ± 2.01), and a small effect size for motor planning errors (-0.06 ± 1.96). All effect sizes had significantly wide confidence intervals. The clinical significance of these results is minimal as there were only two sets of heterogeneous results, thus reducing the validity and generalizability.

Berninger et al.[116] investigated the effectiveness of a reading and writing workshop. The interventions were mostly therapist-led, however, the study also incorporated self- management through the participant-led use of the Rapid Accelerated Reading Program[116] (RAP). The workshops compared two groups who underwent a four- step instruction to reading and writing techniques, which included the RAP for one group. Group A received increased instruction in grapheme-phoneme correspondence in reading and spelling, as well as exposure to the RAP program, orthographic spelling, and morphological awareness training. Group B received instruction with emphasis on grapheme-phoneme correspondence for reading and a later introduction to spelling strategies. Both groups also participated in hope stories to improve motivation. Both

groups demonstrated improvements in spelling with Group B minimizing the gap between groups in the final step, which was after Group A had suspended grapheme-phoneme correspondence instruction. These interventions were also categorized as occupation-as-end because the intervention primarily targeted component-level skills, such as grapheme-phoneme correspondence, with spelling as the overarching goal. Spelling outcomes were measured on the spelling subtest of the WIAT 3 and the Woodcock Johnson III (WJ III) with small effect sizes for Group A and small to medium effect sizes for Group B, all with large confidence intervals (Group A WIAT 3: 0.34 ± 0.81; Group A WJ III: 0.13 ± 0.8; Group B WIAT 3: 0.17 ± 0.8; Group B WJ III: 0.55 ± 0.81).

Overall, the trend for the self-managed interventions was the more independent the use of the technique, the stronger the results, with larger effect sizes and narrower confidence intervals. These intervention strategies lend themselves to occupational therapy with the focus on engagement, ownership, and independence. As occupational therapists, promotion of autonomous strategies to improve engagement in literacy occupations should be targeted. Additionally, the use of meaningful interventions, such as explicit instruction of strategic tools a child can use to self-correct, increases the student engagement in educational performance while improving performance skills and performance patterns. However, these results should be regarded cautiously as many of these studies had smaller sample sizes[103,113] and other methodology considerations, such as unstandardized assessments, may have inflated the effect size results.

2.2.3.9 Strength of Recommendation Taxonomy

This systematic review investigated the effectiveness of interventions to support hand- writing and/or spelling outcomes in children with SLD. The literature search found eleven studies ranging from a level 2b of evidence to a level 4 according to the Centre for Evidence- Based Medicine.[112] The three level 4 studies all had small sample sizes (3–4 participants) and two did not use standardized outcome measures. They were included in this systematic review for their preliminary contribution to the usefulness of these specific techniques. Additionally, these studies provided a more robust sampling as Chang and Yu[46,115] authored two of the eleven articles with similar investigative aims, Berninger et al.[34,116] authored two articles and was on the research team for Thompson et al.[117] Eight of the studies were found to be of moderate quality using the Downs and Black[108] checklist, two of high quality, and one of limited quality. Many potential threats of bias were found throughout the research as there was inconsistent reporting of blinding, compliance, and confounding. The majority of the studies had significant gains in quality and/or speed of handwriting and spelling accuracy for the investigated interventions with effect sizes and confidence intervals that ranged in clinical significance. Accordingly, using the Strength of Recommendation Taxonomy,[109] it was found that there is grade B evidence to support the effectiveness of interventions in improving handwriting and/or spelling outcomes for children with SLD. Grade B evidence is described as the use of patient-oriented evidence that is of limited quality and inconsistent findings.[109]

2.2.4 Discussion

2.2.4.1 Handwriting versus Spelling

The research was varied when comparing the two lines of research investigating handwriting versus spelling intervention effectiveness. There were larger effect sizes associated with the handwriting intervention studies as compared to the spelling studies, indicating more clinically significant results. This trend could have been due to the greater amount of metrics used to measure handwriting as 17 effect sizes were calculated for spelling as compared to 36 for handwriting. The handwriting literature tended to use more standardized assessment measures as well when compared with spelling. Additionally, the handwriting studies had larger sample populations with 122 total participants as compared to 36 for spelling research and 49 for combined spelling and handwriting.

It was found that children with dysgraphia were underrepresented in the spelling literature as only 15% of participants had a diagnosis of dysgraphia, although handwriting difficulty is commonly associated with spelling deficits.[12] Contrastingly, participants with dyslexia were not prevalent in the handwriting research, even though children with dyslexia commonly struggle with handwriting.[12] This may indicate that dysgraphia is not diagnosed formally as frequently as it is being observed with children with dyslexia.

2.2.4.2 Frequency

Hoy, Egan, and Feder[52] conducted a systematic review that analyzed handwriting interventions for children with difficulty with handwriting and found frequency to be a key determinant of success. This systematic review found the frequency of handwriting intervention delivered to the participants varied across studies both in duration of total treatment and frequency of weekly meetings. A positive relationship was found with

frequency as all of the 12 to 13-week studies had significant gains in handwriting outcomes as compared to those studies conducted over a shorter duration with the exception of the Fusco et al.[120] study. The Fusco et al.[120] research had large associated effect sizes in just six weeks. The frequency of spelling interventions did not have as conclusive a relationship between duration and effect sizes. Two to three months was approximately the average treatment time across studies. Zannikos et al.[113] had significant results in just three weeks and Schlesinger and Gray[118] had large effect sizes in six to seven weeks. Contrastingly, Berninger et al.[116] met twice a week for five months with less convincing small-to- medium effect sizes.

2.2.4.3 Assessment Tools

The quality of assessment tools was wide-ranging, which should be acknowledged when determining the clinical significance of the outcomes. The results for handwriting quality were more clinically significant than those for speed, but the measurement tools for speed were more accurate and reliable. Speed was measured using the DASH Best and Fast, Alphabet15s[34,117] and the Elementary Reading and Writing Test,[115] later referenced to as the Battery of Chinese Basic Literacy[46] (BCBL). All of these assessments were reported to be standardized.

None of the assessments used for quality were standardized. Three studies adapted classifications systems and measurement tools for their specific studies.[46,103,120] Verma et al.[119] utilized the HWT screener and the Print Tool® to assess quality. The screener is not intended to be a formal assessment tool, but a quick reference to determine if and in what areas a child requires further instruction.[124] The Print Tool® is also not a standardized or norm-referenced evaluation, however it is utilized in research often,

especially when the intervention is HWT specific. It has undergone pilot studies that have found it has moderate to good reliability, sensitivity, and specificity.[125] A limitation of the overall handwriting literature is much of the research is conducted in various languages, such as Italian, Portuguese, and Chinese, where standardized testing of quality may not be available. This is significant because it does not allow for an accurate examination of where the breakdown is occurring.[126]

Three of the six spelling studies used spelling measurements unique to their studies[113,114,118] and only Zannikos et al.[113] provided enough information for the testing procedures to be replicated. The largest effect sizes with spelling were associated with non-standardized measurements of spelling.[113,118] Thus, the clinical significance of these results is in question because there is the lack of reliability of the assessment tools. Three studies[34,116,117] used standardized measures with high test–retest reliability with the TOC, WIAT 3, and WJ III, but the majority of these outcome measures had small effect sizes with only two of nine metrics scoring in the medium effect size range. The spelling intervention research needs to be continued as the evidence is not persuasive without replicability of the use of standardized measures.

2.2.4.4 Occupation-as-Means versus Occupation-as-End

In a systematic review of occupational therapy interventions to improve academic participation, Grajo et al.[51] found interventions that target component skills, such as sensorimotor, visual motor, in-hand manipulation abilities, did not improve handwriting quality. Thus, this systematic review compared the effectiveness of using a component-level, occupation-as-ends approach versus an occupation-as-means approach at targeting spelling and/or handwriting outcomes. The interventions found in this systematic review

that were categorized as occupation-as-end focused on improving visual perception, visual motor, and sensorimotor skills[46,103,115,116,118,120] when addressing handwriting and/or spelling goals. The studies with an occupation-as-means approach used handwriting- specific or spelling-specific interventions.[34,113-115,117,119] After appraising and synthesizing the research, it is indicated that an occupation-as-means approach leads to more significant outcomes as compared to an occupation-as-ends. The occupation-as-end interventions had 45% of its results associated with medium to very large effect sizes, with 91% of confidence intervals crossing zero, signifying more variability in the results. The occupation-as-means group used handwriting and spelling adaptations itself as the intervention tools. The interventions for handwriting were often broken down to specific letter instruction, but handwriting was interwoven throughout the treatment. This cohort exhibited 72% of results associated with medium to very large effect sizes with 61% of confidence intervals crossing zero. Four of the six occupation-as-means studies[34,113,114,117] employed a form of participant ownership over their performance or intervention and encouraged self-evaluation as well as self-revision. Of these four studies, 64% had medium to very large effect sizes with 50% of confidence intervals crossing zero associated with the results.

2.2.5 Limitations

There are limitations associated with this systematic review. The lack of consistency with assessment measures used as well as the varied standardizations of assessments reduces the ability for direct comparison. Effect sizes and confidence intervals were calculated to provide an unitless measure in which to compare the results, but the majority were found to have wide confidence intervals with 74% of confidence

intervals crossing zero. Additionally, there were two studies where effect sizes were unable to be calculated.[114,119]

The participants' age differences also added an element of variability that decreased generalizability. In the handwriting literature, for example, Chang and Yu[46,115] had participants that were in first and second grades, while Berninger et al.[34] used students from fourth through ninth grades. These participants were developmentally in different stages of acquisition of written handwriting, both cognitively as well as motorically. The expectations of writing and spelling are higher in both quality, speed, and quantity for a ninth grader than a first-grader. For the spelling interventions, the age ranged from second-graders used in the Schlesinger and Gray[118] study to high school students, including seniors, in the Zielinski et al.[114] study. The expectations for spelling are developmentally quite different at these ages as the compositional challenges are greater with increased time restrictions as the student progresses through school.

Another confounder for generalizability in the handwriting interventions is the differences in language. Two articles used Chinese,[46,115] one Portuguese,[120] one Italian,[103] two English,[34,117] and one undetermined, but presumed English given it used the HWT curriculum although completed in India.[119] The occupational demands for Chinese as an orthographic language are different than that of English[126,127] and again may undermine the translatability of these results.

The spelling literature search was restricted to English only studies due to the unique qualities of the English language and subsequent demands on spelling; however, the author may have excluded studies that would have been beneficial and generalizable to English interventions. For example, two studies found neurofeedback to be an

effective intervention to remediate spelling difficulties in children with dyslexia, but they were conducted in Dutch[110] and Persian.[111]

The follow-up testing for the found investigations was limited to immediate posttesting in the majority of the literature. Of the seven handwriting studies, only the Baldi and Nunzi[103] study examined at results three months post-intervention. Of the six spelling studies, all measured at posttest with one study conducting final assessments two to three weeks post.[118] Since most of these studies were completed in six- to twelve-week intervals, none of the articles address the familiarity the participants have with the assessment as a potential to have false-positive results. Additionally, by not having follow-up testing it is undetermined if the improvements were sustained and generalized into the participants' handwriting and spelling skills.

The literature search, although exhaustive, only found eleven studies with six of those investigating similar or same interventions.[34,46,113-115,117] Additionally, there were two sets of research teams represented two to three times in the literature with the Chang and Yu[46,115] studies and Berninger et al.[34,116] and Thompson et al.,[117] which accounted for the majority of the replication in intervention use. This repetition overrepresented these interventions in the results for this systematic review.

2.2.6 Conclusion

In a survey conducted by Polinchino,[87] it was found that 79% of school-based occupational therapists are already supporting a child's literacy participation in treatment. As occupational therapy continues to expand their role in literacy support, it was necessary to examine the research for the effectiveness of handwriting and spelling

interventions for children with literacy difficulties, such as those diagnosed with SLD. The evidence found in this systematic review has moderate overall support of the effectiveness of current hand- writing and/or spelling interventions with children with SLD. The most clinically significant results are for the occupation-as-means approach, and specifically the self-reflection and self-correction as described in the Zannikos et al.[113] and Thompson et al.[117] research. Although these studies had relatively small sample sizes with the Thompson et al.[117] having the largest cohort of 14 participants, it provides preliminary research that this is an effective technique for occupational therapists to use. Traditionally occupational therapists have not directly addressed spelling with clients, but they are able to address participation in spelling endeavors, using occupation-as-means with a focus on client-centered independent management. Further research should target cognitive-based approaches, which center on client involvement and ownership, with more standardized outcome measures as well as a longer length of follow-up. It may also be beneficial to have more studies conducted in English as this is generalizable to larger parts of the population and has more standardized assessment measures in which to test quality of handwriting.

Additionally, it is felt that further handwriting studies with participants who have been diagnosed with dyslexia would be of value. For the handwriting literature, only 25% of participants were diagnosed with dyslexia, yet this group yielded the strongest results. Children with dyslexia account for 80 to 90% of those diagnosed with a SLD.[93] This population of those who have dyslexia is under- represented in the handwriting literature as much of the research in this field is focused on writing composition. Handwriting, however, is the underlying basis for writing composition. If the mechanics

and procedure for handwriting are delayed, there will not be a legible end product. Additionally, if handwriting becomes automatic a larger portion of the working brain can be allotted for composition.[34]

In contrast, children with dysgraphia are underrepresented in the spelling literature as only 15% of participants were diagnosed with dysgraphia. It is frequently seen that dysgraphia is a comorbidity with dyslexia as well as difficulty spelling.[12] If a child has to concentrate on the physical mechanics of handwriting, it will negatively impact spelling.[34] Overall, further research needs to be conducted for all students with SLD to help support the occupation of handwriting and to provide therapists and teachers evidence-based tools to utilize in this arena.

2.2.7 Supplemental Search

The literature search for the above systematic review was last conducted in March 2020.[84] Utilizing the same search criteria, Boolean operators, and databases as listed in the systematic review, two literature searches were conducted to locate research on handwriting interventions and spelling interventions on April 6, 2022. The results yielded 59 articles using the handwriting Boolean operators after duplicates were removed. Upon an abstract and title search, two articles were further reviewed, but did not meet the inclusion criteria. Using the spelling Boolean operators, 29 articles were found once duplicates were removed. Four studies warranted further review, but were not included as they did not meet inclusion criteria. Please refer to Figure 2.5 for a summary flow diagram of the results from this literature search. Thus, no further articles were added to the systematic review of the literature.

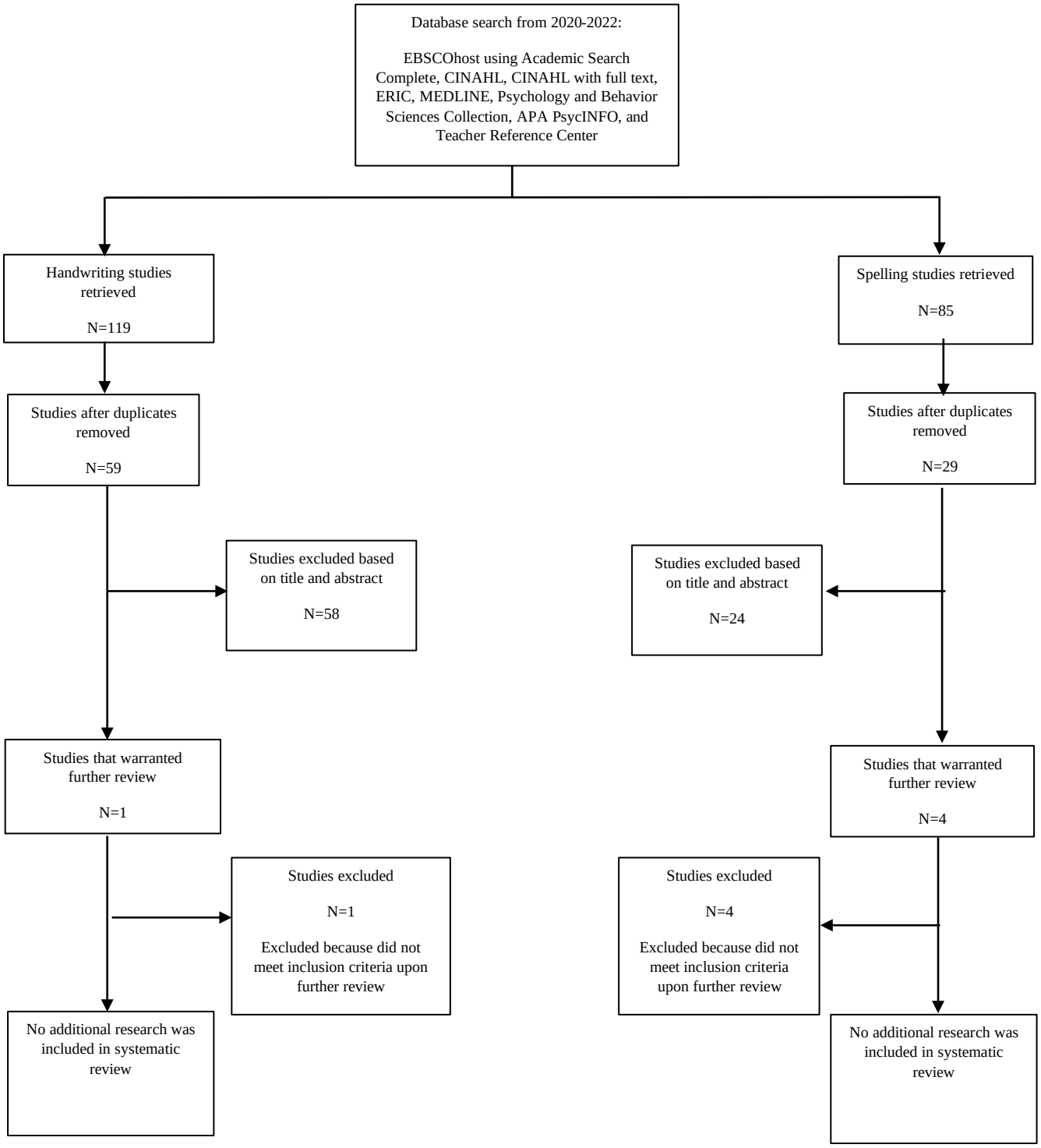


Figure 2.5: Flow Diagram of Second Literature Search Results

2.3 Pediatric Telehealth Literature Review

As this project proposes to examine the feasibility and effectiveness of the HWT program via telehealth, a literature review of telehealth was completed as well. Research on telehealth as a service delivery method for pediatric occupational therapists has received increased attention since the COVID-19 pandemic. A systematic search of the literature was conducted to examine the literature on pediatric occupational therapy telehealth. Articles were included if they were written about telehealth used by allied health professionals and/or occupational therapy; researched telehealth in outpatient and home settings; were written in English; and published in an academic journal. Articles were excluded if they were written in other languages; written about adult therapy; and/or only had an abstract.

The literature search was completed using EBSCOhost with the search databases of Academic Search Complete, CINAHL with full text, ERIC, MEDLINE, Psychology and Behavioral Sciences Collection, APA PsychINFO, and the Teacher Reference Center. The search was conducted in Spring of 2022 with a final search date of April 7, 2022. The search terms included pediatric, occupational therapy, and telehealth with synonyms to maximize results. The search terms and Boolean operators are displayed in Table 2.4 below.

Table 2.4. Search Terms and Boolean Operators

Child OR; Children OR; Pediatric	A N D	Telehealth; OR Telerehab; OR Telerehabilitation	A N D	Occupational Therapy

Using the above criteria, 48 articles were located. The titles and abstracts were screened to determine if the article warranted further review. Nine articles were read in

full and incorporated in the literature review. Using a supplemental search through a hand search and Google Scholar, an additional 19 articles were found. Not all of the articles in the second search focused on pediatric occupational therapy, but provided useful information on occupational therapy usage of telehealth services across the lifespan. Thus, a total of 28 articles were read and considered.

The literature on pediatric occupational therapy telehealth covers a broad range of research topics. The literature can be categorized as follows examining: the family perspective (n=11); occupational therapist perspective (n=9); telehealth utilization (n=4); and telehealth intervention effectiveness (n=11).

2.3.1 Family Perspective on Telehealth

The research eliciting clients' (caregivers and children) perspectives on telehealth delivery was predominantly collected by survey and interview research methods. Eleven articles included information about the familial experience of receiving telehealth pediatric therapy. Therapy administered via telehealth was overwhelmingly perceived as positive by families. The benefits associated with telehealth included the following: adaptable to family routine and work schedules[60,128-130]; continuity of care[59,129]; cost-efficient[58,59,128]; improved family communication with clinician[128,131]; increased access for rural and/or homebound children[58,129-131]; enhanced perception of self-efficacy by caregiver[132]; and families were more comfortable in their setting of choice.[58,60,78,129] There were associated telehealth challenges experienced by families as well, such as technological issues and barriers.[60,128] In a systematic review conducted by Grant et al.,[60] in four studies, participants reported a negative impact on the relationship between the child and the therapist; however, to counter, Grant et al.[60] found an additional seven

studies that reported telehealth had a positive impact on the therapeutic relationship. Thus, the person, environment, and associated occupational performance issue may influence the client-therapist relationship via telehealth.

Even with this abundance of literature of positive caregiver perception of telehealth, the adoption of telehealth was reported to be slow. At the start of the pandemic, Aranki et al.[133] found 40% of families declined the use of telehealth to receive allied health services. In another survey, a tenfold rise in children receiving services via telehealth was reported during the beginning of the pandemic, but this only accounted for a third of their respondents.[78]

Nine of the articles seeking caregivers' perspectives were conducted pre-pandemic[58-60,128-132,134] and two were conducted during the pandemic[78,133]; thus, no research has been collected since the duration of the pandemic where clients and caregivers are more familiar with communication via an online platform, which may impact their perspectives positively or negatively.

2.3.2 Occupational Therapist Perspective on Telehealth

The perspective of the pediatric occupational therapist has been sought in the telehealth research as well. Nine articles discussed the advantages and challenges of telehealth experienced by the occupational therapist delivering services. Benefits associated with telehealth identified by occupational therapists included diminished delays from referral to service delivery[61]; expanded access to clients[56,61,130]; caregiver and families were more actively involved in treatment[58,128,129]; enhanced communication with the interdisciplinary team when delivered in the school[56,128]; decreased travel time[56];

flexibility with scheduling[56,128]; increased client attendance; better adherence to recommended home programs; lower associated costs[62]; and families appeared more comfortable in their homes.[128]

Occupational therapists also reported a number of challenges experienced when using telehealth, including technological issues[56,60,62,63,128,129]; difficulty monitoring client progress[63]; necessity of having a caregiver or e-assistant to deliver services[56,63]; families did not have appropriate intervention materials[63]; inability to provide physical cues[56,60]; scheduling issues[62]; and additional work outside billable hours.[129] While decreased confidence with using technology was relayed as another challenge,[60] Abbott-Gaffney et al.[63] found 69% of occupational therapists felt confident in their abilities to deliver telehealth services. Seventy eight percent of the respondents in an additional survey reported they felt telehealth should remain a permanent service delivery option in their practice once the pandemic subsided.[58]

2.3.3 Telehealth Utilization

Four articles reported on utilization of telehealth with occupational therapy. In a pre-pandemic systematic review, increased client attendance and adherence with home program recommendations were associated with telehealth utilization.[62] Three surveys of occupational therapists were conducted during the pandemic to inform telehealth usage. Ganesan et al.[55] used a cross-sectional survey with occupational therapists globally and determined a 68% increase of telehealth usage by occupational therapists during the pandemic. Abbott-Gaffney et al.[63] had an even higher reported increase in usage with 92% of respondents not using telehealth prior to the pandemic and 99% using telehealth during the pandemic. The World Federation of Occupational Therapy conducted a

survey during the pandemic as well with global occupational therapists.[135] This survey provided information on how occupational therapists were using telehealth, including consultations, interventions, monitoring services, supervision, and evaluations. Further research in this area needs to be conducted to observe usage trends as contact restrictions have lessened.

2.3.4 Telehealth Intervention Effectiveness

Eleven articles discussed the effectiveness of pediatric occupational therapy interventions delivered via telehealth, but there was a wide range in targeted outcomes; interventions used; demographic characteristics of the participants; and client setting where services were received.

2.3.4.1 School-Based Occupational Therapy

Three studies provided school-based occupational therapy via telehealth delivery with promising outcomes.[134,136,137] One telehealth study provided typical occupational therapy and speech therapy services with 98 participants in kindergarten to sixth grade, attending rural schools.[137] The targeted outcomes included classroom participation, which were reported as improved by teachers of the participants. It was noted children in second grade to be most responsive to the telehealth format.[137] An additional case study was conducted to determine the effectiveness of a video-based game to two participants in the school setting.[136] The results indicated a positive correlation between treatment and outcomes, but therapists delivering the therapy noted a difficulty in maintaining participant attention at times. Lastly, Criss et al.[134] researched the effectiveness of targeting fine motor and handwriting goals using telehealth delivery, with the majority of

participants improving in handwriting legibility. Seventy one percent of the participants relayed they preferred the online format as compared to in person. It should be noted these students attended an online charter school and were familiar with the virtual format.

Of the six pediatric occupational therapy telehealth studies conducted in the natural environment, the studied interventions included upper and lower extremity training (n=3); family education and/or coaching (n=3); and typical therapeutic services (n=1).

2.3.4.2 Upper and Lower Extremity Training

Three studies investigated the effectiveness of pediatric upper and lower extremity training delivered via telehealth. A case study was conducted examining the impact of a personalized video game in increasing upper extremity use in an adolescent with cerebral palsy.[138] The study had promising results as the participant used his affected limb more frequently as well as exhibited improved bone density in that limb. Two related research projects with participants with cerebral palsy compared the results of a parent-delivered hand-arm bimanual intensive therapy (HABIT) program with weekly monitoring via telehealth provided by occupational and physical therapists.[139,140] Both studies compared the effectiveness of HABIT program with the lower-limb intensive functional training (LIFT) via telehealth. One study targeted upper extremity outcomes[139]; while the other study focused on lower body measures.[140] In the study targeting upper extremity goals, the HABIT program demonstrated progress in dexterity and functional goals[139], while both interventions improved parent satisfaction.[139,140] In second study, the LIFT intervention had superior results as compared to the HABIT program for lower extremity outcome measures, such as the one-minute walk test.[140] All

three of these studies delivered improvements in the targeted outcomes, providing support to the effectiveness of upper and lower extremity training delivered via telehealth.

2.3.4.3 Family Education and Coaching

Family education was noted as improved throughout much of the telehealth literature, but was directly studied in research in a systematic review[141] and two case series study.[142] The systematic review examined the effectiveness of family education interventions used to reduce caregiver stress associated with raising children with medically complex conditions.[141] Five of the articles included in the systematic review were delivered via telehealth and were found to reduce stress and anxiety experienced by the families; increase access to services; improve family education; and have an overall quality of life benefit. In the case series study, a family education program was provided via telehealth for families who had children with autism.[142] This project was designed pre-pandemic, but conducted during the pandemic, and thus encountered additional family stresses and issues. Of the four participating families, all met at least one self-identified goal and two families met all of their goals for the program. Little et al.[132] investigated the effectiveness of a family coaching model via telehealth for families with young children diagnosed with autism. With the coaching model, the occupational therapist assisted the families to identify goals for their child and facilitated problem-solving occupational performance issues in the client's context. The study demonstrated that this approach improved the child's participation in activities in the home and the parent's self-efficacy in their ability to engage their children.

2.3.4.4 Therapeutic Practice

One study investigated the transition of typical, in-person occupational and speech therapy services to delivery in a telehealth format for four case children aged 5 to 8 who resided in rural Australia.[129] The clinicians perceived the study as a positive experience as they were able to build solid therapeutic relationships with not only the client, but the families and local providers as well. Additionally, they were able to meet client-centered goals, addressing a variety of outcomes. However, additional time was required of the practitioners to set-up and deliver services.

Overall, research into the effectiveness and feasibility of pediatric occupational therapy telehealth is in its infancy. The overwhelming majority of the articles found were pre-pandemic (n=21) or at the beginning of the pandemic when contact restrictions were at their highest (n=7). This literature search did not find any articles since contact restrictions have lessened, which is important to note because families have increased experience with videoconferencing. Olson et al.[143] advocated for telehealth research to indicate if the standard of care is maintained from in person care to a telehealth delivery format, which is relevant as with lessening contact restrictions, families now have a choice of service delivery options. Currently, there is not enough research to support the superiority or equivalency of one service delivery method to another.

2.4 Theoretical Background for Project

As discussed in Chapter 1, the Occupational Therapy Practice 4th edition[1] (OTPF) served as a framework in which to guide the development of this project. Two theories also served as guiding principles in this investigation, neuroplasticity principles[71] and the Self-Determined Occupational Performance Model[2] (SDOP).

2.4.1 Occupational Therapy Practice Framework (OTPF)

The OTPF is a framework developed by the American Occupational Therapy Association[1] (AOTA) to define the domain and process of occupational therapists. It is updated and reviewed every five years in order to maintain a current perspective on the scope of occupational therapy practice. It guides occupational therapists' approach, providing insight in the depth and breadth of what occupational therapists should consider in their practice. The central tenant of the OTPF, and thus of the practice of an occupational therapist, is assisting clients with "achieving health, well-being, and participation in life through engagement in occupation."[1] This is realized through careful attention to the connectedness between client factors, occupations, contexts, performance patterns, and performance skills.

2.4.1.1 Client Factors

Client factors are the internal attributes of a person, not just the physical characteristics, but the mental and spiritual as well.[1] The OTPF defines client factors as values, beliefs, spirituality, body functions, and body structures. This illuminates the holistic nature of the person, guiding the occupational therapist to employ a biopsychosocial approach. By examining the whole person, the occupational therapist can better practice client-centeredness through facilitation of meaningful and engaging occupations.

2.4.1.2 Occupation

Occupations are meaningful and necessary activities of everyday life.[1] Occupations are "central to a client's (person's, group's, or population's) health, identity,

and sense of competence."[1] Humans are occupational beings and require occupational engagement for survival.[144] With the vital role of occupations in the human experience, Pierce[145] described how occupational therapists can use the therapeutic power of occupation in order to promote (re)habilitation. Thus, the OTPF recognizes occupational engagement as the ultimate goal for occupational therapists, separating us from other rehabilitation professionals.[1]

2.4.1.3 Context

The interplay of client, occupation, and context is emphasized in the OTPF.[1] Context includes not only the affordances and barriers of the physical environment, but also products and technology influences; social context; attitudinal, including cultural, factors; institutional impact; and personal factors, such as age, socioeconomic level, education status, ethnicity, race, and gender identity.[1] Context cannot be teased apart from the person or the occupation, and accordingly is paramount in achieving successful occupational engagement.[80]

2.4.1.4 Performance Patterns

Performance patterns are habits, routines, rituals, and occupational roles held by a person or community.[1] They provide occupational rhythms that can support or hinder occupational engagement. By consideration of performance patterns, occupational therapists can work within the temporal context of a person's occupational lives, which is the organizing factor that structures a person's life.[1]

2.4.1.5 Performance Skills

Lastly, the OTPF highlights the importance of performance skills, which are process, motor, and social interaction skills.[1] Occupational therapists are able to observe performance skills, or discrete actions, in occupational performance to determine what is supporting or hindering occupational success. When conducting an occupational analysis, an occupational therapist notes the efficiency and amount of performance skills used as well as the employment of any compensatory methods. Performance skills, along with the other foundational principles listed in the OTPF, are the pillars to support occupational engagement.[1]

2.4.2 Neuroplasticity Principles

Neuroplasticity is the alteration of the brain that is induced from experience or training.[73,146] Essentially, neuroplasticity is our brain's manner of internalizing experience in order to further learning.[71] Mundkur[73] described neuroplasticity as the connection between the age-old nature versus nurture argument. A child is predisposed with a certain neurological and genetic make-up; however, nature exposes children to various experiences, which can influence neurological pathways and gene expression. Accordingly, Weyandt et al.[72] argues it is imperative to consider neuroplasticity principles when designing interventions to maximize a child's potential learning.

Kleim and Jones[71] introduced neuroplasticity principles that are necessary when targeting new learning. These principles include: use it or lose it; use it and improve it; specificity; repetition; intensity; timing; salience; age; transference; and interference. Use it or lose it refers to the principle that if a person does not use a skill over time, neurodegradation can occur. Conversely, the use it and improve it principle means if a

person uses a skill, they will strength the neurological pathways and/or induce neurological pathways associated with learning that skill.[71]

The principles of specificity, repetition, intensity, timing, salience, and age capture the importance of how and when an experience is introduced in order to invoke neuroplastic change.[71] Specificity is when a person uses the actual skill they want to develop in order to promote lasting change, or learning. Repetition must occur in order to achieve neuroplastic results as the repeated experience strengthens the neural pathways. Intensity refers to the concentration of the experience, or stimuli, with a positive correlation between increasing intensity and neuroplasticity promotion. The timing of the experience is important, as certain neuroplastic changes must occur in order to induce a complementary change. In pediatrics, timing is especially important, as children have critical periods for growth, or peak learning times.[73] Salience refers to the meaning of the experience to the person, which has been found to improve attention and motivation for participation.[71] Age is a critical neuroplasticity principle as children's brains have more inherent neuroplasticity as compared to adults.

The last two neuroplasticity principles introduced by Kleim and Jones[71] include transference and interference. Transference refers to the ability of neuroplastic changes from learning one skill promotes skill acquisition for a related occupation. Interference occurs when neuroplasticity actually impedes new learning, or neuroplasticity with a related skill. Kleim and Jones[71] discussed an example of interference as with clients who have developed compensatory strategies that are serving as barriers to occupational performance. The neuroplasticity principles, much as the OTPF, can serve as a

framework in which to best approach a client, a lens with which to maximize their occupational growth.

2.4.3 Self-Determined Occupational Performance Model (SDOP)

The SDOP model was proposed and previously published in the following manuscript:

Bray, L. & Capilouto, G. (2021). Self-determined occupational performance model for children from economically disadvantaged backgrounds. *Canadian Journal of Occupational Therapy, 88*(4), 1-9. https://doi.org/10.1177/00084174211035627

The SDOP model was proposed as a theory-based approach for targeting handwriting outcomes, employing principles from Self-Determination Theory[74] and the Person-Environment-Occupation Performance Model.[80] It was originally written to address handwriting outcomes for children from a low-income background; however, as Bray and Capilouto[2] suggested, the concepts are universal for all children engaging in handwriting. Bray and Capilouto[2] described the SDOP model as seen below:

The SDOP model extends the perspective of a person as a holistic being, appreciating the individual spirit, mind, and body.[80] While each person is unique, the model recognizes that all persons have a shared and universally innate desire for autonomy.[74] When autonomy is supported, motivation is increased, which leads to improved outcomes.[74] For example, families who support autonomy often promote an atmosphere where children thrive, resulting in increased intrinsic motivation and internalized extrinsic motivation[74]. . . . Incorporating collaborative goal-setting and nurturing self-drive through treatment, will result in improved academic success.[74] For

ay goal to be met, the client must want to accomplish the goal and be confident that they can be successful[76]; both of which solidify their intrinsic motivation.[82]

The SDOP model highlights relatedness as an aspect of environment. . . Through the therapeutic use of self, a therapist can influence relatedness and further engage a child.[76,81] By helping a child expand their social network, we increase occupational meaningfulness and therefore internalize motivation. Internalizing motivation will ultimately enhance occupational performance.[74,82]

Occupation is the root of occupational therapy practice. As Law[81] explains, "As members of the profession of occupational therapy, we seek to improve health and well-being through occupation." The drive for competence is one that is at the heart of occupational therapy as clinicians are continually assessing and intervening at both a skill and occupational level. Handwriting is a multi-faceted occupation that has its own set of challenges due to the physical, cognitive, and perceptual demands.[147] By middle school, many students have a decreased self-perception of their writing[148] and it is the role of an occupational therapist to bolster perceived and actual competence. Occupational performance can be achieved through improving the task of writing and providing adaptations, but also through self-reflection. Ryan and Deci[82] explained that competence also includes the need to gain knowledge and learning, which was also recommended by Engel-Yeger et al.[149] who determined that informing a student of their handwriting deficits, empowered them to assess and correct their own writing.

The SDOP model provides a structure in which to address a child holistically. By using competence, autonomy, and relatedness as avenues for addressing occupation, person, and environment, it is hypothesized that improved occupational performance will

enhance well-being. By interweaving basic psychological needs through the lens of the holistic person, environment, and occupation, the practitioner will tap into the intrinsic motivations of the client, thus improving occupational performance and enhancing well-being. Occupational therapists are specifically trained and can innately incorporate the SDOP approach as part of their professional toolbox.[2]

2.4.4 Relationship between the OTPF, Neuroplasticity Principles, and the SDOP model

The OTPF[1], neuroplasticity principles[71], and the SDOP model[2] complement each other, with overlapping principles at micro and macro levels. Please refer to Figure 2.6. All of the models highlight, through different lenses, the interplay of the person, context, and occupation in order to achieve optimal occupational engagement.

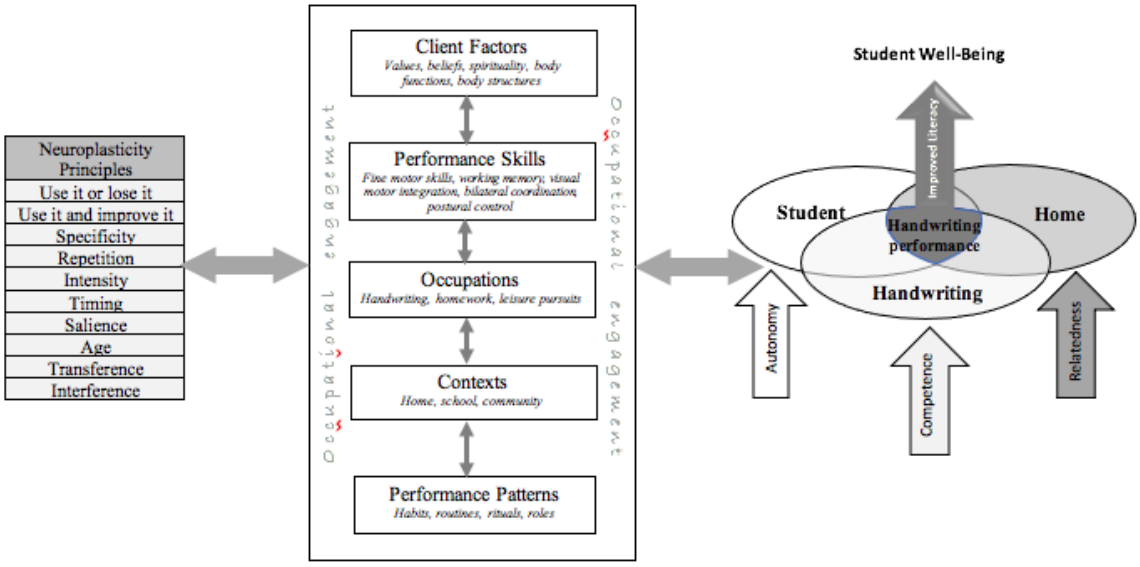


Figure 2.6: Theoretical Foundation

2.4.4.1 Person

The person is where occupational engagement is initiated and meaning is discovered. Neuroplasticity principles explain how occupational performance is interpreted by the person and sustained at the neurological level.[71] The OTPF uses client factors and performance skills to describe the domain of the person.[1] It discusses the contribution of the internal body structures and functions, such as neural pathways, and performance skills to occupational performance; however, the OTPF also considers a person's values, beliefs, and spirituality. Neuroplasticity principles also capture a broader perspective by suggesting salience, or meaning, of the occupation is necessary in order to elicit neuroplasticity.[71] Lastly, the SDOP model uses a holistic view of the person as well, defining the person as the mind, spirit, and body.[2] SDOP emphasizes autonomy as a factor in occupational success as it fuels intrinsic motivation.

2.4.4.2 Occupation

Occupation is also stressed in all three models. Neuroplasticity principles discuss the need for occupational fit with the person in order to achieve positive neuroplasticity results.[71] Occupational considerations include the specificity of the occupation,[71] embracing the therapeutic power of the specific occupation in which engagement is the goal.[145] Intensity and repetition are also aspects of occupational engagement that are highlighted in neuroplasticity principles.[71] Occupational engagement as a pathway for health and well-being are both overarching goals for the OTPF[1] and the SDOP model.[2] The SDOP model also uses occupational competency as foundational for participation in

occupation as this again drives the intrinsic motivation of the person to continue in engagement.[2]

2.4.4.3 Context

Context is also a foundational area found across models. In the neuroplasticity principles, the consideration of the temporal context is promoted through the concepts of occupational timing and age as neurologically there are optimal times to promote learning.[71] Additionally, a supportive multisensory environment and social context has been found necessary for neurogenesis.[79] The OTPF[1] and the SDOP model[2] take a macro perspective on context, including the importance of the physical environment, as well as the social, cultural, temporal, personal, and virtual contexts.

The OTPF,[1] neuroplasticity principles,[71] and the SDOP model[2] remain consistent in the connectedness of the interplay between person, occupation, and context. When these three principles align, optimal occupational engagement can occur and be promoted. The theoretical principles described here were used to guide the conception of this project to consider the fit of the child with handwriting in their home environment. Elements of autonomy, relatedness, and competency were interwoven through the project with guided choice, the use of the therapeutic relationship, and the HWT program to promote progress of handwriting and spelling abilities.

CHAPTER 3. PILOT STUDY

3.1 Submitted Manuscript

Study 1 is a pilot study that was conducted to investigate the feasibility and effectiveness of the HWT curriculum via telehealth for lower elementary aged children who are typically developing. A manuscript of the pilot study, "Handwriting Without Tears® via Telehealth Delivery: A Case Study of Feasibility and Effectiveness for Handwriting and Spelling Outcomes," was submitted to the *Journal of Occupational Therapy, Schools, & Early Intervention* on September 16, 2021. It remains "Under Review" as of this time. The submitted manuscript is below.

3.2 Introduction

As we resume in-person school delivery, we are starting to observe the far reaching effects the coronavirus is having on children, spanning from social and psychological development to academic and motor progress. The sustained impact on children will not be fully realized until we acclimate to this "new normal" after unprecedented times.

In a survey, Flack et al.[150] found that 80% of teachers believed students would need additional instructional supports once in-person school resumed with an estimated nine months of learning loss.[151] Teachers voiced concerns not only over the students' academic and literacy development, but also for their well-being and experienced social deprivation.[150] Schools will need tools to maximize students' success, not only in academics, but also improving a child's confidence during their resumption as a student in an in-person school environment with pandemic-changed social and cultural contexts.

Pediatric occupational therapists, especially those based in schools, are uniquely positioned to help children during this time. Occupational therapists have the skillset to support children during their pandemic acclimation as we have been educated to look at the whole person and their occupations in social and cultural environments.[1] The Occupational Therapy Practice Act (OTPF) recognizes the occupations associated with the student role, including educational participation, social participation, leisure, and play as within the practice domain.[1] In order to serve the most clients with the greatest impact, pediatric occupational therapists will need to rely on their clinical reasoning skills, flexibility, and creativity. One suggestion of how to accomplish this is through targeting handwriting.

Occupational therapists have a longstanding history of addressing handwriting with children[41]; however, skillful handwriting instruction is often not appreciated for the multi-dimensional and comprehensive effect it can have on a child. Telehealth can serve as a service delivery option to reach children with handwriting challenges in an efficient and cost-effective manner[128,152] with minimal disruption due to pandemic complications. The purpose of this manuscript is to review handwriting and its significance as well as the use of telehealth in pediatric occupational therapy; then detail a case study investigating the effectiveness of a handwriting program delivered via telehealth on handwriting and spelling outcomes for a first grader.

3.2.1 Handwriting

Historically, handwriting difficulty has been the most frequent reason for referral to school-based occupational therapy.[41] School-based occupational therapists reported that they worked on handwriting goals with children in up to 75% of their caseload.[48]

Handwriting foundational concept in academic literacy skills, including reading, spelling, and written composition.[34] Handwriting is an occupation that promotes academic and physical development as well as contributes to a child's confidence in their academic abilities,[46,47] and unfortunately has been neglected with online school delivery.[40] This multi-faceted occupation has been found to positively correlate with self-efficacy, outlook, and academic success.[46,47] Handwriting deficits can negatively impact a child's confidence in academics as children with poor handwriting score lower grades even with equivalent content.[42,153] Thus, occupational therapists can use handwriting to support student success with not only handwriting outcomes, but also may be able to simultaneously target confidence, academics, literacy development, motor development, and self-efficacy.[34,46,47,154]

3.2.1.1 Current State of Handwriting

Handwriting has greater influence than is often recognized in academics today; accordingly, there has been a decline in curricular importance since the 1970s.[155] Prior to the transition to online education, children spent 20 to 50% of the school day engaged in pencil-to-paper tasks, primarily handwriting.[33] Yet, even with this practice, 10 to 34% of children still experienced handwriting difficulty.[39] In recent years (pre-pandemic), 88.5% of teachers reported a decrease in handwriting abilities and 85.9% of teachers noted a decline in fine motor skills.[38] The majority of these teachers posited the reason for this change was due to less handwriting practice and more digital play.

As computers, tablets, and smart phones became more prevalent, the perceived importance of handwriting diminished.[34] Research comparing digital devices with handwriting, however, found there is a need for both occupations. In a systematic

review, Wollscheid et al.[156] highlighted the sociocultural importance of digital devices, but emphasized the majority of the research favored the literacy benefits associated with handwriting. Research has demonstrated handwriting has superior correlations with early reading[26,65,66] and writing skills[65] as compared to keyboarding; only Mayer et al.[157] found comparable results between handwriting and keyboarding. Rogers and Case-Smith[158] and Mayer et al.[157] ascertained digital writing with a stylus to be the least beneficial writing mode. Feng et al.[159] conducted a meta-analysis, determining handwriting fluency to be associated with compositional quality and compositional fluency while keyboarding increased speed, but ultimately concluding explicit teaching of handwriting to be a critical contributor to writing development. Teachers agreed with this perspective as 99.3% of teachers reported handwriting as important; however, the majority of teachers felt there was not enough time for explicit instruction of handwriting with other curricular demands.[38]

3.2.1.2 Handwriting significance

The mechanics of why handwriting is important to a child's academic development are two-fold. First, handwriting promotes compositional literacy once it becomes automatic.[95] Berninger et al.[95] proposed a model of writing that distinguishes between the low and high level processes involved in writing. They posited through automaticity of lower level skills, such as handwriting, the writing process would be improved with more cognitive resources available to devote to higher level skills, such as planning and composition. Research has confirmed handwriting automaticity to be a significant predictor in compositional fluency[14,160,161] and thus, improvements in handwriting have been associated with increased compositional abilities,[14,21,22,162]

Secondly, recent research has demonstrated a neural overlap between handwriting and other literacy skills, such as spelling and reading.[26-28] The overlapping neurological pathways between these different literacy occupations positively promote one another. Accordingly, James & Engelhardt[26] and Longcamp et al.[66] determined handwriting to improve letter reading and retention when compared to typing or tracing. Longcamp et al.[66] found the movement of handwriting to activate the sensorimotor area of the brain and Vinci-Booher et al.[31] demonstrated the connection between the visual and motor areas of the brain strengthened through handwriting; which may account for why handwriting contributes to improved memory of what is written. Even the act of just reading a handwritten versus a typed letter without movement activated the sensorimotor area of the brain.[30] Suggate et al.[29] hypothesized that improved handwriting could increase reading abilities because the shared neurological pathways are reinforced. Research has supported this theoretical viewpoint with positive relationships found between handwriting and early reading skills[25-28] as well as handwriting and spelling.[25,162]

As teaching was forced to move to online education, often overlooking handwriting,[40] the impact remains to be known. Keyboarding and handwriting promote different abilities: handwriting has been found to improve fine motor,[154] visual motor integration, and spatial perception skills[157,163]; while keyboarding is positively correlated with bilateral coordination, motor and visual memory.[163] With the transition back to in-person school, students will be expected to resume handwriting tasks, skills which they have not used frequently during the pandemic.

3.2.2 Telehealth

Telehealth is a service delivery model that was already increasing in usage pre-pandemic[152] and has been instrumental in the delivery of therapy during the pandemic. Ganesan et al.[55] found globally occupational therapist use of telehealth has increased from 36.1% pre-pandemic to 60.7% currently. Even vaccination rates rise, virtual platform use, including telehealth, has changed how we are able to interact and its reliance is expected to remain.[164] Seventy eight percent of occupational therapists reported that telehealth should be a permanent service delivery option for clients.[58] Pre-pandemic, families already reported advantages of the convenience of pediatric telehealth, including flexible timing, location, as well as decreased travel time.[130] Both caregivers and therapists found parent involvement improved with the use of telehealth and recognized the benefits of holding the sessions in a child's natural environment.[58,59,128] Kairy et al.[62] determined better attendance and compliance of home programs associated with telehealth. The Tanner et al.[61] study demonstrated pediatric telehealth to be a feasible delivery option with a high satisfaction response from 98.7% of families. School-based telehealth has also been found to be an effective service delivery model with students improving in targeted outcomes.[134,137] In a systematic review, Shigekawa et al.[165] concluded telehealth outcome attainment to be equivalent to in-person therapy. In response to the increased usage of telehealth, the American Occupational Therapy Association[64] (AOTA) called for further research to determine the effectiveness of telehealth as a service delivery option for occupational therapists. Telehealth may offer a time-effective option for occupational therapists to maximize their caseloads, and

ultimately their impact, as well as provide families with a convenient and flexible therapy option with minimal disruption.

3.3 Present Study

The purpose of this study is to determine the effectiveness of handwriting intervention on handwriting and spelling outcomes using telehealth service delivery. The Handwriting Without Tears® (HWT) program was selected for this study as it is widely disseminated, with adoption as the state curriculum in ten states, as well as easily accessible.[166] HWT was developed by an occupational therapist, using a foundation of developmental and sensorimotor techniques.[122] It infuses multisensory components into handwriting education with tactile, visual, and auditory feedback, in order to solidify letter memory and correct letter formation.[122] The HWT program builds upon a child's fine and visual perceptual development through a sequential introduction of letters based not on alphabetic order, but on complexity of developmental skills required to form the letter.[122] HWT emphasizes a simplified letter form, using vertical, horizontal, and diagonal lines to streamline letter production. Additionally, HWT introduces letters through gross motor modeling; then forming letters through manipulatives to build on a child's kinesthetic skills as well as visual abilities; lastly, the child practices handwriting in isolated letter, word, sentence, and paragraph formats, providing opportunities for reading and spelling to emphasize handwriting in context of academic literacy practices.

Research supports the instructional strategies incorporated in the HWT program. HWT uses explicit verbal and visual instruction for individual letter formation; followed with demonstration of letter formation; student guided practice and modeling; and lastly independent handwriting work.[122] This approach aligns with Vygotsky's theory of

scaffolded teaching within a social environment[167] and provides a safe context in which a student can learn.[168] Additionally, the research performed by Reutzel et al.[27] supports the use of building letters with manipulatives as seen throughout the HWT program. Reutzel et al.[27] found that when children were taught letters with an emphasis on the identifying features of the letters (i.e., F is made of a vertical line and two horizontal lines), handwriting not only improved, but letter naming abilities did as well, an early reading skill.

The researched-based techniques used in the HWT program have been proven to be effective in improving children's handwriting outcomes. The majority of the HWT research has been conducted with children who are typically developing. As a handwriting curriculum, HWT has been found to deliver either more significant results when compared to controls of alternate handwriting instruction[68,69] or equivalent results.[70] Donica[169] and Randall[170] found superior handwriting gains associated with the HWT program using a consultative occupational therapy approach, while Schneck et al.[171] found HWT analogous to the control with the consultative approach. Smaller studies conducted with pre-school participants with developmental delays found the HWT program to be effective in improving children's handwriting.[172,173] Verma et al.[119] used HWT toolkits with participants in first through fourth grades to produce significant handwriting gains. However, there is a gap in the literature investigating the effectiveness of the HWT program using a telehealth delivery model as well as determining if there are additional associated literacy benefits, such as spelling.

Thus, there is a need to explore the effectiveness of the HWT program on literacy outcomes of handwriting and spelling using telehealth delivery in children in order to

have an evidenced-based program for occupational therapists to utilize. The purpose of this case study was to explore the effectiveness of the HWT program on handwriting and spelling outcomes for a first grader via a telehealth delivery. The researchers were able to gain an in-depth analysis of the feasibility of the HWT program via telehealth delivery as well as observe any changes in participant's handwriting and/or spelling over the course of the study. As a case study was used, the results are unable to be generalized, but this research informs practice as well as further research projects.

3.4 Materials and Methods

A case study design was used to investigate the effectiveness of the HWT program on handwriting and spelling outcomes using a telehealth delivery. The data from this case study was supplemented with observational fieldnotes of the participant's performance and response to the intervention. Additionally, the investigator maintained a journal of biases of interpretation and an audit trail of decisions made throughout this process. Author also had weekly peer debriefings with co-author, an occupational therapist with 37 years of experience to reflect on study. This case study served as a pilot to inform the feasibility and utility of a larger dissertation project. The study was approved by the institutional review board at a southeastern university.

3.4.1 Participant

The participant was recruited using convenience sampling through community contacts. Informed consent and assent were obtained from the participant and caregiver. Data collected included demographics and comorbidities of the child participant per caregiver report.

Inclusion criteria were as follows: (1) child in first or second grade, ranging from 6 to 9 years old; (2) speaks English fluently as the English language has its own unique orthographic, phonetic, and morphological features; (3) able to give informed consent and assent. Exclusion criteria included children who have severe cognitive or motor delays and non-English speakers. The criterion to have a participant in first or second grade was selected because handwriting and spelling improvements in children can be detected at this age,[174,175] but yet they are early in their development in these skills.[176] Additionally, Langbecker et al.[137] found second graders to be the most receptive to the telehealth format as compared with children in older grades.

3.4.2 Measures

The outcome measures to assess handwriting quality, handwriting speed, and spelling used at pretest and post-test were: The Print Tool®, Alphabet15, Words Their Way Primary Spelling Inventory, and the Test of Written Spelling (TWS-5).

3.4.2.1 Handwriting Measures

The Print Tool®[175] was developed by HWT to examine legibility and letter formation for children in kindergarten to fifth grades. This assessment systematically evaluates handwriting quality (orientation, sizing, placement on the line), generation (how the letter is started and formed), and letter memory. Donica and Holt[125] established strong concurrent validity with other handwriting assessments (r=.606) and determined it was a valid representation of teachers' perceptions of handwriting. Additionally, Criss[134] found the Print Tool® to be an effective method to assess handwriting in a telehealth format. The scores generated percentages correct with age expectations for comparison.

The Alphabet15[147] assesses handwriting speed and automaticity. This task involves writing as much of the lowercase alphabet from memory as quickly as possible in 15 seconds as detailed by Berninger et al.[107] The raw score generated is the number of legible letters in correct alphabetic order written in 15 seconds, to capture an "index of automaticity."[147] This writing task is designed to assess a child's ability to access, retrieve, and produce the lowercase alphabet. For this case study, only manuscript writing speed was evaluated.

3.4.2.2 Spelling Measures

The TWS-5[174] is a norm-referenced spelling assessment that was designed for both instructional and research purposes.[177] It utilizes dictation to assess written spelling, generating raw scores, standard scores, age and grade equivalents, and percentiles. It has two stimulus forms to diminish bias from repeat testing; thus, different stimulus words were used for pre- and post-testing.

The Words Their Way Primary Spelling Inventory[178] is a qualitative spelling assessment that determines a child's spelling developmental level and provides areas of growth for the child to inform instruction. The child writes spelling words from a dictated stimulus. The results are percentages of words spelled correctly and feature points spelled correctly (i.e., initial consonants, diagraphs, short vowels, blends, etc.) as well as the spelling developmental level. While this assessment is not norm-referenced or validated, it was used to provide a more descriptive perspective of the participant's spelling level.

3.4.3 Procedure

Hoy et al.[52] found in a systematic review of the handwriting literature that frequency, specifically 20 total sessions at least biweekly, to be the leading determinant in the effectiveness of handwriting interventions. As this study was conducted in the final month of school, 18 total sessions (including pre- and posttest sessions) were offered to the participant to accommodate to their full schedule.

Zoom, an online teleconferencing platform, was used to deliver the telehealth services. Zoom is compliant with the Health Information Portability and Accountability Act, ensuring privacy and confidentiality of study sessions.[179]

3.4.3.1 Initial and Final Sessions

The participant participated in completion of the assessments in the initial and final sessions via Zoom. The author conducted the Print Tool®, the Alphabet 15, the TWS-5, and the Words Their Way Primary Spelling Inventory. Prior to the study, the participant had been provided with recording forms and pencils to use for assessments using contactless delivery.

3.4.3.2 Treatment Sessions

The participant participated in sixteen 30-minute HWT treatment sessions conducted by the author via Zoom three times a week. Prior to the initial session, the participant was provided with a HWT Grade 1 workbook as well as HWT manipulatives to practice letter formation (Roll-a-Dough set, Wooden pieces for capitals, Stamp and See set, and Wet-Dry-Try set) via contactless delivery. The sessions began with a short review of previously taught letters and introduction to the letter instruction for that

session completed via Zoom whiteboard. Next, HWT warm-ups were completed, including: a HWT song that aligned with the session goal (i.e., Magic C Rap when teaching c, o, a, d, g which are termed Magic C letters by HWT), postural and grip

Table 3.1. Sequence of HWT Intervention Session for Presented Letters Introduced[180]

	Examples of activities as further detailed in the HWT teachers guide
HWT warm-ups	Posture and grasp skills, letter stories for presented letters, songs
Gross motor character introduction	Air writing, door writing, gross motor imitation, song and related dance
Fine motor character introduction	Wet-dry-try activity, Stamp and See activity, Roll-a-dough activity, Wooden pieces for capitals
Character practice	HWT worksheets practicing writing at a character and word level
Review	Verbal review and self-evaluation

activities; gross motor character introduction; fine motor character introduction using the HWT manipulatives; handwriting practice in the HWT workbook; and a review and self-evaluation of comfort with presented topics of the session. See Table 3.1 for further detail.

3.4.4 Data Analysis

As this was a pilot case study to determine futility and feasibility for future studies, only descriptive statistics were used. Pre-test and post-test scores were visually examined from the Print Tool®, Alphabet 15, TWS-5, and the Primary Spelling Inventory results; further statistical analysis was not merited due to the lack of standard deviation from having only one participant. Changes that were made from pre-test to post-test were contemplated and compared to previous research findings to determine clinical relevance. Field notes were made throughout the sessions to capture the

participant's responses and reactions to the treatment to provide descriptive support to the findings; however, not enough qualitative data was generated to warrant further analysis.

3.5 Results

3.5.1 Participant

"MB" was a 7-year-old female who lived at home with her parents, older brother, and older sister. MB attended public school in kindergarten and completed the end of the 2019-2020 school year online with no explicit handwriting instruction and incidental practice when she completed assigned worksheets. For the 2020-2021 academic year, she enrolled in first grade at a private school with intermittent disruption to in-person instruction. MB and her mother relayed that she did not receive explicit handwriting instruction in first grade, but was allotted time for handwriting practice with occasional written and verbal teacher feedback. MB was typically developing with no concerns in physical or cognitive development per mother report. She attended well and was engaged during all intervention sessions. She was able to verbally tell the author her preferences for activities and if she had any dislikes about study intervention. She interacted with Zoom with minimal assistance once logged on by her mother.

3.5.2 Handwriting Results

MB exhibited handwriting gains over the course of the intervention as presented in Table 3.2. MB increased her handwriting speed as measured by the Alphabet15 from

Table 3.2. Handwriting Assessment Results

		Pre-test		Post-test	
Alphabet 15	Total letters written	10		15	
The Print Tool®*	Overall score	90.8		94.6	
		Capital	*Lowercase*	*Capital*	*Lowercase*
	Memory	100	96	100	100
	Orientation	100	100	100	100
	Placement	85	80	100	88
	Size	100	100	100	92
	Start	92	96	92	96
	Sequence	65	80	77	92

** Percentage scored correct*

10 to 15 written letters in 15 seconds. MB also improved multiple subtests of her handwriting quality as measured by the Print Tool®, including her overall handwriting score from 90.8 to 94.6% correct; 5 of 12 subtest scores increased, including lowercase memory, capital and lowercase sequencing, capital and lowercase placement; 6 of 12 subtests scores remained the same (4 sustained at 100% correct); and one subtest, lowercase sizing, declined. A visual depiction of her Print Tool® results can be seen in Figure 3.1. Overall, the participant made advances in handwriting, both in quality as measured by the Print Tool® and speed as measured by the Alphabet15.

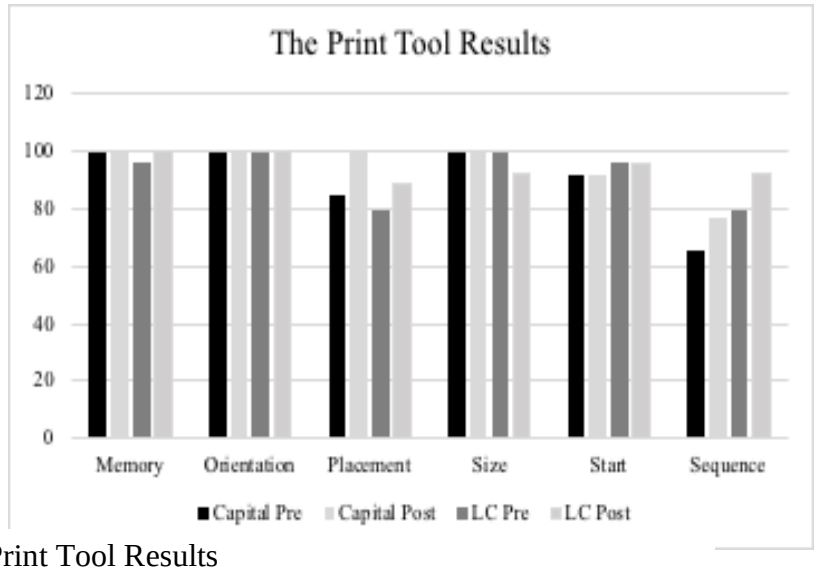


Figure 3.1: The Print Tool Results

3.5.3 Spelling Results

The spelling results were inconclusive as MB had a slight decrease in the TWS-5 score and a slight increase with the Primary Spelling Inventory score. The results of the spelling assessments are presented in Table 3.3.

Table 3.3. Spelling Assessment Results

		Pre-test	**Post-test**
TWS-5	Standard score	109	104
	Percentile	73rd	61st
Primary Spelling Inventory	Words spelled correctly	12 of 20	13 of 20

MB exhibited a slight decrease in pre-test and post-test scores for the TWS-5, but remained in the average range. With the Primary Spelling Inventory, MB stayed in the developmental Within Words Spelling stage, which was age appropriate for a first grader. This tool had more data points to compare and improvements were made in 2 of 8 word features as well as total words spelled correctly as displayed in Figure 3.2.

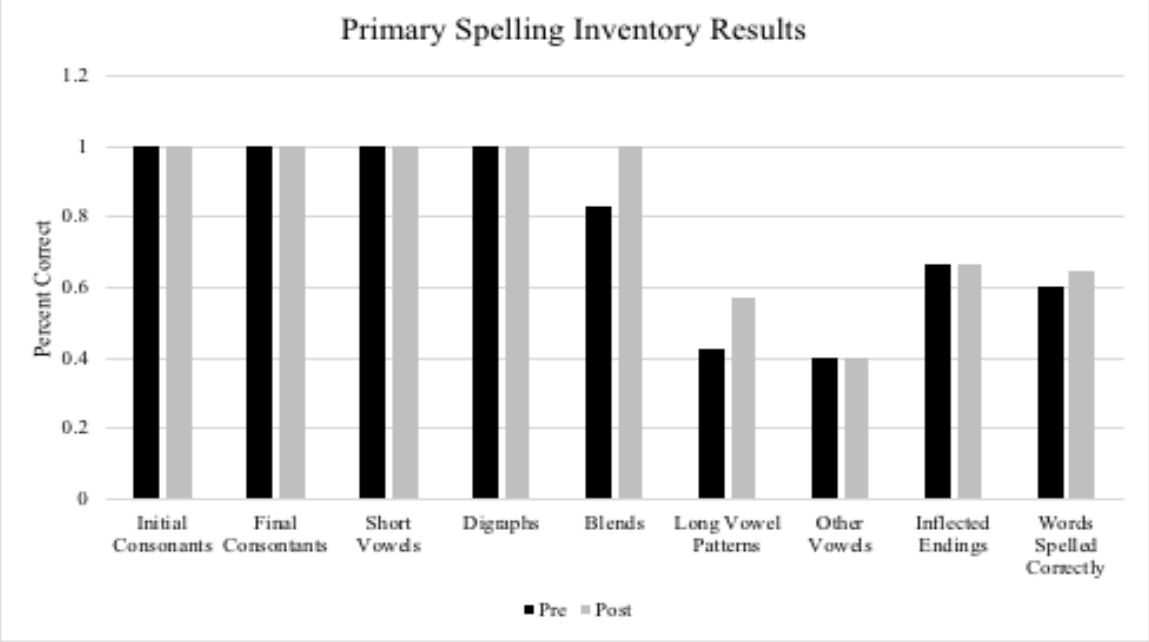


Figure 3.2: Primary Spelling Inventory Results

3.6 Discussion

As this was a single participant case study, the results provided preliminary insight into the feasibility and the associated handwriting and spelling benefits of the HWT program via telehealth delivery for a first grader over a six-week period.

3.6.1 Handwriting Discussion

The first handwriting change noted was the participant demonstrated gains in handwriting legibility from pre-test to post-test after receiving HWT instruction via telehealth delivery. The participant improved on 5 of 12 legibility subtests and remained at the same level (often the ceiling) in 6 of 12 subtests. On lowercase letter sizing, the participant's score declined, but remained above age expectations for her grade level. The results from this case study align with previous research of the utility of the HWT program on legibility outcomes for typically developing first graders in a classroom.[68-70,171] The results also support the telehealth findings of Criss.[134] Criss[134] found improved legibility outcomes in elementary students who received school-based telehealth interventions that incorporated components of the HWT program.

Another noted change was the participant demonstrated gains in handwriting speed after receiving HWT instruction via telehealth delivery. MB exhibited a 150% increase in handwriting speed from pre- to posttest. Previous research has established a positive correlation between handwriting instruction and handwriting speed.[34,44,117,160] The Alphabet15 task assesses handwriting speed, but also is an indicator of handwriting automaticity because it requires the child to independently recall and form letters in alphabetic order.[161] The importance of handwriting automaticity to other literacy areas,

such as compositional quality and reading performance, has been found repeatedly in research.[14,160,161]

This author selected the HWT program because it is easily accessible and replicable for occupational therapists, as well as educators and caregivers, combining sensorimotor and motor approaches as well as opportunity for literacy reinforcement (i.e., simple reading passages, worksheets to instruct on sentence and poem structure).[180] Clark et al.[181] found that when an intervention is "readily transferable to a wide range of practice settings," the intervention has a quicker dissemination from research to practice. This case study supports the use of the HWT curriculum via telehealth delivery with positive gains in handwriting legibility and speed made in a short delivery period. Previous research has also found the HWT program effective in targeting handwriting outcomes. Hape et al.[68] and Roberts et al.[69] determined greater improvements in handwriting outcomes associated with HWT as compared to other instructional methods; while Salls et al.[70] and Schneck et al.[171] found HWT to be comparable to controls of teacher-specific handwriting curricula with both groups exhibiting handwriting progress.

3.6.2 Spelling Discussion

From pretest to posttest, the participant exhibited both spelling gains and losses, dependent on the spelling measure. The differences in these results could be due to the variations in how these spelling assessments are administered. The TWS-5 uses two different stimulus cards with no repetition of spelling words from pre- to posttest. The Primary Spelling Inventory used the same stimulus words; however, feedback was not provided during pre-testing for the participant to self-correct. Overall, the participant remained in the same descriptive category for the TWS-5 (average) and developmental

stage for the Primary Spelling Inventory (Within Word); thus, the difference in results were most likely due to performance variations.

As this was a case study of a child who was within the average range for spelling, the correlation between HWT and spelling benefits should be further explored with a larger sample. Previous research has supported the relationship between handwriting improvement and spelling improvement.[25,162] Graham et al.[182] found utility associated with a combined handwriting and spelling intervention in improving handwriting and spelling outcomes, especially for children who were delayed in developing these skills. Clark[183] determined that a child's competence with letter sounds significantly benefits spelling, writing, and reading abilities. Thus, as occupational therapists, if we can reinforce the letter sounds while conducting handwriting instruction, this minor additional step can impact literacy, such as spelling. The HWT program incorporates age appropriate reading with short sentences on each letter page as well as simple spelling tasks, which is an opportunity for the student to practice their reading and spelling abilities.

3.6.3 Feasibility of HWT via Telehealth Delivery

The case study provided insight as to feasibility of the HWT program via telehealth delivery. The author selected telehealth as a service delivery method to decrease attrition as better attendance rates have been associated with telehealth than in-person visits[184] and to minimize disruptions that may arise due to the pandemic. Reflectively, the author found the assessments and the HWT program easy to transition into the telehealth format in accordance with previous handwriting telehealth research.[134] Only minor adjustments had to be made to translate the HWT program to this format;

including delivering the HWT materials to the participant prior to study, taking time to instruct the participant about Zoom features, completing handwriting demonstrations via Zoom whiteboard, and having the participant complete certain handwriting activities via Zoom whiteboard. Prior research supports the feasibility of transitioning to telehealth pediatric occupational therapy.[58,61] The participant remained engaged throughout the sessions and anecdotally reported enjoying the activities. Additionally, her mother relayed that the Zoom platform was easy to navigate and was satisfied with the telehealth experience. This confirms other findings where high rates of client satisfaction have been associated with pediatric telehealth.[61,128,134] Lastly, although no comparisons were able to be made about the differences in effectiveness of the telehealth delivery versus in person delivery method in this case study, previous research has demonstrated equivalent results between telehealth to in-person occupational therapy delivery.[165]

School-based telehealth has been found to be an effective and feasible method of delivering occupational therapy services.[131,134,137] Rortvedt and Jacobs[131] found telehealth to be an option to counteract the demanding caseloads and practitioner shortages experienced by school-based occupational therapists. As people are more familiar with teleconferencing over the past year, telehealth may be an option to offer school-based telehealth service where both the teachers and caregivers can be present to offer more family-centered practice.

3.6.4 Frequency

An unexpected observation during this case study was in regards to visit frequency. A systematic review by Hoy et al.[52] found frequency, specifically at least 20 visits twice a week, to be the most important factor for handwriting intervention

effectiveness. This 20 visit target for intervention frequency has been seen across research studies[70,185,186] and cited repeatedly in the literature. The current study used eighteen visits over six weeks to accommodate to the participant's full schedule. The participant's mother repeatedly reported satisfaction with the intervention, but found the frequency to be "a lot" to which the author concurred. To this author, 20 visits twice a week with a handwriting focus seems pragmatically unrealistic for pediatric occupational therapists and families, even with the flexible telehealth delivery, due to time constraints, participant interest, and other occupational goals that need to be addressed, especially in the current pandemic climate. Glasgow and Emmons[187] found interventions that require a lot of time and effort are less likely to be translated from research to clinic, which is an important consideration for further research in this area.

As the recommendations for frequency by Hoy et al.[52] could also be implemented in a classroom setting; even with a consultative occupational therapy approach, it is unlikely to be accomplished as teachers already have considerable hurdles to overcome in the upcoming academic years with the delays caused by the pandemic.[151] Additionally, instruction of handwriting was already varied among teachers and schools, pre-pandemic. Survey research by Collete et al.[37] found the duration and instruction of handwriting among kindergarteners to second graders to be inconsistent, with explicit teaching averaging between 30 to 45 minutes per week, and evidence suggests minimal to no instruction occurred this past year during online education.[40] Occupational therapists are highly skilled to address the occupation of handwriting with clients as we are educated in sensorimotor, visual perceptual, and motor skills as well as contextual influence. Additionally, occupational therapists are able to hold individual sessions, which the

social connection with instructors has been reported to be missing with online education.[150] However, the frequency target should possibly be addressed differently to improve carryover into a clinical or school setting, such as asynchronous, or without real-time interaction, sessions that could be completed on the families' schedule. One such example of this is HWT offers a customizable digital tool where occupational therapists can assign client-specific activities, addressing individual handwriting goals.[188] Also, further research should be conducted on lower frequency handwriting interventions delivered via telehealth as telehealth improves familial collaboration, provides insight into the client's and family's routines and home environment, and reduces both therapist and client time costs.[128,131] This additional familial involvement can lead to more carryover of goal practice[58,59]; thus, making occupational therapy visits more efficient and cost-effective.[130]

3.7 Limitations

Although this case study provides information that can be beneficial for pediatric occupational therapists addressing handwriting goals, the findings cannot be generalized and interpreted for statistical significance. The participant exceeded age expectations in handwriting results and was typically developing in spelling at both pre- and post-tests; thus, her gains are not comparable to a participant experiencing handwriting and/or spelling delays. Additionally, she experienced a ceiling effect with the handwriting assessment as she scored 100% correct in many of the subtests at both pre- and post-tests. The participant's high abilities may have contributed to the feeling of the intervention as time demanding because there was not a true need for the participant to participate in handwriting instruction as she was not experiencing handwriting or spelling delays. In

regards to the observations about the feasibility of HWT on Zoom, the participant already was familiar with Zoom from online education, adding to her and her mother's competence with navigating the platform. Additionally, the participant and mother had previously met the author through community contacts, which may have also contributed to their reliable participation and engagement in the intervention. Lastly, the participant experienced complete online education for the end of the 2019-2020 school year and only intermittent disruptions to in-person school for the 2020-2021 school year, which is not representative of the majority of children in her age group. Further research with larger and more diverse samples will need to be conducted to confirm the current results.

3.8 Conclusion

This case study and manuscript provided insight into the occupational importance of handwriting and how handwriting interventions can address not only handwriting outcomes, but literacy outcomes as well, using telehealth delivery. Effectiveness, flexibility, and ease of use is an important consideration in the current pandemic climate where children are in need of support and adjusting to new contexts. The HWT program is an easily accessible, commercial curriculum that can be used by occupational therapist as occupation-based handwriting instruction that incorporates sensorimotor, motor, and visual perceptual skills with opportunities to reinforce simple reading and spelling skills. Occupational therapists can efficiently incorporate reinforcing letter sounds with any handwriting practice to provide additional literacy benefit.[183] As handwriting, spelling, writing, and reading are such interrelated skills,[14,95,107] it may be beneficial, as Clark[183] proposed, for occupational therapists to have education on literacy included in their professional or post-professional training.

A benefit of being thrust into an online world with the pandemic is the utility of the telehealth delivery system has been highlighted, including flexibility, ease, and high satisfaction.[59,61] Telehealth can be used as a service delivery system to assist occupational therapists, especially school-based occupational therapists, to reduce time constraints associated with travel and improve cost-effectiveness.[128,131] Telehealth can incorporate and elicit family involvement, even in a school-based environment. Cason[152] proposed in the current healthcare environment, occupational therapists must be prepared to effectively utilize telehealth as a service delivery option; and in response to the growing importance of telehealth, the AOTA[64] called for further research to be conducted to determine the effectiveness and feasibility of telehealth in the delivery of occupational therapy.

Further research needs to be conducted to validate the results of this case study. As this was a pilot study, the author recommends tailoring the research aims to be more clinically applicable for occupational therapists. First, research needs to adapt to the client's schedule and routines, including requiring fewer synchronous visits with possible supplemental asynchronous visits to incorporate the target of 20 interventions twice weekly as proposed by Hoy et al.[52] Additionally, further research should investigate the associated benefits for children who have delays or are at risk of delay in the areas of handwriting and spelling. This line of research will more readily translate to practice as these are typically the clients who are seen by occupational therapists. Lastly, the literacy benefits of commercially available curriculums, such as HWT, should be further determined to establish the impact of handwriting instruction.

The pilot study described above informed the development of Study 2 described in Chapter 4, which investigated the use of the HWT program via telehealth for children with handwriting and/or spelling challenges on handwriting and spelling outcomes. The results as well as the spontaneous verbal feedback from the participants shaped the next study to investigate an intervention that better translates to clinical practice.

CHAPTER 4. CASE SERIES STUDY

4.1 Introduction

The purposes of this chapter were to: 1) review the literature on handwriting, Handwriting Without Tears® (HWT), and telehealth delivery; 2) discuss the methods and results of this case series study investigating the effectiveness of the HWT program via telehealth on handwriting and spelling outcomes for children with handwriting and/or spelling issues; 3) examine the results and clinical implications of the aforementioned study.

4.2 Literature Review

The interest in literacy development has been at the forefront of societies globally for centuries to varying degrees and perspectives.[189] This has been especially prevalent in the modern era in the United States. In recent decades, "the transformation of literacy from an education concern to a national political issue has been swift and significant."[190] Literacy education is emphasized in American academics. Academic literacy refers to literacy skills situated within an academic context.[191] These include reading, writing, speaking, and listening, which have been identified as foundational skills for school-based literacy by the Common Core State Standards Initiatives.[10] Thus, these are the curricular components most often stressed in school settings.

Components of academic literacy are neurologically and developmentally related. The research conducted by Berninger et al.[107,192] demonstrated the interrelated nature of the foundational literacy abilities (speaking, listening, reading, writing).[10] Berninger[192] described these skills as four language systems: Language of the Ear (listening), Language of the Mouth (speaking), Language of the Eye (reading), and Language of the

Hand (handwriting and composition). Each of these systems share common neural pathways with each other, but were also unique; dependent on the purpose and context in which the literacy skills were used.[08,192] These systems developed not sequentially, but simultaneously, impacting one another.

Accordingly, all components of academic literacy are of importance and can influence the development of corresponding literacy skills. Often academic literacy research focuses on reading instruction and intervention; however, writing is an equally important contributor to literacy. The writing research lags significantly behind that of reading,[14,18] especially handwriting. The Simple View of Writing, as discussed in Chapter 1, emphasizes the need to master foundational writing skills (e.g., handwriting, spelling, keyboarding) before compositional mastery can be achieved.[15] However, explicit instruction of the foundational skill of handwriting has declined in curricular presence.[193]

4.2.1 Handwriting in Literacy

Handwriting is a multi-faceted occupation that has positive correlations with different areas of literacy, such as spelling,[23,25,194] composition,[16-18,20] and early reading abilities.[26-28]

4.2.1.1 Handwriting and Spelling

Research found when handwriting is not internalized, the associated cognitive demand has a negative impact on spelling and compositional abilities.[14,21,22,25,195] In other words, when children devote conscious attention to handwriting, cognitive resources are siphoned away from concurrent emergent literacy tasks, such as spelling and composition.

Research supports this postulation. A correlational study established a direct relationship between handwriting and spelling.[25] Participants who fell into the very poor to poor handwriting categories had not yet developed automaticity as their handwriting speed was significantly slower than their counterparts and researchers postulated this negatively contributed to the participants' spelling performance. Another study determined handwriting was a predictor of spelling development.[23] An inquiry by Gosse et al.[196] also confirmed a significant positive correlation between handwriting speed and spelling accuracy.

4.2.1.2 Handwriting and Composition

Handwriting mastery also has a positive impact on compositional development. Children who scored in the very good to good handwriting descriptive had increased compositional speed and fluency as compared to those who did not, again suggesting the importance of handwriting automaticity.[25] A study by Alves et al.[17] concluded a positive association between handwriting and longer and higher quality compositions. Lastly, three related correlational studies investigated determinants in writing development.[14,21,22] All confirmed the unique contribution of handwriting to compositional ability and length.[14,21,22] Handwriting contributed to the most significance variance in compositional abilities as compared to other factors, such as demographic characteristics, spelling proficiency, and oral language skills.[21]

4.2.1.3 Handwriting and Reading Development

Handwriting promotes early reading abilities. Research has found a significant direct relationship between letter naming fluency and letter writing with kindergarteners,

which has been attributed to the shared perception, cognition, and application of orthographic features of letters in both reading and handwriting.[27] Research has supported the positive influence handwriting has on the early reading skill of letter naming with adults as well through a case with a man with acquired dyslexia.[28] Viewing handwritten letters as compared to typed produced superior results with letter recognition, concluding reading a typed letter employs different neural pathways than the graphomotor letter identification required of reading a handwritten letter. Functional magnetic resonance imaging (fMRI) has confirmed this postulation as participants recruited neural pathways associated with reading when reading handwriting, and these pathways were not used when reading typing.[26]

4.2.2 Handwriting and Occupational Therapy

Even as handwriting has an influential relationship with other literacy areas, handwriting continues to be overlooked in explicit academic instruction.[193] Research has found a significant number (ranging from 10 to 56%) of typically developing children have difficulty with handwriting.[18,39] Subsequently, handwriting difficulty is the most frequent reason for referral for school-based occupational therapists.[41]

When addressing handwriting outcomes with clients, occupational therapists are diverse in their utilized techniques. Federer et al.[50] conducted a survey where 90% of occupational therapists reported using a sensorimotor approach to handwriting interventions; how the sensorimotor approach translated into practice varied significantly. A subsequent survey of occupational therapists identified multisensory approaches as the most frequent manner in which to target handwriting goals, but this also encompassed a wide range of specific intervention techniques.[49]

Systematic reviews of the handwriting research confirm occupational therapists are heterogeneous in their approach to handwriting.[51,52,197] Cahill and Beisber[197] determined the evidence for therapeutic practice was stronger than that of sensorimotor techniques, finding a combined approach to be valuable. In an additional systematic review of the handwriting research, the strongest evidence supports the use of self-evaluation techniques when addressing handwriting outcomes.[51] The systematic review by Hoy et al.[52] concluded frequency of intervention was the most significant predictor of positive outcomes. All systematic reviews found interventions that focused on component-level skill development removed from handwriting to be ineffective.[51,52,197]

4.2.3 Handwriting Without Tears®

Manualized handwriting programs that combined therapeutic practice and sensorimotor opportunities have been found to be effective in handwriting instruction.[197] Handwriting curricula provide a systematic, easily replicable approach for direct instruction of handwriting, which improves both legibility and speed.[198]

The Handwriting Without Tears® (HWT) program is a widely used handwriting curriculum by occupational therapists, teachers, and caregivers. Currently ten states have adopted the HWT program into their state curriculum for a systematic approach to teach handwriting, receiving public funding for HWT workbooks and materials.[166] The HWT program is designed to be used with children who are typically developing as well as those with special needs.[122]

HWT is a multisensory handwriting program that provides explicit instruction in a sequential, developmental order.[122] The HWT program incorporates sensorimotor

feedback into handwriting teaching to elicit multiple tactile, visual, and auditory experiences to master letter memory and formation.[122] HWT utilizes a streamlined letter to decrease extraneous effort exerted in letter production. Letter introduction in the HWT program begins with gross motor modeling; followed by fine motor manipulatives to create the letter; and lastly, the child practices handwriting in isolated letter, word, sentence, and paragraph formats. The HWT workbooks provide students with practice of letter writing within the larger context of academic literacy practices. The HWT program is designed to support occupational mastery of handwriting through activities that can be adjusted to a child's abilities and interest.

Evidence supports the use of the HWT program to improve handwriting outcomes. The HWT curriculum has been determined to achieve equivalent[70,199] or superior results as compared to other handwriting curricula.[68,69] There are two subsets of HWT research including those that examine its effectiveness as an individual intervention versus as a consultative handwriting curriculum. As an individual intervention, the strength of the HWT research is limited due to smaller sample sizes. In a case study with a four year old with developmental delay, the HWT program improved letter sizing and form.[173] Grindle et al.[172] investigated the effectiveness of the HWT with three children with autism. All improved in handwriting scores after 32 weeks of the HWT program. In a study of the effectiveness of a modified HWT program, developed into "handwriting kits" for children with dysgraphia, significant legibility gains were noted.[119] As an individual intervention, the research is promising to improve handwriting legibility, but has yet to be researched into the impact on handwriting speed.

The research of the impact of the HWT program delivered by an occupational therapist consulting in a classroom is stronger as the studies employ larger sample sizes and control groups.[170,171,200] Donica[169] consulted with classroom teachers on delivering the HWT program as compared to teacher-developed lessons. The kindergarteners who received the HWT program outscored the control group on all measures. Another study also determined the HWT program combined with a consultative occupational therapy approach, to be effective with 70% in the HWT cohort demonstrating handwriting improvements.[170] Schneck et al.[171] found positive results associated with the use of the HWT program using a consultative approach, but it was not superior to the control teacher-designed instruction. While there is research supporting the use of the HWT program, it is limited in its scope of the effectiveness with children with literacy difficulties as well as its determination of associated literacy benefits.

4.2.4 Pediatric Occupational Therapy Telehealth

The effectiveness of the HWT program has also not been researched in a telehealth delivery format. The use of telehealth was increasing steadily, but with the advent of the current COVID-19 pandemic, telehealth had a sharp utilization incline. Surveys of global occupational therapists reported increases in telehealth use ranging from 159%[55] to 1137%.[56] Even as contact restrictions have lessened, the use of telehealth has remained and perceived as valuable among occupational therapists, with 78% reporting they will continue to use telehealth.[58]

For pediatric occupational therapy, research has determined many perceived benefits and challenges associated with telehealth by both caregivers and clinicians. Benefits include increased caregiver communication and incorporation into treatment;

more accessible; flexible to family routines and schedules[59]; client comfort at home[60]; improved access to clients; less time between referral and initiation of services[61]; better consistency and attendance; and carryover of home programs.[62] The disadvantages of telehealth delivery include issues with technology[57]; less effective evaluation and monitoring of client progress[63]; and inability to provide physical facilitation.[60]

As the utilization of telehealth continues to grow, the research into the effectiveness of interventions delivered via telehealth must catch up. Even in 2010, the AOTA recognized this gap, requesting further research into the effectiveness of occupational therapy telehealth.[64] The pediatric telehealth occupational therapy research is limited in scope with Criss[134] as the sole study to research handwriting outcomes using an adapted fine motor approach. This gap in literature calls for further investigations, especially into the effectiveness of the widely used HWT program.

Thus, there is a need to examine the effectiveness of the HWT program on handwriting and spelling outcomes via telehealth delivery for children with handwriting and/or spelling delays. The hypotheses for this study are:

1. Second and third grade students with handwriting and/or spelling delays receiving HWT instruction via telehealth delivery will demonstrate:
    a. significantly greater handwriting legibility at post-intervention.
    b. significantly greater handwriting speed at post-intervention.
    c. significantly greater spelling ability at post-intervention.
2. The HWT program will be a feasible intervention for literacy skills via telehealth delivery.

4.3 Materials and Methods

4.3.1 Study Design

A repeated baseline case series design was used for this study to research the effectiveness of the HWT program on handwriting and spelling outcomes for children with spelling and/or handwriting difficulties using telehealth delivery. A case series design was chosen because it translated to the clinical settings where context and participants characteristics are variable.[201] The participants served as their own controls to account for the developmental differences amongst participants. Repeated baseline testing was used to establish the variability in handwriting and spelling skills for each participant, accounting for typical handwriting and spelling instruction they received regularly. Each participant received baseline handwriting and spelling testing, two weeks without intervention, second handwriting and spelling testing, HWT intervention (7 weekly synchronous visits; 14 biweekly asynchronous lessons), and posttest.

Throughout the study, extensive reflexive journaling was used to document the principle investigator's subjective experience to reflect on any potential biases.[202] Another method to address internal bias was to maintain an audit trail of decisions made throughout the study,[203] supplemented with weekly peer debriefing meetings with an outside occupational therapist with over 35 years of experience. Lastly, any spontaneous, unsolicited verbal or written qualitative feedback that was provided by the participants was recorded. The study was approved by the institutional review board (IRB) at a southeastern university.

4.3.2 Participants

The participants were recruited using convenience sampling through community contacts at local elementary schools, pediatric therapy clinics, and non-profit organizations in Central Kentucky. Each facility was provided with an IRB-approved flyer and an email template to provide to potentially interested families. Informed consent and assent were then obtained from the caregiver and participant respectively. Demographic data of age, grade level, identified gender, co-morbidities, and handwriting and spelling history was collected per caregiver report. A target of 9 participants was selected as this would achieve 90% power using Criss[134] as a comparative study, which investigated the effectiveness of fine motor interventions, including HWT manipulatives, on telehealth with elementary-aged participants.

Inclusion criteria were as follows: children who are 1) in second or third grade, ranging from 7 to 10 years old; 2) speak English fluently as the English language has its own unique orthographic, phonetic, and morphological features; 3) able to give informed consent and assent; and 4) score 2/3 a standard deviation below norms in the Test of Handwriting Skills-Revised and/or the Test of Written Spelling-5. Exclusion criteria included children who 1) have been diagnosed with autism, down syndrome, intellectual disabilities, and/or severe cognitive delay; and 2) are non-English speakers. Participants in second to third grade were chosen because it has been found they are receptive to handwriting and spelling interventions,[174,175] but are still in the development of these skills.[176] Additionally, in a study conducted on the effectiveness of pediatric telehealth therapy, it was found that participants in second grade were the most responsive to this type of service delivery as compared to those in upper elementary.[137]

4.3.3 Measures

The outcome measures assessed handwriting quality, handwriting speed, and spelling at repeated baseline pretests and posttest were: The Test of Handwriting Skills-Revised (THS-R) and the Test of Written Spelling (TWS-5).

The THS-R is a standardized, norm-referenced assessment that measures manuscript handwriting legibility and speed.[204] It has ten subtests to evaluate uppercase and lowercase alphabetic writing from memory, writing from dictation, copying at a letter, word, and sentence level, and recording dictated spelling words. Handwriting speed is assessed as an ancillary test during the alphabetic writing subtests. The interrater reliability for this assessment ranged between 0.59 to 1.0, with the majority of the subtests ranging between 0.75 to 0.9 agreement. Additionally, temporal stability was established over a two week period. For overall scores, the temporal stability was 0.82 for the overall standard score, ranging between 0.49 to 0.82 for the individual subtests.[204]

The TWS-5[174] is a norm-referenced spelling assessment that was designed for both instructional and research purposes.[177] It utilizes dictation to assess written spelling, generating raw scores, standard scores, age and grade equivalents, and percentiles. It has two stimulus forms (Form A and Form B) to diminish bias from repeat testing; thus, different stimulus words were used for pre- and posttests. The TWS-5 has strong interrater reliability at 0.99 for Form A and 0.95 for Form B. The temporal stability was also tested over a two week period, ranging between 0.84 to 0.95 dependent on grade levels.[174]

4.3.4 Procedure

All synchronous sessions with participants were conducted via Zoom. Zoom is an online teleconferencing platform frequently used to deliver telehealth services.[179] Zoom was the delivery platform selected because it is compliant with the Health Information Portability and Accountability Act, ensuring privacy and confidentiality of participant visits.[179]

4.3.4.1 Testing

Prior to the initial participant meeting, informed consent was obtained from the caregiver. Upon the first telehealth visit, the participants were assented and then subsequently tested and screened for inclusion into the study dependent on participant agreement. The primary investigator conducted the THS-R and Form A of the TWS-5 with each participant. After the initial testing, if the participant scored within the inclusion criteria, the participants were assessed again after a two week period without intervention in an attempt to capture the variability in pediatric development. During the second baseline testing, the THS-R and Form B of the TWS-5 were used. The two-week period was selected as both the TWS-5 and the THS-R used two weeks to establish temporal stability.[174,205] Lastly, a posttest was conducted after the final intervention visit with the THS-R and Form A of the TWS-5.

Recording forms for the assessments were provided virtually through a data-encrypted, secure online portal or contactless delivery depending on participant preference and location. The forms were returned to the primary investigator in the same manner.

Two blinded scorers were used to decrease potential scoring bias as well as establish interrater reliability for this study. The scorers were both pediatric occupational therapists with 15+ years of experience, who were students in a post-professional clinical occupational therapy doctorate program. Each scorer was provided training in both assessments by the primary investigator via Zoom as neither had used the assessments previously. The scorers and the primary investigator together worked through a case example, scoring the THS-R to compare reasoning of scores and process. After training, the primary investigator did not view scores completed by the blinded scorers in an effort to not bias her scoring of the outcomes. The scorers were provided as blinded, uploaded assessments through a secure, encrypted online portal as scorers resided across the country. The primary investigator also scored each assessment to serve as a point of reference.

4.3.4.2 Intervention

As discussed in Chapter 3, the systematic review by Hoy et al.[52] found a basal of 20 visits, twice weekly, to be the most important predictor to improve handwriting outcomes. Using the experiences and participant feedback from the Chapter 3 pilot study, 20 synchronous telehealth visits was cumbersome for the participant and felt pragmatically difficult to translate into clinical practice. Thus, the delivery was adjusted to reflect the findings from the Chapter 3 pilot study. Each participant met with the primary investigator in a synchronous telehealth session once weekly for seven weeks. Two additional asynchronous lessons were assigned to the participants each week through the HWT Interactive Digital Teaching Tool®™ (IDTT), for a total of 21 visits (7 synchronous, 14 asynchronous). All upper case and lowercase manuscript letters were

reviewed either in the synchronous or asynchronous visits. Weekly email reminders were provided with the login information to the IDTT.

The participants participated in seven 30-minute HWT treatment sessions conducted by the primary investigator via Zoom once weekly. A reminder email with the participant's secure Zoom link was sent weekly to the caregiver in an effort to maintain consistency. If a participant was unable to meet at the scheduled time, the visit was rescheduled. Prior to the initial intervention visit, each participant was provided with a HWT Grade 2 workbook as well as HWT manipulatives to practice letter formation (Roll-a-Dough set, Wooden pieces for capitals, Stamp and See set, and Wet-Dry-Try set) via contactless delivery. The HWT Grade 2 workbook was chosen for all participants because the HWT curriculum transitions to emphasizing cursive instruction in Grade 3. There is a Grade 3 HWT manuscript workbook available, but after consulting with a HWT representative it was found this workbook provides manuscript practice without upper case and lower case explicit instruction (Christina Bretz, O.T.D., email communication, September 17, 2021); thus, the HWT Grade 2 workbook was used for all participants.

Each session used the same format as used in the pilot study (Chapter 3). The primary investigator started with a review of previously taught letters and introduction to the letter instruction for that session completed using the Zoom whiteboard. Next, HWT warm-ups were completed, including: a HWT song that aligned with the session goal (i.e., the "Vowel" song when reviewing vowels), postural and grip activities; gross motor character introduction; fine motor character introduction using the HWT manipulatives; handwriting practice in the HWT workbook; and finally, the participant provided a self-

assessment of their confidence in what they had learned during that session. When possible, the participants were provided choice of activities within the HWT manipulatives and warm-up activities in efforts to support their autonomy.

For consistency with the synchronous lessons, the Grade 2 curriculum was also used for the asynchronous IDTT visits. The 14 assigned IDTT lessons were approximately 10 minutes in length dependent on the material presented. All participants were introduced to the IDTT lessons during the first synchronous visit with the primary investigator. Caregivers were provided written login instructions, which were also included in each weekly visit reminder email. In order to access the IDTT session, participants would need assistance from caregivers to login. Each IDTT session maintained a similar, but condensed format to the synchronous visits. The lessons began with a warm-up activity, which included animations of letter formation, videos of gross motor letter games, grip activities, or HWT songs. This was followed by individual letter writing practice on the computer, first with tracing and then with copying the letter on the computer. Whether the participant used their finger, trackpad, or mouse to complete the writing portion relied on the computer setup of the individual participant. Each participant was assigned individual lessons and the primary investigator was able to monitor their progress through the IDTT platform.

4.3.5 Data Analysis

As mentioned above, the blinded scorers accessed de-identified recording forms of the TWS-5 and THS-R uploaded by the primary investigator through a secured, encrypted online portal. At the conclusion of the study, the primary investigator used the blinded scorers' raw scores to calculate standard scores and percentiles. Once the primary

investigator completed scoring all participant assessments for all scorers, the scores were inputted into Excel 2019, Version 16.30 for primary analysis of means and percent change.

IBM SPSS Statistics Software 2021, Version 28.0 was used to calculate interrater reliability, variability among the pretest data sets, confirm normality of the data set, and run paired t-tests to determine significance of changes between pre- to posttest. Interrater reliability to determine the level of agreement between the blinded scorers was calculated through Cohen's kappa statistic.[206] Since the inclusion criteria for participants was difficulty with handwriting and/or spelling, a wide range of overall standard scores could be calculated for the TWS-5 and the THS-R because participants may or may not have deficits in either or both of these areas. Therefore, per statistician recommendation (Stacey Slone, M.S., zoom meeting, May 3, 2022), the scorers' standard scores were classified into descriptive categories, ranging from Very Poor to Very Superior rather than using the raw data. These descriptive categories were outlined in the TWS-5 with standard score ranges as seen in Table 4.1[174] The THS-R does not provide

Table 4.1. Descriptive categories standard score range[174]

Descriptive Category	**Standard Score Range**	**Assigned Numerical Value**
Very Superior	>129	7
Superior	120-129	6
Above Average	110-119	5
Average	90-109	4
Below Average	80-89	3
Poor	70-79	2
Very Poor	<70	1

descriptive categories and suggests to use the standards of professional practice[205]; thus, the descriptive categories of the TWS-5 were adopted for both measures to maintain consistency. Numerical values were assigned to the descriptive categories ranging from 1 (Very Poor) to 7 (Very Superior). The Cohen's kappa was also run between pretest 1 and pretest 2 scores for both blinded scorers to determine levels of agreement and stability amongst the baseline measures. Cohen's kappa statistic ranges in values between -1.0 to 1.0.[206] Kappa values of ≤ 0 indicate no agreement, 0.01 to 0.20 as no to slight agreement, 0.21 to 0.40 as fair agreement, 0.41 to 0.60 as moderate agreement, 0.61 to 0.80 as substantial agreement, and lastly 0.81 to 1.0 as near perfect agreement.[206]

For the normality tests and the paired t-test, the average baseline scores for the overall standard score for the TWS-5 and the THS-R were compared to the posttest scores for each participant. For the ancillary test for speed, the number of letters written in 40 seconds from alphabetic memory were recorded; then pretest numbers were averaged and compared to posttest for each participant. The two baseline measurements for each assessment were averaged for each participant as scored by each individual outside scorer (i.e., for the TWS-5, pre1 and pre2 for participant A was averaged by scorer 1 and by scorer 2). Then the two scorers' baseline averages were averaged together to generate a baseline average for comparison to the posttest average between the two scorers.

The normality for each data set (pre/posttest letters/40 seconds for speed and overall standard scores for the TWS-5 and THS-R) was calculated using SPSS. Normality was determined by the Shapiro-Wilk test and measures of skewness and kurtosis. Additional visual examination of the points plotted on a histogram were used as

a point of reference. The Shapiro-Wilk test was selected as it is a normality test for sample sizes under 50 participants[207] and has greater associated power than comparable tests.[208] When the $p > 0.05$, the data is assumed normally distributed.[209] Skewness and kurtosis were also calculated using SPSS; skewness measures the symmetry of the data and kurtosis, the pointedness of the data.[208,209] Z values were subsequently determined by dividing the statistic of skewness or kurtosis by standard error. If Z values were between -1.96 and 1.96, the data was found to be normally distributed. Lastly, visual inspection of histogram plots was used as a secondary point of reference for normality.[208,209]

Once the data was confirmed to be normally distributed, the paired t-test was selected to determine significance of difference between pretest and posttest values. The paired t-test is used to determine differences between two data groups, which in this case is pretest and posttest measurements.[210] A p-value of < 0.05 was determined to be significant.[210]

Lastly, field notes were made throughout the intervention to capture the participants' responses and reactions to the treatment to provide descriptive support to the findings; however, not enough qualitative data was generated to warrant further analysis. The field notes provided qualitative validation of outcomes with spontaneous verbal feedback provided by participants.

4.4 Results

The primary purpose of this study was to determine the effectiveness of the HWT program delivered via telehealth on handwriting and spelling outcomes for second and third grade participants.

4.4.1 Participants

Twelve participants were recruited, screened, and completed 100% of synchronous sessions for this study, including two repeated baseline pretests, seven synchronous telehealth visits, and a final posttest. Only four participants completed any portion of the asynchronous IDTT lessons, ranging from 14% to 100% of sessions completed. Eleven participants were male with one female. The ages upon enrollment ranged from 7 years, 10 months to 9 years, 9 months, with an average of 8 years, 6 months. Six participants were in second grade and six in third. Five participants attended public schools and seven were in private schools. All participants were right-handed with the exception of one left-handed participant. Four participants met the inclusion criteria for handwriting speed and the remaining eight met the inclusion criteria for combined spelling and legibility or speed deficits (legibility n=6, speed n=7, spelling n=8). One participant was enrolled in occupational therapy at the start of the study, but was discharged by the end. Otherwise, five other participants reported previous history with occupational therapy, but no active participation. Four caregivers reported participant experiencing issues with attention, but only one had a diagnosis of Attention Deficit Disorder (ADD). It was noted, however, that six participants, including the four with attentional issues, required more cueing to attend to task than the remaining six. The participants varied in the total time they were enrolled in the study from 55 to 91 days since many participants missed and rescheduled visits due to illness, outside commitments, and/or travel.

Of the twelve participants, one of the pages of the posttest THS-R recording form was lost before secured by the primary investigator; thus, data for only 11 participants

were scored for handwriting speed and the overall THS-R legibility. Spelling results for all 12 participants was ascertained. Additionally, all of the recording forms for one participant were discarded upon initial testing, so this participant went through three rounds of baseline testing with two weeks between each testing session. Therefore, the participant had TWS-5 form B for the first scored pretest as compared with form A for all other participants. See Table 4.2 for a summary of demographic information.

4.4.2 Handwriting Results

The pretest averages were compared to the posttest averages for both handwriting speed and the overall THS-R standard scores, indicating overall handwriting legibility.

4.4.2.1 Handwriting Speed

Handwriting speed was calculated as total letters written from alphabetic memory in 20 seconds for the uppercase alphabet and 20 seconds for the lowercase alphabet. Handwriting speed was determined as an ancillary test apart of the THS-R subtests 1 and 2. One of the outside scorers consistently recorded the handwriting speed (33 of 35 tests) whereas the other only scored it in 13 of 35 tests. Cohen's kappa for interrater reliability was calculated with the paired 13 tests between the outside scorers at 0.915. Since there were less that 50% points of comparison, Cohen's kappa was also run with the values tabulated by the primary investigator and the first outside scorer (with 33 of 35 tests) as a reference and a 0.862 kappa was achieved. Thus, the interrater reliability was near perfect agreement across scorers since both were above 0.80.[206]

Table 4.2. Participant Characteristics

Participant	Age	Gender	Handedness	Grade	School	Inclusion Criteria	IDTT lessons completed	Days from Pretest 2 to Posttest	Device
P1	8-1	Male	Right	2	Private	L, S	0	69	D
P2	9-1	Male	Right	3	Public	L, S	14/14	71	L
P3	8-0	Male	Right	2	Private	HS	10/14	62	L
P4	8-5	Male	Right	3	Private	HS	14/14	71	D
P5*	8-2	Male	Right	2	Public	L, S	0	57	L
P6	9-4	Male	Right	3	Private	L, S	0	71	D
P7	9-2	Male	Right	3	Private	HS, S	0	71	D
P8	8-2	Female	Right	2	Public	HS, S	2/14	78	P
P9	8-0	Male	Right	2	Private	HS	0	67	T
P10	7-10	Male	Right	2	Private	HS	0	55	L
P11	9-9	Male	Right	3	Public	L, S	0	85	D
P12**	8-8	Male	Left	3	Public	L, HS, S	0	91	L

L=legibility, S=spelling, HS=handwriting speed, T=tablet, L=laptop, D=desktop
** Participant who discarded first testing forms, thus had three rounds of baseline testing*
*** Participant who discarded first page of THS-R posttest; only spelling results used*

Variability was observed in speed scores from pretest 1 and pretest 2 across participants and scorers with a Cohen's kappa of 0.045 between paired pretests indicating slight agreement. The change between pretest scores ranged from -11 to 14 with an average of -0.5 of letters/40 seconds.

The Wilk Shapiro statistic was run to determine the normality of the data. Since the second scorer had not calculated the speed consistently, the averages between the primary investigator and the first scorer were used. The data was found to be normally distributed with a p-value of 0.096 for pretest speed and 0.584 for posttest speed. P-values above 0.05 were found to indicate normally distributed data.[209] Z-values for skewness and kurtosis also confirmed normal distribution as all values (skewness: Zpre=0.0635, Zpost=0.343; kurtosis: Zpre=-1.538, Zpost=0.631) were between -1.96 and 1.96.[208,209] Lastly, visual inspection of the data appeared to be in a normally distributed bell-shape.

As the data was confirmed to be normally distributed, a paired t-test was used to determine the significance between the pretest speed scores and the posttest scores. The p-value was 0.001 indicating significant increase in speed scores with a mean average change of 4.70. A direct relationship was plotted between the pretest and posttest scores as seen in Figure 4.1.

4.4.2.2 Handwriting Legibility

Handwriting legibility was determined by the overall standard scores of the THS-R. Both outside scorers scored all subtests of the pretests and posttests with the exception of the one subtest the participant reported as missing from a posttest THS recording form packet. The primary investigator used the scorers' subtest scores to calculate the standard scores for 11 participants, omitting the data from the participant with an incomplete posttest.

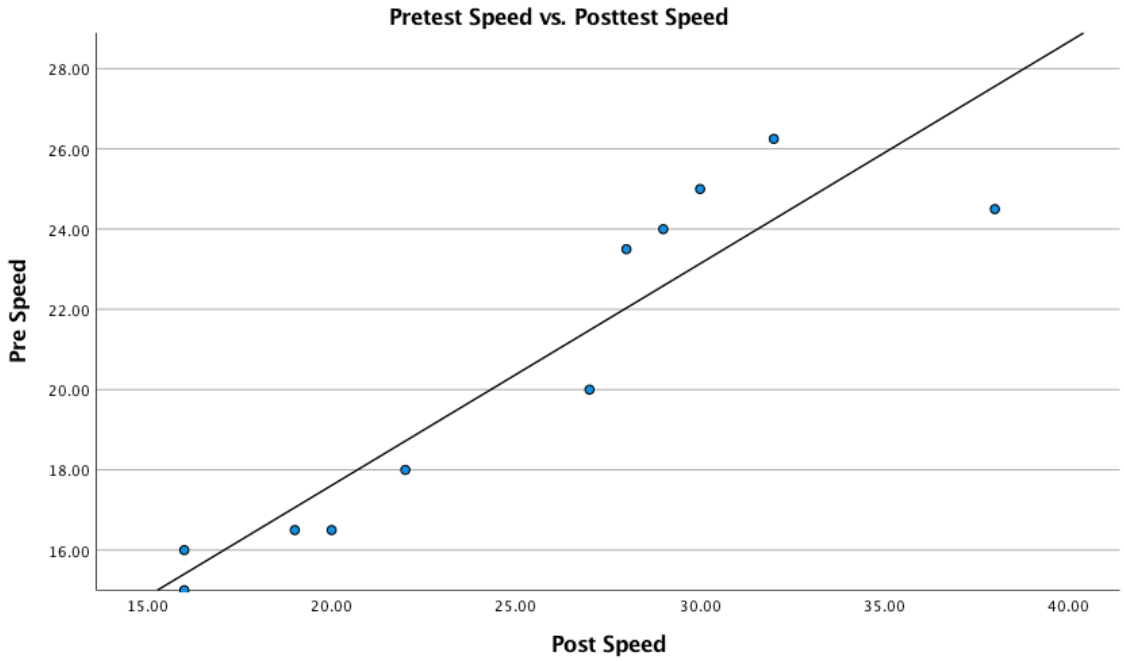


Figure 4.1: Pretest vs. Posttest Handwriting Speed Scores

Interrater reliability was determined for the outside scorers using comparisons between descriptive categories of the standard scores. The Cohen's kappa was found to be 0.172 between the outside scorers, which indicates a slight agreement. Each scorer was compared to the primary investigator's scoring and had higher agreement with Cohen's kappa of 0.231 and 0.350, but still only in the fair agreement range.[206] As compared to the interrater reliability of found by the THS-R, which ranged between 0.59 to 1.0,[205] the agreement between the two scorers was much lower. Both blinded scorers received uploaded copies of the recording forms. Interrater reliability may have been impacted by the quality of the uploads and how the scorers viewed the recording form (i.e., printed version versus virtual), which is a potential limitation of the study and will be discussed further.

Variability between pretest 1 and pretest 2 scores for participants was noted with a Cohen's kappa of 0.091 again suggesting slight agreement. The change between pretest scores ranged from -11.5 to 9.5 with a mean of -1.5.

The Wilk Shapiro statistic indicated the pretest and posttest data was normally distributed with a p-value of 0.312 for pretest and 0.346 for posttest. The Z-values for skewness was found to be -0.351 for pretest and 0.115 for posttest, which again supports normal distribution. The Z-values for kurtosis were -1.01 for pretest and -1.16 for posttest, within the normal distribution range. The histogram of results also indicated a bell-shaped distribution.

A paired t-test was run between pretest and posttest scores to determine significance and none was found with a p-value of 0.241. The mean average of change from pretest to posttest was -3.09. Please see Figure 4.2 to see a scatterplot of the THS-R

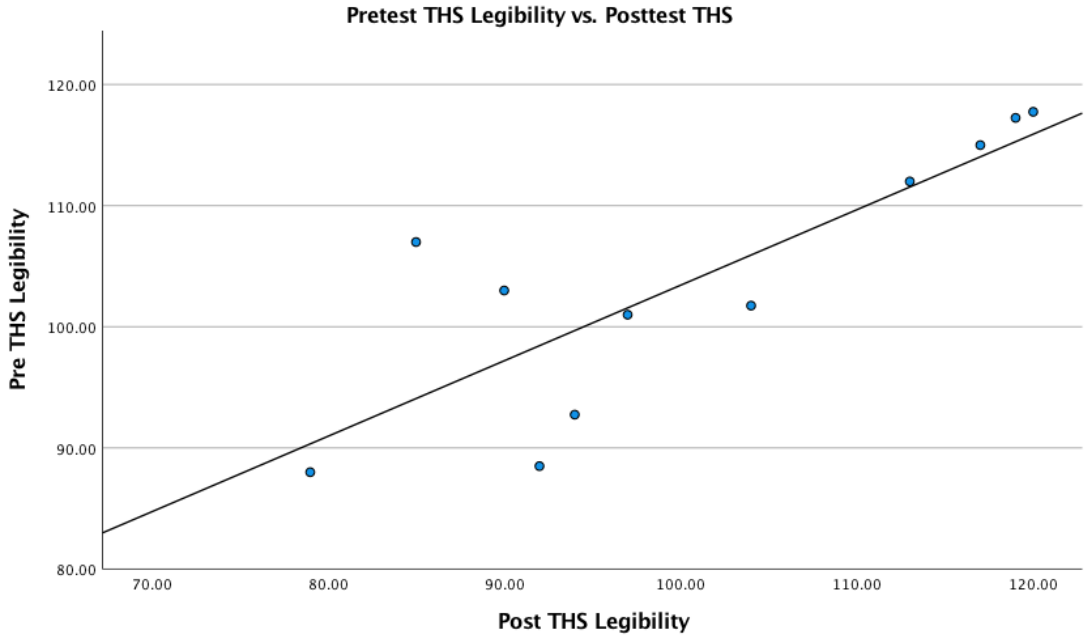


Figure 4.2: Pretest vs. Posttest Overall THS-R Standard Legibility Scores

standard score results.

4.4.3 Spelling Results

The pretest averages were compared to the posttest averages for TWS-5 standard scores. Full data sets for all 12 participants were ascertained. Raw scores were calculated by the outside scorers and the primary investigator generated the standard scores based on these tabulations. The interrater reliability was again determined using the descriptive categories for the standard scores. The Cohen's kappa found was 0.783 between the two scorers. Although this is lower than the interrater reliability found by the TWS-5, which ranged from 0.95 to 0.99,[174] there was still substantial agreement.[206]

The Cohen's kappa between pretest 1 and pretest 2 scores was 0.450, indicating moderate agreement. The range of change between participants was -13 to 7.5 with an average of -3.5.

The Wilk Shapiro generated a statistic of 0.979 for both pre- and posttests, suggesting normally distributed data. The skewness Z-values were -0.324 and -0.584 for pretest and posttest respectively. The kurtosis Z-values were -0.496 for pretest and 0.040 for posttest, which corroborated normality as well. Lastly, the histogram was in a bell curve as another point of reference for normality.

The paired t-test was run comparing pretest spelling scores to posttest scores. There was not a significant change between pretest to posttest with a p-value of 0.337. The mean change between pretest to posttest was 2.145, ranging between changes of 14.75 to -10.75 (8 improved and 4 declined). Please see Figure 4.3 for a scatterplot of spelling results. Refer to Table 4.3 for a table of participant-level results.

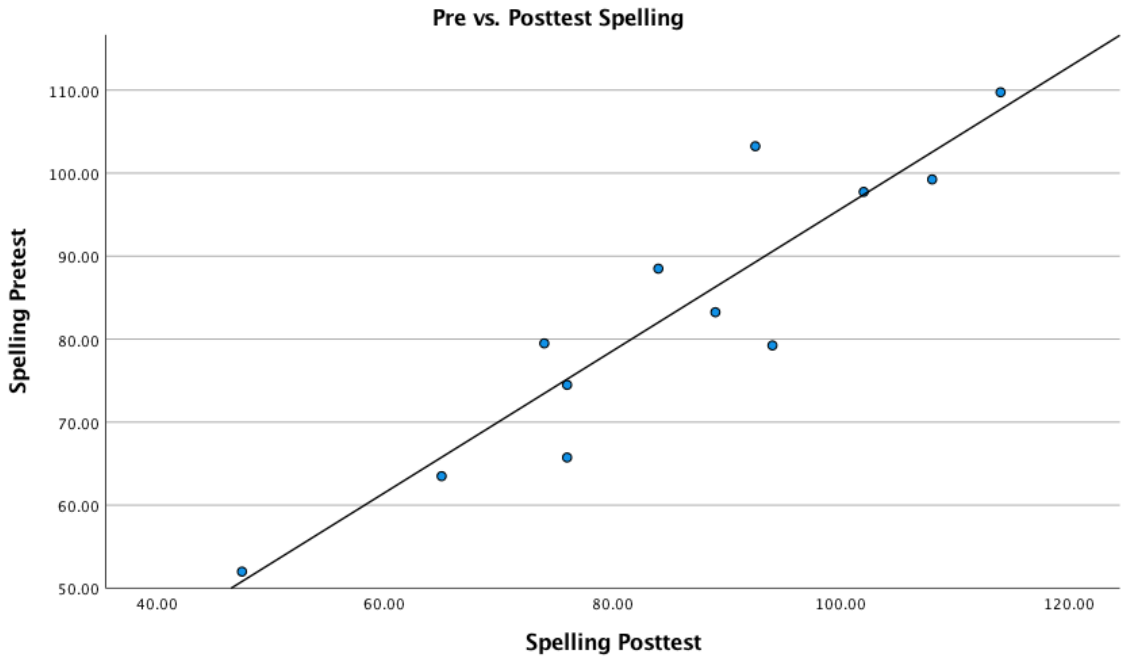


Figure 4.3: Pretest vs. Posttest Overall TWS-5 Standard Spelling Scores

Table 4.3. Summary of Participant Results

	P1	P2*	P3	P4	P5**	P6	P7	P8	P9	P10	P11	P12***
Speed												
Pretest Avg	26.25	23.5	16.5	16	25	24	16.5	20	18	15	24.5	
Posttest Avg	32	28	19	16	30	29	20	27	22	16	38	
Pre Change	3.5	-3	3	-1	-8	10	-7	14	0	-6	-11	
Change	5.75	4.5	2.5	0	5	5	3.5	7	4	1	13.5	
THS-R												
Pretest Avg	89.75	81.5	118.5	100.5	92.75	97.5	119.5	113.5	96.25	119	99.5	
Posttest Avg	94	72	111.5	102	89	91.5	112	107.5	85.5	110.5	94.4	
Pre Change	3.5	9.5	-1	0	-10	3	-9.5	-8.5	-11.5	9.5	-2	
Change	4.25	-9.5	-7	1.5	-3.75	-6	--7.5	-6	-10.75	-7.5	-5	
TWS-5												
Pretest Avg	83.5	74.5	99.25	103.25	79.25	88.5	65.75	79.5	109.75	97.75	63.5	52
Posttest Avg	89	76	108	92.5	94	84	76	74	114	102	65	47.5
Pre Change	-9.5	-13	7.5	-1.5	-6.5	-2	0	5	-5	-2	-11	-4
Change	5.75	1.5	8.75	-10.75	14.75	-4.5	10.25	-5.5	4.25	4.25	1.5	-4.5

*P=participant; Pre Change=change between pretest 1 and 2 baseline measures *P2 reported sustaining a concussion 3 days prior to posttest ** Discarded first testing forms, thus had three rounds of baseline testing ***P12 misplaced first page of recording packet of THS-R, which included the speed subtest*

4.5 Discussion

This repeated baseline case series investigation sought to gain insight into the effectiveness of the HWT program via telehealth delivery to improve handwriting and spelling outcomes for a second and third graders with handwriting and/or spelling delays. Additionally, this study provided information on the feasibility of delivering the HWT program via telehealth.

4.5.1 Handwriting Discussion

4.5.1.1 Handwriting Speed

The participants demonstrated significant increases in handwriting speed after completing the synchronous HWT telehealth visits with a p-value of 0.001and mean improvement of 4.70 letters/40 seconds. The range of change in speed across participants was 0 to 13.5 letters/40 seconds. This corroborates the findings of the pilot study in Chapter 3, where the participant exhibited a 150% change in handwriting speed from pretest to posttest. Previous handwriting research also supports the use of handwriting interventions on improving handwriting speed.[44,45,117,160]

The effectiveness of the HWT program on handwriting speed is relevant as handwriting speed has been found to be an indicator of automaticity of handwriting skills.[161] When handwriting becomes internalized, more cognitive resources can be allotted to composition allowing for further writing development.[15] The findings of previous research support this postulation as handwriting speed accounted for the most unique variance at 4.1% for compositional abilities as compared to other demographic and literacy factors.[21] Skar et al.[211] found handwriting accounted for 7.4% of the variance

in compositional quality in a study with almost 5000 first through third graders. Children who write at a depressed speed subsequently have decreased overall compositional output[43]; thus, children who are not automatic with their handwriting are at higher risk for compositional difficulties.[212] In a systematic review of the literature examining the relationship between handwriting and literacy for kindergartners, strong evidence was found that supports the relationship of handwriting fluency to compositional and early reading abilities.[194] Handwriting speed had not been studied as an outcome in the HWT literature previously; therefore, these results add support to the effectiveness of the HWT program to improve handwriting speed via telehealth.

4.5.1.2 Handwriting Legibility

Significant increases in overall handwriting legibility as determined by the THS-R standard scores were not observed with a p-value of 0.241 and mean change of -3.09 The pretest/posttest change ranged from -10.75 to 4.25 across participants with only two of eleven participants exhibiting increases in handwriting legibility. This contradicts the previous HWT research, which has consistently demonstrated significant improvements in legibility after receiving the HWT program.[68-70,119,170,173,199] Additionally, Criss[134] conducted a pilot program delivered via telehealth, which incorporated HWT manipulatives and HWT notebook paper. Of the eight elementary-aged participants, all demonstrated gains in their overall legibility. Thus, the results of the current study oppose the existing research.

The potential reasons for the diverging results between the literature and the legibility results of this study are wide-ranging. A longitudinal correlation study found a negative relationship between handwriting speed and handwriting legibility for children

in third grade.[196] As children wrote faster, they tended to incur more legibility mistakes, which was observed in the current study. In 9 of 10 participants in this study (one participant did not change in handwriting speed) speed improved, but their legibility declined. The overall means of change also demonstrate this relationship with a mean change of 4.70 for handwriting speed and -3.09 for legibility. This negative relationship could have also been observed because the participants' legibility did not have sufficient time to adjust to the increased speed and no follow-up testing was conducted, which warrants further research into sustained results. Additionally, fluency has been found to be a determinant in compositional ability; thus, the impact of possible declined legibility on compositional quality needs to be further researched.

Hoy et al.[52] conducted a systematic review where they determined the most significant predictor for legibility improvement was frequency, specifically twice weekly visits for a total of at least 20 visits. The pilot study targeted 20 synchronous visits, but fell slightly short at 18 visits due to end of the year commitments of the participant; however, positive results were still achieved. As discussed in Chapter 3, spontaneous anecdotal feedback by the participant and her caregiver was the frequency of visits was difficult to maintain, which was experienced by the primary investigator as well. The author found the frequent visits cumbersome and unrealistic to translate that rate of handwriting-devoted interventions into clinical practice and accordingly adjusted the intervention frequency for the current study. Each participant completed 7 synchronous visits once weekly and was assigned 2 additional asynchronous weekly IDTT lessons for a total of 21 visits. The completion of the IDTT lessons were minimal with only four participants accessing the software outside of the synchronous visits; two participants

completed all IDTT lessons, one completed 71%, and one 14%. Thus, the frequency was not met as suggested by the Hoy et al.[52] systematic review. There was not a correlation observed, however, between those participants who completed the asynchronous visits and improvements in legibility. Retrospectively, the IDTT program may not have been the appropriate fit for asynchronous lessons. IDTT was chosen because it is a product of HWT, and thus the consistency of the lessons, including terminology, letter formation, and activities, was maintained. However, pencil-to-paper practice was not achieved through IDTT. In a study conducted by Mayer et al.[157], a stylus or writing on a touchscreen was deemed the least favorable writing tool option because the surface of the device provides less friction and consequently requires increased motor control to maintain legibility. Frequency of handwriting visits and suitable avenues in which to elicit supplemental handwriting practice warrants further study to find a balance of applicability to practice and intervention effectiveness. These findings may support the use of consultations within the classroom setting in order to achieve more frequent handwriting practice, while also allowing handwriting to be practiced within the wider scope of a literacy lens.

Another factor into the legibility null results could be characteristics of the participants. In a longitudinal study of early elementary students, Gosse et al.[196] found that the development of handwriting legibility plateaued at second grade while handwriting speed and spelling continued to progress. They postulated that the critical period of development of handwriting legibility may be in first grade. Mudkar[73] emphasized that the potential for neuroplasticity is highest during critical periods of development. Timing and age are a pivotal contributors to neuroplasticity according to

neuroplasticity principles.[71] Reflecting on the results of this study, it is hypothesized that compensatory handwriting strategies for legibility may be ingrained in older elementary students; thus, a short-term handwriting intervention may not be an appropriate fit for older students with issues with legibility. The relationship between explicit instruction of handwriting, age, and frequency of practice needs to be further researched.

Another characteristic of the participants was many had difficulty with attention. Fifty percent of the participants in this study were observed to need moderate cueing to attend to task as observed and reflexively journaled by the primary investigator (n=4 with caregiver reports of attentional issues; n=6 observed to require increased cueing to maintain attention). Increased screen time usage has been found to have adverse effects on attention,[213] which may be impactful in this telehealth study where there is a high percentage of participants struggling with concentration. Attention effects of ADD have are exacerbated in an online learning context, causing inattention-related mistakes.[214] Becker et al.[215] found adolescents with an ADD diagnosis participating in online education struggled with their educational experience as compared to their peers without attentional concerns, including increased difficulty to concentrate and an associated low affect. The use of telehealth delivery with participants with attentional issues should be further examined to determine the effectiveness of this service delivery option.

4.5.2 Spelling Discussion

The effectiveness of the HWT program via telehealth on spelling outcomes was not significant with a p-value of 0.337. The mean change between pretest to posttest was 2.145, however 75% of participants increased their spelling scores. Ten participants remained in the same descriptive category from pretest to posttest while two increased

(one participant increased from poor to average and one participant increased from average to above average). With visual analysis of the spelling scatterplot, a direct relationship between pretest to posttest after the HWT intervention was observed, but this should be interpreted with caution as the results were not significant. The spelling results of the Chapter 3 pilot study were inconclusive as well. The participant experienced a slight decrease in TWS-5 scores were found whereas there were minimal gains associated with the Primary Spelling Inventory. The participant remained in the same descriptive category of average for spelling throughout the study, exhibiting inconclusive results.

Moderate strength of evidence has been found that supports the direct relationship between handwriting fluency and spelling abilities.[194] Increases in handwriting skills correspond with growth of spelling development.[23] This correlation has been postulated due to the reinforcement provided by the physical and kinesthetic nature of handwriting with understanding of orthographic patterns with spelling. McCarney et al.[25] concluded participants with poor to very poor handwriting performed significantly lower on spelling tasks. The researchers inferred that participants with handwriting difficulties had not yet developed automaticity and cognitive resources were pulled away from spelling to devote to the act of handwriting. Conversely, research has shown spelling challenges predicted decreased handwriting fluency in older students.[196]

The significance of the current investigation spelling results may have been negatively impacted by design factors of the study. Due to the nature of the telehealth format, difficulty with hearing occurred frequently with dictation during both the administration of the TWS-5 and the THS-R. The primary investigator self-corrected by repeating the directions and annunciating more clearly, but this may not have translated

into the participant adequately hearing the dictation, especially with the TWS-R. For example, differentiating between the words “to” and “two” was difficult for some participants even with the provided sentence to place the word into context. The primary investigator speculates this was due to challenges with the directions rather than spelling ability because on one attempt the participant would spell it correctly and the second, they would not. These mistakes did not occur consistently or with all participants, however. Testing fatigue may have also influenced the significance of the results as well. In future research on the relationship between handwriting and spelling, these factors need to be considered.

4.5.3 Telehealth Feasibility

The last aim of this study was to inform the feasibility of the HWT program delivered via telehealth. To garner information on this area, the primary investigator maintained extensive field notes.

4.5.3.1 Role of the Device Type

The type of device the participant used to access the telehealth visit varied from desktops (with 1 to 2 screens; n=5), laptops (n=5), tablets (n=1), and smartphones (n=1). The device type influenced the delivery of sessions. The participants with desktops, tablets, and smartphones were unable to adjust their cameras, therefore, in the majority of instances, the primary investigator often could not view the act of handwriting, but only the product. Additional activities, such as grip instruction, were addressed in the air rather than in a paper-to-pencil context. Participants with laptops were able to adjust their screens for the primary investigator to observe them in the act of handwriting; thus,

laptops (or desktops with adjustable cameras) were the best devices for telehealth delivery in this study. The contribution of the device type was apparent and warrants further investigation as to the effectiveness of telehealth delivery versus device.

4.5.3.2 Benefits of Telehealth

Many of the benefits found in the telehealth literature were experienced during this study as well. The study experienced no attrition of synchronous visits, which can be attributed to the telehealth format. Research has shown there is improved continuity of care[59,129] and attendance,[62] which was demonstrated in this study. Three participants were put into quarantine for COVID-19 exposure, but were still able to attend their visits. The primary investigator experienced slight illness as well and was able to continue to administer the HWT visits. The telehealth service delivery supported consistency during this study.

Additionally, research has shown that telehealth visits adapt more easily to the family routine,[60,128-130] which was noted during the study as the schedule was adjusted to the participants' school and activity schedules. The participants were drawn from a greater geographical range, which was possible due to the telehealth delivery. Expanded access to clients and clients in rural locations has found to be a beneficial aspect of telehealth.[56,61,130] Research has also determined clients are more comfortable during telehealth visits as they are in the context of choice.[58,60,78,129] Comfort of the participants was observed during this study as the therapeutic relationship was quick to be established.

4.5.3.3 Associated Challenges of Telehealth

The main challenges reported by both families and therapists associated with telehealth were technological in nature.[56,60,62,63,128,129] This was a consistent difficulty encountered throughout the study, especially with internet issues. Only on one occurrence, however, was the session stopped due to internet challenges, but on multiple occasions computers froze. Other device factors included difficulty with sound, indicated above with the challenges with assessment dictation. Difficulty with screen clarity was also noted, especially when administering the TWS-5. In order to monitor the participants' progress towards the ceiling on the TWS-5, the participants would show the primary investigator the spelling recording form. Often, the form was difficult for the primary investigator to read; thus, adjustments were made for the participant to write and dictate their spelling. One participant had a cracked screen and could not complete any of the whiteboard drawing or IDTT activities.

Abbott-Gaffney et al.[63] discussed other challenges providers experienced with telehealth. Therapists reported difficulty monitoring progress, which was experienced by the primary investigator, especially influenced by the participant device type as discussed above. The need for an e-helper was a challenge reported in the Abbott-Gaffney et al. study.[63] All of the participants in this study were familiar with teleconferencing and had participated in virtual education in the past year. Because of this background, most caregivers were not present during the visits (only 2 consistently were available). Thus, if technological or logistical issues arose, it was more difficult to navigate. Additionally, if a participant was distracted by teleconferencing attributes (i.e., using the chat, virtual backgrounds, emojis), it at times was difficult to redirect them back to the HWT lesson. Lastly, multiple studies found the inability to provide physical cueing a barrier to

telehealth,[56,60] which was a challenge in the present study as it appeared many participants needed additional proprioceptive input to attend to task.

Pediatric occupational therapy telehealth research continues to lag, but the acceptance of families to use telehealth services has increased.[63] The research of the effectiveness of pediatric occupational therapy interventions via telehealth is limited. Criss[134] investigated the impact of telehealth interventions on handwriting outcomes; however, the majority of the intervention research in pediatric telehealth examined the effects of caregiver education,[132,141,142] gross motor upper and lower body interventions,[136,138-140] and adapting school-based intervention for telehealth delivery.[131,137] None of the interventions studies have been conducted as the pandemic has sustained and children have increased in their online usage.[216] The impact of this greater utilization has demonstrated positive and negative effects, which needs to be further investigated.[216] The HWT program also incorporates fine motor manipulatives and gross motor activities, accordingly physical guidance may be influential to the results, which did not translate into telehealth service delivery. Interventions requiring more physical components need to be further studied to determine if it is effective to deliver these interventions via telehealth as compared to in-person. Lastly, null results need to be reported,[217] especially with telehealth delivery as this service delivery is often more convenient and accessible to clients, but it needs to be established as equally effective as in-person treatment.

4.6 Limitations

There are limitations associated with this study, therefore the results should be carefully interpreted. Even though the 90% power was met, a case series studies with a

sample size of 12 has limited external validity and thus needs to be expanded in future research to a greater sample size with controls. The participants were not representative of the larger population. Seven participants attended private school and five public. In the United States, approximately ten times as many children attend public school as compared to private.[218] Only one participant was female and all, but one, were of middle to upper socioeconomic levels. Additionally, only one participant was left-handed, which is the participant who did not return a full THS-R posttest; thus, their data are not included in the handwriting results. Among participants, there were also inconsistencies between delivery of telehealth services depending on the device upon which they were using.

The primary investigator was unable to view approximately 50% of the participants in the act of handwriting dependent on the participant's device as discussed above. While the primary investigator was able to observe the participants complete appropriate letter formation using the whiteboard feature on Zoom, this correct letter formation may not have been translated into handwriting on paper. Thus, the participants could have been practicing incorrect letter formation, which may have negatively impacted the legibility results, and a limitation of this study.

The limited access to the asynchronous visits was an additional limitation to the study. As previously mentioned, four of 12 participants initiated asynchronous IDTT lessons, ranging from 14% to 100% of sessions completed. Weekly reminder emails with login information for IDTT were sent to the caregivers; however, participants did not have direct access to the IDTT lessons. Participants required the assistance of caregivers in order to login to the asynchronous platform, which was a limitation.

While the HWT workbooks provided word and sentence-level reading practice, there was limited opportunities for spelling practice. A limitation of this study was to not include spelling practice combined with handwriting, which is the natural context in which a child conducts handwriting.

The interrater reliability should also be considered when examining the results of this study as there was little agreement among scorers for overall THS-R scores (Cohen's kappa=0.172). Blinded scorer 1 had 3 positive changes, 1 no change, and 7 negative changes; scorer 2 had 5 positive changes and 6 negative changes from pretest to posttest; and the primary investigator had 4 positive changes, 2 no change, and 5 negatives. The interrater reliability as examined by the THS-R indicated agreement among raters ranging from 0.59 to 1.[205] The interrater reliability for the THS-R, however, was established between three scorers with the majority of the samples (77%) scoring the cursive test. In addition, the blinded scorers in this study did not examine original recording forms, but rather uploaded forms. It is postulated that this may contribute to the variability among results as handwriting is highly nuanced, especially for children who have difficulty with handwriting and may not apply adequate force when writing resulting in lighter (and harder to see) print. Thus, further research into the interrater reliability for the manuscript THS-R test needs to be conducted.

The uploaded format and the handwriting difficulties of the participants may have influenced the scoring of the TWS-5 as well. While the Cohen's kappa was high for this study at 0.783 between the two blinded scorers, it was lower than the interrater reliability demonstrated by the TWS-5 ranging from 0.95 to 0.99.[174] Also as discussed above, the administration of the TWS-5 had to be slightly adjusted depending on the participant's

context. At times, participants required additional verbal instructions as they had difficulty hearing via online format. The ceiling was hard to determine via visual inspection on telehealth and at times the participants had to spell aloud as well as write their responses.

The variability between all baseline pretests were high. The level of agreement between the pretest handwriting speeds was minimal with a Cohen's kappa of 0.045. This number may be quite low since raw data was analyzed; thus, there was a wide range of possible values that could be achieved (i.e., a participant could score 11 letters/40 seconds on pretest 1 and 12 on pretest 2 and would not have agreement). There was a high variability among pretest scores with legibility as well with a kappa of 0.091. Test-retest reliability was determined by the THS-R with repeated testing of 17 participants for manuscript version in 2 weeks increments, ranging between 0.47 to 0.80 reliability between overall scores. The Cohen's kappa for the TWS-5 between pretest 1 and pretest 2 scores was 0.450, indicating moderate agreement, but still lower than the test-retest reliability indicated by the TWS-5 ranging between 0.84 to 0.95. It was noted by the primary investigator that amount of effort and attention devoted to all assessments varied among participants and instance, as the THS-R is a lengthy and exhaustive handwriting assessment. Depending on the contextual influences of the visit (i.e., time of day, amount of sleep, attention, etc.), the performance on the participant was observed to be highly variable.

4.7 Conclusion

This case series supported the use of the HWT program via telehealth to improve handwriting speed. While not significant results, 75% of participants also experienced a

positive trend in their spelling outcomes. Handwriting legibility was not improved. Additionally, many benefits and challenges were associated with the telehealth service delivery format. Consistency was the most beneficial aspect of telehealth experienced in this study, which is relevant in a time where unpredictability is common due to COVID-19. Telehealth is a service delivery format that is on the rise; thus, research of specific intervention delivered via telehealth needs to be conducted to determine if the effectiveness is equivalent to that of in-person delivery.

Further research needs to be conducted to validate the results of this study. As demonstrated in the current study and the Gosse et al[196] study, a negative relationship between handwriting speed and legibility was noted. Follow-up testing is warranted to examine sustained results as well as to determine if handwriting speed and legibility have a true negative relationship or if legibility is lagging due to newly acquired speed. Gosse et al.[196] also further noted in their study that the development of handwriting legibility plateaued in second grade. Thus, research needs to determine if this inverse relationship continues to exist in earlier elementary grades during the critical period of legibility development.[196] A replication of this study is warranted with participants in earlier grades to maximize the neuroplastic potential[73] to adequately investigate the effectiveness of the HWT program delivered via telehealth.

Lastly, occupational therapy research on handwriting interventions within the wider context of literacy need to be conducted. As handwriting, spelling, writing, and reading development are interrelated in their development,[14,95,147] occupational therapists need education on literacy to continue to situate handwriting in the larger literacy picture, which will be further addressed in Chapter 5.

CHAPTER 5. SYNTHESIS OF RESULTS

5.1 Introduction

Literacy is an evolving practice area for pediatric occupational therapists.[89] A survey by Polichino[87] found that 79% of school-based occupational therapists felt they supported clients' literacy occupations. Pediatric occupational therapists, especially those working in early intervention, preschools, or schools, are members of a literacy-focused, interdisciplinary team.[88,90] With handwriting being the primary occupational performance issue school-based therapists address,[41] the relationship of handwriting in the realm of literacy needed to be further investigated.

In addition, globally as we have traversed our way through the COVID-19 pandemic, online communication systems have become more prevalent. In response, the use of telehealth in occupational therapy has drastically risen.[55,63] However, research to validate the effectiveness of interventions delivered via telehealth is lagging in comparison.

The purpose of this chapter is to 1) review how the studies of this dissertation project contributed to the knowledge of handwriting in relation to other literacy areas, such as spelling; 2) to review how the studies informed the effectiveness of delivering handwriting interventions via telehealth for children with handwriting and/or spelling difficulties; and 3) provide insights to contribute to future directions on how handwriting interventions should be considered, both theoretically and clinically, in occupational therapy.

5.2 Dissertation Overview

This section will provide an overview of the dissertation project in order to highlight findings and emerging implications observed. A summary of the dissertation will provide a foundation for the discussion of the broader themes noted throughout the project.

5.2.1 Literature Review

An examination of the literature was completed in Chapter 2. A systematic review of the effectiveness of handwriting and/or spelling interventions for children with specific learning disorders (SLD), including dysgraphia, was conducted.[84] Through the review of the literature, it was determined that the current research has a grade B of evidence to support the effectiveness of interventions to improve handwriting and/or spelling outcomes for children with SLD using the Strength of Recommendation Taxonomy; otherwise, the literature is of limited quality and inconsistent findings[109] and warrants further research. The most significant results across the literature supported the use of occupation-as-means,[53] or the use of handwriting and/or spelling activities during the intervention treatment, which support previous findings in the handwriting literature.[51,52]

A review of the pediatric occupational therapy telehealth research was also performed. The majority of the research in this area discussed the perceived benefits and barriers associated with telehealth as well as utilization patterns. Eleven studies investigated the effectiveness of pediatric occupational therapy interventions delivered via telehealth. These studies were wide-ranging in their aims, from upper and lower extremity training to using a family coaching model. Criss[134] was the sole study

investigating the use of fine motor interventions to improve fine motor and handwriting outcomes via telehealth. Twenty one of the studies in the review were conducted pre-pandemic, when both clients and therapists were less familiar with virtual teleconferencing, and seven studies were completed when contact restrictions were the tightest and there was no choice for in-person service delivery. Research has not yet examined the effectiveness of telehealth interventions when there is a choice between in-person and online services to determine if standard of care is maintained across service delivery models.

Chapter 2 concluded with a description of the theoretical background used to guide the dissertation project. The theoretical underpinnings of this project included the Occupational Therapy Practice Framework (OTPF),[1] neuroplasticity principles,[71] and the Self-Determined Occupational Performance model(SDOP).[2] These three models complemented and informed one another, supporting broader themes of person, occupation, and environment in order to improve occupational engagement. Please see Figure 5.1 for an overview of the theoretical foundation of the dissertation project.

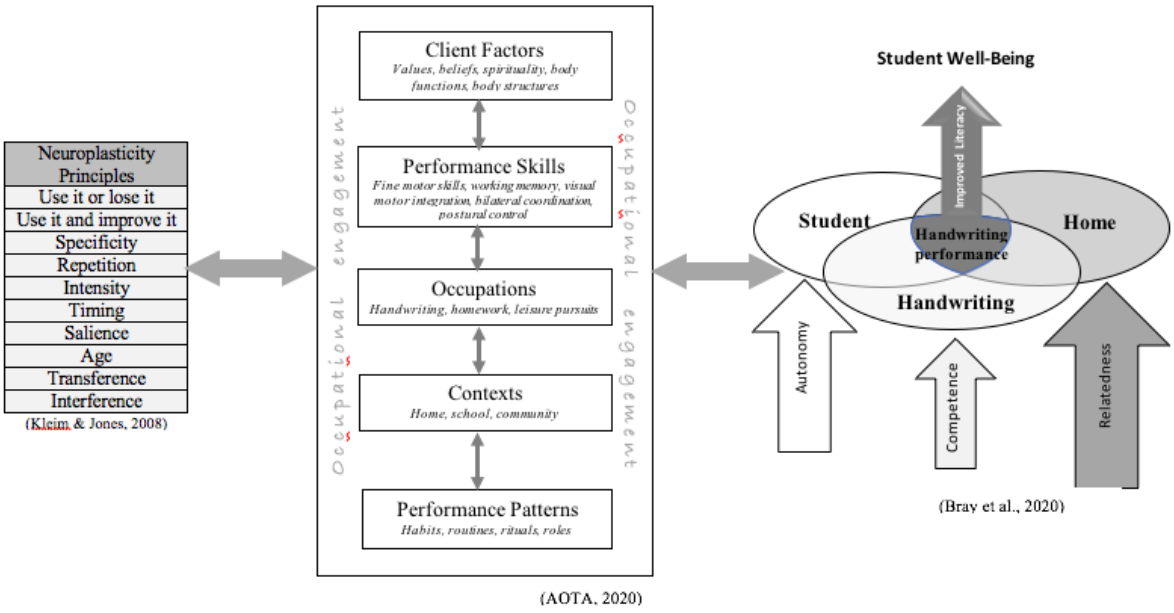


Figure 5.1: Project Theoretical Foundation

5.2.2 Pilot Study

Chapter 3 was a pilot case study with a two-pronged purpose: to explore the effectiveness of the Handwriting Without Tears® (HWT) program to improve handwriting and spelling outcomes delivered via telehealth; and to provide insight into the feasibility of telehealth as a service delivery option for the HWT program. The participant was a first-grade female who was typically developing. A participant without literacy challenges was selected to prevent confounding factors, such as physical or cognitive delays, from impacting the relationship between handwriting and spelling. The participant met synchronously with the primary investigator for 16 HWT intervention sessions, three times weekly for 30 minutes. The frequency was based upon the recommendation of a systematic review of the handwriting research by Hoy et al.[52] They found 20 visits, twice weekly, to be the optimal target of practice for handwriting

intervention effectiveness. As this was the end of the school year and the participant had other outside engagements, therefore, only 16 visits were scheduled and completed.

Upon posttest, improvements were noted in both handwriting legibility and speed. The participant increased in 5 of 12 legibility subtests and remained at the same level (usually the ceiling) for 6 of 12 subtests. She exhibited a 150% increase in handwriting speed from pretest to posttest. Spelling improvements were inconclusive as on one measure she improved and the other declined, but remained within the average descriptive category throughout. The differences in spelling results were postulated to be due to performance variations rather than true change.

The feasibility of the HWT program delivered via telehealth was promising. The HWT manipulatives were provided to the participant prior to the initiation of the study, allowing for only minor adjustments to be made in order to complete the strategies provided in the HWT Instructor's manual. Previous research reported increased attendance associated with telehealth use,[184] which was supported in the case study as well with no missed visits. Throughout the sessions, the participant remained engaged and reported enjoying the intervention, which corroborates the current telehealth research.[128 61,134]

The case study provided preliminary information into the effectiveness of the HWT program delivered via telehealth on handwriting and spelling outcomes. However, adjustments were recommended for future research to improve the translation of the findings into clinical practice. Twenty visits were targeted in accordance with the suggestions of the Hoy et al.[52] systematic review. However, the participant and her caregiver both felt the frequency was consuming, especially in the context of other

school-year commitments, including homework and after school activities. Interventions that require an intensive amount of time and effort are less likely to be carried out in practice.[187] While a basal level of intensity for practice has not been established, Glasgow and Emmons[187] advocated for research to better inform minimal visits needed for change with intervention effectiveness. Additionally, a client with no challenges with handwriting and/or spelling would be less invested to participate in this robust of a handwriting intervention and is not representative of typical caseloads held by pediatric occupational therapists. These study attributes should be considered and adjusted in future research in this area.

5.2.3 Case Series Study

A repeated baseline case series study to investigate the effectiveness of the HWT program via telehealth delivery on handwriting and spelling outcomes for second and third grade students with handwriting and/or spelling difficulties was detailed in Chapter 4. This case series also informed research on the feasibility of telehealth to deliver the HWT program.

Twelve second and third graders were recruited for the study, 11 males and 1 female with an average age of 8 years, 6 months. Four participants exhibited difficulty with handwriting speed and the remaining had combined handwriting and spelling deficits (legibility n=6, speed n=7, spelling n=8). Repeated baseline measures were conducted with a two-week non-intervention period to gain information about typical performance variability. Each participant had seven synchronous HWT visits once weekly and two additional asynchronous lessons assigned weekly through the HWT Interactive Digital Teaching Tool®™ (IDTT) in an effort to meet the 20-visit target

suggested by the Hoy et al.[52] systematic review, but in a less time intensive manner. All participants attended 100% of the synchronous lessons whereas the participation in the asynchronous lessons was minimal. Only four participants accessed the IDTT program (n=2 with 100% completion, n=1 with 71% and n=1 with 14%); thus, 20 visits were largely unmet among participants. Also, one participant lost a page of the posttest handwriting recording form; therefore, none of the participants' handwriting measures were included in the handwriting results.

This study measured handwriting speed, legibility, and spelling. Significant improvements were found among participants for handwriting speed (p=0.001). All participants increased their handwriting speed with the exception of one who did not exhibit change. Participants did not have significant associated handwriting legibility changes (p=0.241). In fact, only two participants improved in their legibility with nine decreasing in their overall legibility scores. This is in contrast to the existing HWT research, which has seen associated improvements in legibility.[68-70,119,170,173,199] However, it supports the research conducted by Gosse et al.[196] where an inverse relationship between handwriting speed and legibility was observed. Additionally, the interrater reliability among two blinded scorers for the handwriting legibility assessment indicated only slight agreement (Cohen's kappa=0.172).

The results for spelling were also insignificant with a p-value of 0.337. Seventy five percent of participants improved in their spelling scores from pretest to posttest. Ten participants remained in the same descriptive category while two increased; thus, the majority of the change was relatively minor. The previous research into the relationship between handwriting and spelling has observed that increases in handwriting fluency

were positively correlated with spelling.[23,25,194] Although not significant, it is interesting to observe that the majority of the participants in this study both improved in handwriting fluency and spelling; whereas legibility declined. It is postulated, especially in older grades (i.e., fourth grade and above), the impact of handwriting legibility on spelling may be minimal to none. Further research needs to be conducted to confirm this hypothesis.

Perceived benefits and challenges associated with telehealth were noted throughout the study. Benefits included no attrition, ability to include participants in wider geographical range, and participants were able to attend visits in their environment of choice. The main telehealth barrier observed during this study was associated with the type of device used by the participant. The majority of the participants had an immobile camera (i.e., on a smartphone, tablet, or desktop), so the primary investigator was limited in their field of vision, including the ability to observe the participant in the act of handwriting. The exchange of the recording forms was also difficult as two participants discarded parts of the forms. The other barriers were minor in nature, such as internet difficulties or attentional challenges, but manageable.

This case series supports the use of the HWT program via telehealth to improve handwriting speed. Further examination needs to be conducted with possible adjustments for visit frequency and participant age. As the Hoy et al.[52] systematic review determined, a frequency of 20 visits, twice weekly is a significant predictor of improvement in handwriting. This case series study attempted to structure its visits for 7 synchronous visits and 14 asynchronous biweekly visits in order to accommodate the participants' schedules. However, with minimal carryover of the asynchronous visits, the 20-visit mark was far from met. Thus, this frequency needs to continue to be adjusted, focusing on a

balance of frequency effectiveness and practical translation into clinical practice. Additionally, it has been found that children typically plateau in their legibility in second grade, so the HWT program via telehealth should be investigated further with younger participants.[196] With older children where handwriting compensatory strategies have already been developed, an approach for self-evaluation and correction may be more beneficial.[51]

5.3 Synthesis of Dissertation Studies

This section will overview the multi-faceted nature of handwriting as a component of literacy; discuss an evolved theoretical foundation; and apply the aforementioned concepts to practice.

5.3.1 Handwriting in Literacy

In occupational therapy, handwriting is frequently targeted as an isolated occupational modality and/or goal for clients. As the OTPF detailed, occupations "have particular meaning and value to that client."[1] Does handwriting as a singular occupation mesh with this description? For most students, probably not. However, if you place handwriting into the greater lens of relevant literacy-based and academic occupations, for most students, the occupational meaning is enhanced.

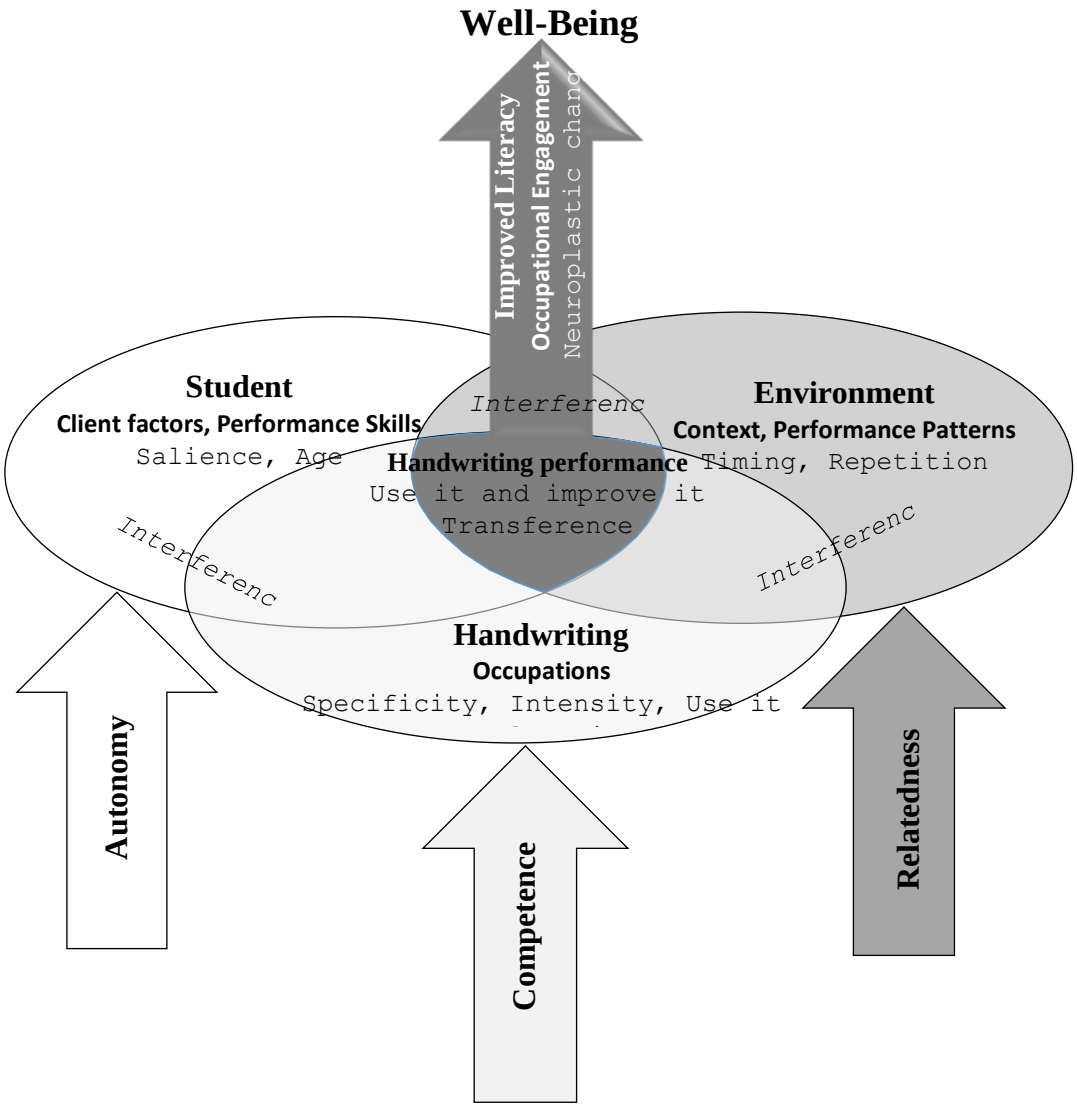
As a profession, occupational therapy has transitioned away from a reductionist approach,[219] where occupational performance issues were strained down to component-level deficits rather than concurrently considering the broader perspective of person, environment, and occupation.[80] A reductionist approach has been found to be ineffective when addressing handwriting outcomes. When therapists do not actually employ

handwriting into treatment, but rather focus on remediation of contributing skills, the results are ineffective.[51,52] A wider lens is needed to continue to progress occupational therapy practice by consideration of the role handwriting plays in literacy-based occupations. By explicitly recognizing the role of handwriting in literacy, it is postulated occupational therapists will be able to address handwriting outcomes more successfully as well as contribute to an interdisciplinary team more efficiently. Gerde[220] described the focus on handwriting instruction should be within the parameters of a meaningful writing experience rather than rote letter practice. This concept will subsequently be pursued further in relation to an evolved theoretical foundation.

5.3.2 Evolved Theoretical Foundation

As this dissertation project progressed, it became more apparent how the three guiding models of the OTPF, neuroplastic principles, and the SDOP model were intertangled, informing one another. Please see Figure 5.2 below.

All of the models viewed the interaction of the person, environment, and occupation in order to achieve occupational performance, and ultimately engagement and wellness, but used different terminology and varying micro or macro perspectives. Each model has an important and vital role to play in informing practice, especially in the realm of handwriting and literacy. These models should guide occupational therapists when considering evaluation and practice of handwriting without losing sight of its role in literacy.



* SDOP model components is indicated by Times New Roman. OTPF components are indicated by Bradley Hand. Neuroplastic Principles are indicated by American Typewriter

Figure 5.2: Evolved Theoretical Foundation

5.3.2.1 Person

The person is an integral part of the OTPF, neuroplasticity principles, and the SDOP model. The OTPF looks at the "mind-body-spirit connection" of the person, focusing on the domains of client factors and performance skills.[1] Client factors are internal attributes of a person, capturing the "mind and spirit" through values, beliefs,

spirituality, and "mind and body" through body functions and body structures. Performance skills are a person's abilities to execute motor, process, and social interaction skills.

Neuroplastic principles begin with a microscopic view of the person by examining the brain's neurological potential for change and learning.[71] To maximize this ability for neuroplastic change, the neuroplastic principles consider age of importance as the younger the person is, the more plastic their neural networks are. Neuroplastic principles also consider salience, or importance of an activity to a person, to be a defining principle in eliciting neuroplastic change; using OTPF terminology, a person's beliefs and values. For example, Molesh et al.[221] found participants with aphasia exhibited increased success with word naming when using salient, or meaningful, word targets in comparison to words that were not indicated as motivating to the person.

The SDOP model corroborates the holistic, "mind-body-spirit" view of the person as outlined in the OTPF, but emphasizes the Self-Determination theory principle of autonomy.[2] Autonomy is the desire for personal choice of salient, or valued, occupations.[76] Autonomy is a basic psychological need that when fulfilled will help support intrinsic motivation.[74] When a person is intrinsically motivated, outcomes are improved.[74]

Within the discourse of this dissertation project, the concept of the person as outlined above refers to the student. These models support the student having a choice of occupations that are meaningful and salient to them in order to obtain occupational engagement.[1,2,71] Students who are highly motivated demonstrated increased outcomes with reading, writing, and spelling.[148] Contrastingly, when a student finds writing to not

be meaningful, they perceive it as more strenuous.[222] Taking an ecological approach, occupational therapists need to provide handwriting opportunities that are valuable to the student, which often is within the larger context of the literacy occupation of writing rather than isolated letter practice.

Additionally, the student's abilities need to be considered, such as age, body functions, body structures, and performance skills. As postulated in this study, the age of the student and appropriateness of the intervention may not have been aligned. For third graders, when compensatory handwriting strategies and neuroplastic interference are more established, it may have been beneficial to focus on a self-correction intervention rather than formation and practice of handwriting through the HWT program in the context of a short-term intervention. Physical and cognitive attributes of the student also need to be assessed when working with children on handwriting to determine the most beneficial approach to improve their engagement. An occupational therapist should regard all of a client's foundational academic literacy skills, including not only handwriting, but reading, spelling, and writing aptitude as well. These skills influence one another as they are interrelated. For example, handwriting fluency can be negatively impacted when a child has difficulty with spelling as there are more frequent associated pauses.[196] Additionally, children need to be able to read their written products to determine accuracy.[223]

5.3.2.2 Environment

The importance of environment is highlighted in all of the models as well. The OTPF has a broad definition of environment that includes the physical, technological, social, attitudinal, and institutional influences that transact with the person and

occupation.[1] All of these aspects of context play an instrumental role in how a person engages in an occupation. The temporal context is captured through a person's performance patterns, which includes their habits, routines, roles, and rituals. Through performing these patterns of tasks and occupations, a person is able to structure their time at a micro and macro level, allowing the person to reflect, engage, and prospect.

Environmental neuroplastic principles include the tenets of timing and repetition,[71] correlating with the temporal context of the OTPF. Timing in neuroplastic principles refers to the scaffolding of plasticity or skill development. In other words, in certain situations, specific skills or activities need to be learned prior to another one; thus, learning one skill is dependent on the development of the other. Repetition of an occupation is needed in order to sustain neuroplastic change, similar to a task or occupation being repeated in order for a habit or routine to be established.

The SDOP model, in alignment, with the OTPF considers the physical, social, cultural, spiritual, and institutional aspects of environment.[2] The relatedness element of Self-Determination theory is highlighted as pivotal in the environmental domain of the SDOP model. Relatedness refers the need for social connections and again contributes to intrinsic motivation,[76] which can improve occupational performance.[82]

For the dissertation project, the impact of environmental influence was central in the research question through the examination of the feasibility of delivering the HWT program via telehealth. Thus, the participants were engaging with both their home environments and the virtual context of telehealth. In alignment with previous research, participants were able to adapt to the telehealth visits within the parameters of their typical routines[59] as well as appeared more comfortable being in their home.[58,60,78,129]

Additionally, the participants were able to engage in handwriting in an environment where it typically occurs. As discussed previously, the temporal context of the study could have been a limitation. Without the completion of the asynchronous lessons, the dissertation project did not employ enough repetition to promote lasting neurological change with legibility.

The relatedness aspect of environment was emphasized through the therapeutic relationship throughout both dissertation studies.[76,81] Through the individual sessions, the primary investigator was able to build rapport without difficulty and build an individual social connection with the participants, which was reported to be waning during online education.[150]

The timing neuroplasticity principle is also relevant as according to the Simple View of Writing, once the lower level skills of handwriting and spelling become automatic, more cognitive resources can be devoted to the higher level writing processes of planning, composition, evaluation, and reflection.[15] Accordingly, once neuroplastic changes associated with handwriting are established, the potential for further neuroplasticity in the literacy realm of writing is enhanced.

5.3.2.3 Occupation

Lastly, occupation is instrumental in the OTPF, neuroplasticity principles, and the SDOP model. The OTPF describes the importance of occupation as "central to a client's (person's, group's, or population's) health, identity, and sense of competence."[1] The OTPF outlines the nine domains of occupation as activities people want and need to do.

As Townsend and Wilcock[144] explained, occupation is the modality with which occupational therapists use to assist clients.

While Kleim and Jones[71] do not use occupation in their terminology, occupation is apparent within the neuroplastic principles as well. The notion of "use it or lose it" implies the choice of occupational engagement is required in order to elicit neuroplasticity. The specificity principle of engaging with the specific occupation that is desired to be learned will contribute to neuroplastic change. The intensity ascribed to an occupation also is correlated to neuroplastic results. Thus, the attributes of occupation are vital in eliciting neuroplasticity.

Occupation is at the forefront of the SDOP model as well.[2] In alignment with the OTPF, the SDOP model emphasizes the necessity of occupation over the lifespan. It also incorporates the Self-Determination principle of competence into occupation. Competence is the desire for occupational achievement.[76] When a person perceives occupational competence, their intrinsic motivation is bolstered.[74]

Occupation was central to the research of this dissertation project. The aim of the project was to investigate the effectiveness of a handwriting occupation-as-means intervention, the HWT program, to increase handwriting and spelling occupational outcomes for children with handwriting and/or spelling difficulties. The HWT program was selected because of its use of multiple forms of letter writing practice, including at a word, sentence, and essay level as well as its incorporation of a play-based, multisensory approach to warm-up letter formation activities.[122] The program can be adjusted according to skill, interest, and activity demands to promote a perceived level of competence.[77] The specificity of the activity is in alignment with neuroplasticity

principles[71] as handwriting is actually practiced; however, it is not so for spelling, which may have contributed to the spelling results not producing a significant change.

Again, occupational therapists should not consider handwriting as an occupation in isolation, but within the broader landscape of academic literacy skills. Pontart et al.[24] conducted a study to examine the relationship of handwriting to spelling. They found that handwriting and spelling are co-occupations that occur simultaneously, where the student is often producing a handwritten word while concurrently either spelling the current or future words in the sentence. Accordingly, in a systematic review of the role of handwriting in literacy for kindergarteners, the strongest evidence supported the positive correlation between handwriting fluency and written composition skills.[194] Ehri[223] discussed the bidirectional nature of reading and spelling. To spell, a student must be able to read spelled words and to spell words; and to read, the student must know spellings of read words. While Ehri does not address handwriting specifically, handwriting can be implied in this relationship when spelled or read words are manually printed. It is impossible to tease handwriting apart from other components of academic literacy; thus, occupational therapists need to embrace the literacy aspects associated with handwriting with further education into these relationships.

5.3.2.4 Occupational Performance, Engagement, Well-being

All of the models have an associated overarching goal of engagement, although different nomenclature. The OTPF explicitly identifies occupational engagement as the target to measure occupational therapy success.[1] Neuroplastic principles aim to elicit sustained neuroplastic change, or learning, ultimately in order for a person to attain further occupational engagement.[71] Lastly, the SDOP model transcends intrinsically

motivated occupational performance into wellness as guided by Self-Determination principles, which can be achieved through engagement.[2] This engagement outcome occurs when there is alignment of the domains person, environment, and occupation in order to promote occupational performance.[80]

5.3.3 Practice Application

In order to pragmatically appreciate the above concepts, the case of Tom will be used to apply these principles to practice. Tom is an 8 and a half year old boy in second grade. He lives with his mother and younger sister in low-income housing. Tom attends a public school where he is in a class of 27 students. His teacher has observed that Tom is experiencing difficulty with handwriting, which is impacting the quality of his written work. Accordingly, she referred him to school-based occupational therapy.

5.3.3.1 Evaluation

During Tom's Individualized Education Plan meeting, an occupational therapist is introduced to the interdisciplinary team of Tom, his mother, the counselor, teacher, and speech language pathologist to address Tom's challenges with handwriting. In order to complete a comprehensive evaluation of Tom, the occupational therapist will need to speak to the team and refer to his academic records to gain a greater sense of Tom's foundational academic literacy abilities. Upon this background work, it is discovered that Tom also experiences challenges with spelling as well. The occupational therapist consults with the teacher and the speech language pathologist to understand how and when Tom is struggling with his spelling as well as if he has any existing strategies to bolster his spelling in order to reinforce these techniques during therapy visits.

Standardized assessments should be used in accordance with current standard of care to evaluate any component level and handwriting deficits contributing to Tom's handwriting struggles. However, the handwriting evaluations should be supplemented with an assessment of Tom's handwriting in context. Westwood[224] proposed utilizing an ecological approach to assessment of writing skills where skills are assessed in context. Handwriting is not specifically addressed, but it should be examined in the context of other literacy activities in the physical, social, and institutional environment where the child is having difficulty. As seen in this dissertation project, interrater reliability on handwriting legibility was low and variability among test/retest among participants was high. Performance of the student is dependent on a variety of factors, including the cultural expectations associated with the act of handwriting in a specific situation; thus, handwriting needs to be evaluated in a standardized format, but also in a natural context where occupational therapists may capture a truer representation of a child's handwriting without the influence of a formal handwriting test. Previous handwritten activities should also be viewed to supplement observations.

Tom and his family will participate in a client-centered assessment to promote autonomous goal-setting assessment to understand what Tom finds meaningful and valuable in relation to handwriting in order to guide therapeutic practice. This can be accomplished through a tool, such as the Canadian Occupational Performance Measure (COPM), where clients eight years and above and their caregivers provide opinions on their perception of occupational competence issues.[225] By promoting a student's autonomy in the goal-setting and assessment process, it has been found to decrease the needed length of treatment by two months[226] as it promotes intrinsic motivation.

5.3.3.2 Intervention

As guided by the evolved theoretical foundation described above, the occupational therapist for Tom needs to consider the person, environment, and the occupation in intervention to increase Tom's engagement in handwriting, and ultimately handwritten literacy-based occupations.

The occupational therapist considers Tom's values and interests when collaborating with him on salient, meaningful handwriting occupations. During the evaluation, Tom relayed his passion for animals, especially reptiles, to the occupational therapist. Accordingly, the occupational therapist includes ample choice of activities, especially reptile-focused activities, for Tom to support his autonomy. The occupational therapist consistently checks in with Tom for feedback on his preferences, goals, and needs for the session. Additionally, using the information provided by Tom's teacher and speech language pathologist, the occupational therapist reinforces spelling strategies Tom uses within the handwriting occupations when possible to enhance his role as a student. The occupational therapist also considers Tom's physical and cognitive attributes through supporting and building body functions, body structures, and performance skills to optimize occupational performance. For example, during a visit, Tom chose to create a diorama of a lizard in its natural habitat supplemented with a written description of that species of lizard. He addressed handwriting and spelling strategies while writing the description and promoted fine and sensorimotor skills through crafting the diorama with clay.

Environmental influence is another instrumental piece of the intervention for the occupational therapist. The occupational therapist determines social, physical, temporal,

and institutional affordances and barriers that impact Tom's handwriting. The occupational therapist uses a hybrid of in-person services with Tom and concurrent telehealth with his mother within the school environment to promote the involvement of his mother, building on Tom's sense of relatedness. Engagement of his teacher and other students may also contribute to the value and meaning ascribed to handwriting through the use of peer groups or tutoring. Returning to the previous diorama example, environment is promoted through a teleconferencing visit with Tom's mother to discuss the lizard's habitat. Tom has the opportunity to show her his product as well as the occupational therapist is able to discuss strategies they used during the visit to promote occupational support at home. Additionally, Tom could display his diorama in the classroom for his peers to view, providing conversation topics in an effort to build relatedness with his classmates.

The occupational therapist uses the occupation of handwriting to target Tom's goal, while also considering handwriting within the larger context of academic literacy. Competence will be achieved through an occupation-as-means approach to elicit the neuroplasticity principles of specificity and intensity.[71] Competence can also be bolstered through explicit instruction of handwriting and the importance of handwriting.[82] Engel-Yeger et al.[149] found empowering a student to recognize their occupational performance issues associated with handwriting provided students with ownership to overcome these challenges. During the diorama activity, the occupational therapist scaffolds discussion with Tom of handwriting strategies, such as self-correction and proper letter formation, in order to improve his competence with the activity. Tom provides a practical example of

how the broader concepts of the above intermeshed theoretical models can be applied to practice while targeting handwriting and supporting Tom's overall literacy abilities.

5.4 Conclusion

Handwriting deficits are the most frequent reason for referral for school-based occupational therapists[41]; thus, occupational therapists need to continue to develop a gold standard of practice to address handwriting. This includes the most effective and efficient service delivery method, whether in-person, telehealth, or a hybrid approach. Addressing handwriting as an isolated occupation is contributing to fragmented care in interdisciplinary teams with a literacy focus.[88,90] Occupational therapists need to develop a stronger foundational knowledge of the relationship of handwriting in academic literacy, collaborating with other interdisciplinary team members to reinforce concepts across disciplines.

REFERENCES

1. Association AOT. Occupational therapy practice framework: Domain and process fourth edition. *American Journal of Occupational Therapy.* 2020;74:87. doi: https://doi.org/10.5014/ajot.2020.74S2001.
2. Bray LMP, Capilouto G. Self-determined occupational performance model for children from economically disadvantaged backgrounds. *Can J Occup Ther.* 2021;88(4):285-293. doi: 10.1177/00084174211035627.
3. Statistics NCfE. *The condition of education 2020.* Institute of Education Sciences;2020.
4. Development OfEC-Oa. *Skills matter: Additional results from the survey of adult skills. United states.* 2019.
5. Skar GBU, Graham S, Huebner A. Learning loss during the covid-19 pandemic and the impact of emergency remote instruction on first grade students' writing: A natural experiment. *Journal of Educational Psychology.* 2021. doi: 10.1037/edu0000701.
6. Montoya S. Defining literacy [powerpoint slides]. 2018; http://gaml.uis.unesco.org/wp-content/uploads/sites/2/2018/12/4.6.1_07_4.6-defining-literacy.pdf.
7. Bell BS, Y. . Defining the role of occupational therapy to support literacy development. *School System Special Interest Section Quarterly.* 2005;12(3):4.
8. Davidson K. The integration of cognitive and sociocultural theories of literacy development: Why? How? *The Alberta Journal of Educational Research.* 2010;56(1):10.
9. Moje EB, Overby, M., Tysvaer, N., Morris, K. . The complex world of adolescent literacy: Myths, motivations, and mysteries. *Harvard Educational Review.* 2008;78(1):49. doi: https://doi.org/10.17763/haer.78.1.54468j6204x24157.
10. Initiative CCSS. English language arts standards. 2022; http://www.corestandards.org/ELA-Literacy/RF/introduction/.
11. CoreStateStandardsInitiative C. Common core state standards for english language arts and literacy in history, social studies, science, and technical subjects. 2010; http://www.corestandards.org.
12. Angelelli P, Notarnicola A, Judica A, Zoccolotti P, Luzzatti C. Spelling impairments in italian dyslexic children: Phenomenological changes in primary school. *Cortex.* 2010;46(10):1299-1311. doi: 10.1016/j.cortex.2010.06.015.
13. Roessingh H, Nordstokke D, Colp M. Unlocking academic literacy in grade 4: The role of handwriting. *Reading & Writing Quarterly.* 2019;35(2):65-83. doi: 10.1080/10573569.2018.1499160.
14. Kim YS, Otaiba SA, Sidler JF, Gruelich L. Language, literacy, attentional behaviors, and instructional quality predictors of written composition for first graders. *Early Child Res Q.* 2013;28(3):461-469. doi: 10.1016/j.ecresq.2013.01.001.
15. Berninger VW, Vaughan K, Abbott RD, et al. Teaching spelling and composition alone and together: Implications for the simple view of writing. *Journal of Educational Psychology.* 2002;94(2):291-304. doi: 10.1037//0022-0663.94.2.291.

16. Torrance M, Arrimada M, Gardner S. Child-level factors affecting rate of learning to write in first grade. *Br J Educ Psychol.* 2021;91(2):714-734. doi: 10.1111/bjep.12390.
17. Alves RA, Limpo T, Fidalgo R, Carvalhais L, Pereira LÁ, Castro SL. The impact of promoting transcription on early text production: Effects on bursts and pauses, levels of written language, and writing performance. *Journal of Educational Psychology.* 2016;108(5):665-679. doi: 10.1037/edu0000089.
18. Roessingh HN, D.; Colp, M. Beyond presentation effects: Understanding the role of handwriting in the holistic rating of young students' writing in grade 4. *Alberta Journal of Educational Research.* 2019;65(1):72-93. doi: https://doi.org/10.11575/ajer.v65i1.56630.
19. Connelly V, Gee D, Walsh E. A comparison of keyboarded and handwritten compositions and the relationship with transcription speed. *Br J Educ Psychol.* 2007;77(Pt 2):479-492. doi: 10.1348/000709906X116768.
20. Kent SC, Wanzek J. The relationship between component skills and writing quality and production across developmental levels. *Review of Educational Research.* 2016;86(2):570-601. doi: 10.3102/0034654315619491.
21. Puranik CS, Alotaiba S. Examining the contribution of handwriting and spelling to written expression in kindergarten children. *Read Writ.* 2012;25(7):1523-1546. doi: 10.1007/s11145-011-9331-x.
22. Kent S, Wanzek J, Petscher Y, Al Otaiba S, Kim YS. Writing fluency and quality in kindergarten and first grade: The role of attention, reading, transcription, and oral language. *Read Writ.* 2014;27(7):1163-1188. doi: 10.1007/s11145-013-9480-1.
23. Pritchard VE, Malone SA, Hulme C. Early handwriting ability predicts the growth of children's spelling, but not reading, skills. *Scientific Studies of Reading.* 2020;25(4):304-318. doi: 10.1080/10888438.2020.1778705.
24. Pontart V, Bidet-Ildei C, Lambert E, Morisset P, Flouret L, Alamargot D. Influence of handwriting skills during spelling in primary and lower secondary grades. *Front Psychol.* 2013;4:818. doi: 10.3389/fpsyg.2013.00818.
25. McCarney D, Peters L, Jackson S, Thomas M, Kirby A. Does poor handwriting conceal literacy potential in primary school children? *International Journal of Disability, Development and Education.* 2013;60(2):105-118. doi: 10.1080/1034912x.2013.786561.
26. James KH, Engelhardt L. The effects of handwriting experience on functional brain development in pre-literate children. *Trends Neurosci Educ.* 2012;1(1):32-42. doi: 10.1016/j.tine.2012.08.001.
27. Reutzel P, Mohr KAJ, Jones CD. Exploring the relationship between letter recognition and handwriting in early literacy development. *Journal of Early Childhood Literacy.* 2017;19(3):349-374. doi: 10.1177/1468798417728099.
28. Schubert T, Reilhac C, McCloskey M. Knowledge about writing influences reading: Dynamic visual information about letter production facilitates letter identification. *Cortex.* 2018;103:302-315. doi: 10.1016/j.cortex.2018.03.020.
29. Suggate S, Pufke E, Stoeger H. Children's fine motor skills in kindergarten predict reading in grade 1. *Early Childhood Research Quarterly.* 2019;47:248-258. doi: 10.1016/j.ecresq.2018.12.015.

30. Longcamp M, Hlushchuk Y, Hari R. What differs in visual recognition of handwritten vs. Printed letters? An fmri study. *Hum Brain Mapp.* 2011;32(8):1250-1259. doi: 10.1002/hbm.21105.

31. Vinci-Booher S, James TW, James KH. Visual-motor functional connectivity in preschool children emerges after handwriting experience. *Trends in Neuroscience and Education.* 2016;5(3):107-120. doi: 10.1016/j.tine.2016.07.006.

32. Wiley RWR, B. The effects of handwriting experience on literacy learning. *Psychological Science.* 2021;32(7):1086–1103. doi: https://doi.org/10.1177/0956797621993111.

33. McMaster E, Roberts T. Handwriting in 2015: A main occupation for primary school–aged children in the classroom? *Journal of Occupational Therapy, Schools, & Early Intervention.* 2016;9(1):38-50. doi: 10.1080/19411243.2016.1141084.

34. Berninger VW, Nagy W, Tanimoto S, Thompson R, Abbott RD. Computer instruction in handwriting, spelling, and composing for students with specific learning disabilities in grades 4 to 9. *Comput Educ.* 2015;81:154-168. doi: 10.1016/j.compedu.2014.10.005.

35. Santangelo T, & Graham, S. A comprehensive meta-analysis of handwriting instruction. *Educational Psychology Review.* 2016;28(2):225–265. doi: https://doi.org/10.1007/s10648-015-9335-1.

36. Asher A. Handwriting instruction in elementary schools. *American Journal of Occupational Therapy.* 2006;60:461-471. doi: https://doi.org/10.5014/ajot.60.4.461.

37. Collette D, Anson K, Halabi N, Schlierman A, Suriner A. Handwriting and common core state standards: Teacher, occupational therapist, and administrator perceptions from new york state public schools. *Am J Occup Ther.* 2017;71(6):7106220010p7106220011-7106220010p7106220019. doi: 10.5014/ajot.2017.021808.

38. Marquardt C, Meyer, M.D., Schneider, M. & Hilgemann, R. . Learning handwriting at school-a teachers' survey on actual problems and future options. *Trends in Neuroscience and Education.* 2016;5:82-89. doi: http://dx.doi.org/10.1016/j.tine.2016.07.001.

39. Smits-Engelsman BCM, Niemeijer, A.S., & van Galen, G.P. Fine motor deficiencies in children diagnosed as dcd based on poor grapho-motor ability. *Human Movement Science.* 2001;20:22. doi: https://doi.org/10.1016/S0167-9457(01)00033-1.

40. Jan A. Online teaching practiced during covid-19: An observation case study. *Social Sciences & Humanities Open Advance online publication.* 2020. doi: http://dx.doi.org/10.2139/ssrn.3584409.

41. Lee TI, Howe TH, Chen HL, Wang TN. Predicting handwriting legibility in taiwanese elementary school children. *Am J Occup Ther.* 2016;70(6):7006220020p7006220021-7006220020p7006220029. doi: 10.5014/ajot.2016.016865.

42. Klein J, Taub D. The effect of variations in handwriting and print on evaluation of student essays. *Assessing Writing.* 2005;10(2):134-148. doi: 10.1016/j.asw.2005.05.002.

43. O'Mahony P, Dempsey M, Killeen H. Handwriting speed: Duration of testing period and relation to socio-economic disadvantage and handedness. *Occup Ther Int.* 2008;15(3):165-177. doi: 10.1002/oti.255.
44. Limpo T, Parente N, Alves RA. Promoting handwriting fluency in fifth graders with slow handwriting: A single-subject design study. *Reading and Writing.* 2018;31(6):1343-1366. doi: 10.1007/s11145-017-9814-5.
45. Tanimoto S, Thompson R, Berninger VW, Nagy W, Abbott RD. Computerized writing and reading instruction for students in grades 4 to 9 with specific learning disabilities affecting written language. *J Comput Assist Learn.* 2015;31(6):671-689. doi: 10.1111/jcal.12110.
46. Chang SH, & Yu, N. Visual and haptic perception training to improve handwriting skills in children with dysgraphia. *American Journal of Occupational Therapy.* 2017;71(2):1-10. doi: 10.5014/ ajot.2017.021311.
47. Poon KW, Li-Tsang CW, Weiss TP, Rosenblum S. The effect of a computerized visual perception and visual-motor integration training program on improving chinese handwriting of children with handwriting difficulties. *Res Dev Disabil.* 2010;31(6):1552-1560. doi: 10.1016/j.ridd.2010.06.001.
48. Moscowitz B, Carswell, B., Kitzmiller, J., Buschell, M., Neikrug, L., Gottesman, C., Pfeiffer, B., Rai, G., & Murray, T. The effectiveness of the size matters handwriting program. *American Journal of Occupational Therapy.* 2017;71(4):7111520304p7111520301–7111520304p7111520301. doi: https://doi.org/10.5014/ajot.2017.71S1-PO5147.
49. Woodward S, & Swinth, Y. Multisensory approach to handwriting remediation: Perceptions of school-based occupational therapists. *American Journal of Occupational Therapy.* 2002;56:305-312. doi: https://doi.org/10.5014/ajot.56.3.305.
50. Feder K, Majnemer, A., & A, Synnes. Handwriting: Current trends in occupational therapy. *Canadian Journal of Occupational Therapy In Health Care.* 2000;67(3):197-204. doi: https://doi.org/10.1177/000841740006700313.
51. Grajo LC, Candler C, Sarafian A. Interventions within the scope of occupational therapy to improve children's academic participation: A systematic review. *Am J Occup Ther.* 2020;74(2):7402180030p7402180031-7402180030p7402180032. doi: 10.5014/ajot.2020.039016.
52. Hoy MM, Egan MY, Feder KP. A systematic review of interventions to improve handwriting. *Can J Occup Ther.* 2011;78(1):13-25. doi: 10.2182/cjot.2011.78.1.3.
53. Trombly CA. Occupation: Purposefulness and meaningfulness as therapeutic mechanisms. 1995 eleanor clarke slagle lecture. *American Journal of Occupational Therapy.* 1995;49(10):960-972. doi: 10.5014/ajot.49.10.960.
54. Association AOT. Telehealth in occupational therapy. *American Journal of Occupational Therapy.* 2018;72(Supplement 2):7212410059p7212410051–7212410059p7212410018. doi: https://doi.org/10.5014/ajot.2018.72S219.
55. Ganesan BF, K.N.K; Meena, S.K., Prasad, P.; Tong, R.K.Y. Impact of covid-19 pandemic lockdown on occupational therapy practice and use of telerehabilitation – a cross sectional study. *European Review for Medical and Pharmacological Sciences.* 2021;25:3614-3622. doi: 10.26355/eurrev_202105_25845.

56. Abbott-Gaffney C, Jacobs K. Telehealth in school-based practice: Perceived viability to bridge global ot practitioner shortages prior to covid-19 global health emergency. *Work.* 2020;67(1):29-35. doi: 10.3233/WOR-203240.

57. Srinivasan RW, K.E.; Soares, N. Global trends in telehealth among clinicians in developmental-behavioral pediatric practice: A covid-19 snapshot. *Journal of Developmental & Behavioral Pediatrics.* 2022;43(1):32-37. doi: doi: 10.1097/DBP.0000000000000963.

58. Dahl-Popolizio S, Carpenter, H., Coronado, M., Popolizio, N.J., & Swanson, C. . Telehealth from the provision of occupational therapy: Reflections on experiences during the covid-19 pandemic. *International Journal of Telerehabilitation.* 2020;12(2):77-92. doi: https://doi.org/10.5195/ijt.2020.6328.

59. Wallisch A, Little, L., Pope, E., & Dunn, W. Parent perspectives of an occupational therapy telehealth intervention. . *International Journal of Telerehabilitation.* 2019;11(2):15-22. https://orcid.org/0000-0003-0951-8810.

60. Grant C, Jones A, Land H. What are the perspectives of speech pathologists, occupational therapists and physiotherapists on using telehealth videoconferencing for service delivery to children with developmental delays? A systematic review of the literature. *Aust J Rural Health.* 2022. doi: 10.1111/ajr.12843.

61. Tanner K, Bican, R., Boster, J., Christensen, C., Coffman, C., Fallieras, K., Long, R., Mansfield, C., O'Rourke, S., Pauline, L., Sagester, G., & Marrie, J. . Feasibility and acceptability of clinical pediatric telerehabilitation services. *International Journal of Telerehabilitation.* 2020;12(2):43-52. doi: https://doi.org/10.5195/ijt.2020.6336.

62. Kairy D, Lehoux, P., Vincent, C., & Visintin, M. . A systematic review of clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation. *Disability and Rehabilitation.* 2009;31:427-444. doi: https://doi.org/10.1080/09638280802062553.

63. Abbott-Gaffney CR, Gafni-Lachter L, Cason J, et al. Toward successful future use of telehealth in occupational therapy practice: What the covid-19 rapid shift revealed. *Work.* 2022;71(2):385-394. doi: 10.3233/WOR-210789.

64. Association AOT. Telerehabilitation position paper. *American Journal of Occupational Therapy.* 2010;64:397-405. doi: https://doi.org/10.5014/ajot.59.6.656.

65. Kiefer M, Schuler S, Mayer C, Trumpp NM, Hille K, Sachse S. Handwriting or typewriting? The influence of pen- or keyboard-based writing training on reading and writing performance in preschool children. *Adv Cogn Psychol.* 2015;11(4):136-146. doi: 10.5709/acp-0178-7.

66. Longcamp M, Zerbato-Poudou MT, Velay JL. The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing. *Acta Psychol (Amst).* 2005;119(1):67-79. doi: 10.1016/j.actpsy.2004.10.019.

67. Suggate S, Pufke E, Stoeger H. Do fine motor skills contribute to early reading development? *Journal of Research in Reading.* 2018;41(1):1-19. doi: 10.1111/1467-9817.12081.

68. Hape K, Flood N, McArthur K, Sidara C, Stephens C, Welsh K. A pilot study of the effectiveness of the handwriting without tears®curriculum in first grade. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2014;7(3-4):284-293. doi: 10.1080/19411243.2014.975071.

69. Roberts GI, Derkach-Ferguson, A.F., Siever, J.E., & Rose, M.S. . An examination of the effectiveness of handwriting without tears® instruction. *Canadian Journal of Occupational Therapy.* 2014;81(2):102-113. doi: 10.1177/0008417414527065.

70. Salls J, Benson JD, Hansen MA, Cole K, Pielielek A. A comparison of the handwriting without tears program and peterson directed handwriting program on handwriting performance in typically developing first grade students. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2013;6(2):131-142. doi: 10.1080/19411243.2013.810958.

71. Kleim JAJ, T.A. . Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. *Journal of Speech, Language, and Hearing Research.* 2008;51(1):S225-S239. doi: https://doi.org/10.1044/1092-4388(2008/018).

72. Weyandt LL, Clarkin CM, Holding EZ, et al. Neuroplasticity in children and adolescents in response to treatment intervention: A systematic review of the literature. *Clinical and Translational Neuroscience.* 2020;4(2). doi: 10.1177/2514183x20974231.

73. Mundkar N. Neuroplasticity in children. *Indian Journal of Pediatrics.* 2005;72:855-857. doi: https://doi.org/10.1007/BF02731115.

74. Deci ELR, R.M.. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry.* 2000;11(4):42. doi: https://doi.org/10.1207/S15327965PLI1104_01.

75. Broaddus K, Ivey G. Taking away the struggle to read in the middle grades. *Middle School Journal.* 2015;34(2):5-11. doi: 10.1080/00940771.2002.11495347.

76. Ziviani J. Occupational performance: A case for self-determination. *Aust Occup Ther J.* 2015;62(6):393-400. doi: 10.1111/1440-1630.12250.

77. Ryan RM, Patrick, H., Deci, E.L., & Williams, G.C. Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *The European Health Psychologist.* 2008;10:4. http://selfdeterminationtheory.org/SDT/documents/2008_RyanPatrickDeciWilliams_EHP.pdf.

78. Allison KM, Levac DE. Impact of the covid-19 pandemic on therapy service delivery and functioning for school-aged children with disabilities in the united states. *Disabil Health J.* 2022;15(2):101266. doi: 10.1016/j.dhjo.2021.101266.

79. Shaffer J. Neuroplasticity and clinical practice: Building brain power for health. *Front Psychol.* 2016;7:1118. doi: 10.3389/fpsyg.2016.01118.

80. Law M, Cooper, B., Strong, S., Stewart, D., Rigby, P., & Letts, L. The person-environment-occupation model: A transactive approach to occupational performance. *Canadian Journal of Occupational Therapy In Health Care.* 1996;63(1):9-23. doi: https://doi.org/10.1177/000841749606300103.

81. Law M. Participation in the occupations of everyday life. *American Journal of Occupational Therapy.* 2002;56(6):640-649. doi: https://doi.org/10.5014/ajot.56.6.640.

82. Ryan RM, & Deci, E. L. Self-determination theory and the facilitation of intrinsic motivation, social development, and wellbeing. *American Psychologist,*. 2000;55(1):68-78. doi: https://doi.org/10.1037/0003-066X.55.1.68.
83. Burke DC, C.; Dixon, M.; Gunter, A.; Hampton, A.; Higgins, P.; Hruby, G.; Hurley, A.; Lovett, P.; O'Daniel, R.; Parker, C.; Pendleton, V.; Philbeck, K.; Privett, N.; Ray, M.; Rogers, J.; Shepherd, S.; Smith, F.; Willhoite, K.; Williams, M.; Wolph, J. *Kentucky literacy plan: Guide for communities, districts and schools.* 2018.
84. Bray L, Skubik-Peplaski C, Ackerman KB. A systematic review of the effectiveness of interventions to improve handwriting and spelling in children with specific learning disabilities. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2021:1-29. doi: 10.1080/19411243.2021.1934227.
85. Wasik BH, & Herrmann, S. Handbook of family literacy In: Wasik BH, ed. *Family literacy: History, concepts, services*. New York, NY: Lawrence Erlbaum Associates Publishers; 2004:3–22.
86. Fisher D, Frey, N., & Hattie, J. *Teaching literacy in the visible learning classroom, grades k-5.* Thousand Oaks, CA: Corwin; 2017.
87. Polichino JE. Ponderings of an occupational therapy administrator: Beyond handwriting—are we ready? *Journal of Occupational Therapy, Schools, & Early Intervention.* 2016;9(1):2-5. doi: 10.1080/19411243.2016.1153870.
88. Frolek Clark G. The occupations of literacy: Occupational therapy's role. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2016;9(1):27-37. doi: 10.1080/19411243.2016.1152835.
89. Strong K, Wolff M, Meier C, et al. Occupational therapy and literacy. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2018;11(4):485-511. doi: 10.1080/19411243.2018.1558523.
90. Hanser G. Emergent literacy for children with disabilities. *OT Practice*2010:5.
91. Scanlon D. Specific learning disability and its newest definition: Which is comprehensive? And which is insufficient? *Journal of Learning Disabilities.* 2013;46(1):26–33. doi: 10.1177/ 0022219412464342.
92. Act IwDE. Sec. 300.8 (c) (10). 2004.
93. Creativity YCfDa. What is dyslexia? 2017; https://dyslexia.yale.edu/#:~:text=What%20is%20Dyslexia%3F,dampen%20one's%20creativity%20and%20ingenuity.
94. Hakkaart-van Roijen L, Goettsch WG, Ekkebus M, Gerretsen P, Stolk EA. The cost-effectiveness of an intensive treatment protocol for severe dyslexia in children. *Dyslexia.* 2011;17(3):256-267. doi: 10.1002/dys.436.
95. Berninger VW, Vaughan, K.B., Abbott, R.D., Abbott, S.P., Rogan, L.W., Brooks, A., Reed, E., & Graham, S. Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology.* 1997;89(4):15. doi: https://doi.org/10.1037/0022-0663.89.4.652.
96. Chang SH, Yu NY. Visual and haptic perception training to improve handwriting skills in children with dysgraphia. *Am J Occup Ther.* 2017;71(2):7102220030p7102220031-7102220030p7102220010. doi: 10.5014/ajot.2017.021311.

97. Datchuk S. Teaching handwriting to elementary students with learning disabilities. *TEACHING Exceptional Children.* 2015;48(1):19-27. doi: 10.1177/0040059915594782.
98. Graham SJ, Harris, K.R., & Fink, B. Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. *Journal of Educational Psychology.* 2000;92(4):14. doi: 10.1037/10022-0663.92.4.620.
99. Edwards L. Writing instruction in kindergarten: Examining an emerging area of research for children with writing and reading difficulties. *Journal of Learning Disabilities.* 2003;36(2):136-148.
100. Hebert M, Kearns DM, Hayes JB, Bazis P, Cooper S. Why children with dyslexia struggle with writing and how to help them. *Language, Speech, and Hearing Services in Schools.* 2018;49(4):843-863. doi: 10.1044/2018_lshss-dyslc-18-0024.
101. Graham S, & Santangelo, T. Does spelling instruction make students better spellers, readers, and writers: A meta-analytic review. *Reading and Writing.* 2014;27(9):1703–1743. doi: 10.1007/s11145- 014-9517-0.
102. Jongmans MJ, Linthorst-Bakker, E., Westenberg, Y., & Smits-Englesman, B. C. M. Use of a task-oriented self-instruction method to support children in primary school with poor hand- writing quality and speed. *Human Movement Science.* 2003;22(4/5):549-566. doi: humov.2003.09.009.
103. Baldi S, Nunzi M, Brina CD. Efficacy of a task-based training approach in the rehabilitation of three children with poor handwriting quality: A pilot study. *Percept Mot Skills.* 2015;120(1):323-335. doi: 10.2466/10.15.PMS.120v15x5.
104. Wanzek J, Vaughn, S., Wexler, J., Swanson, E. A., Edmonds, M., & Kim, A. H. A synthesis of spelling and reading interventions and their effects on spelling outcomes of students with ld. *Journal of Learning Disabilities.* 2006;39(6):528–543. doi: 10.1177/00222194060390060501.
105. Sumner E, Connelly V, Barnett AL. The influence of spelling ability on handwriting production: Children with and without dyslexia. *J Exp Psychol Learn Mem Cogn.* 2014;40(5):1441-1447. doi: 10.1037/a0035785.
106. Donovan JL, & Marshall, C. R. Comparing the verbal self-reports of spelling strategies used by children with and without dyslexia. *International Journal of Disability, Development and Education.* 2016;63(1):27-44. doi: 10.1080/1034912X.2015.1111302.
107. Berninger VW, Abbott, R.D., Jones, J., Wolf, B.J., Gould, L., Anderson-Youngstrom, M., Shimada, S., Apel, K. Early development of language by hand: Composing, reading, listening, and speaking connections; three letter-writing modes; and fast mapping in spelling. *Developmental Neuropsychology.* 2006;29(1):33. doi: https://doi.org/10.1207/s15326942dn2901_5.
108. Downs SH, & Black, N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology Community Health.* 1998;52(6):377-384. doi: https://doi.org/10.1136/jech.52.6.377.
109. Ebell MH, Siwek, J., Weiss, B.D., Woolf, S.H., Susman, J., Ewigman, B., Bowman, M. . Strength of recommendation taxonomy (sort): A patient-centered approach to grading evidence in medical literature. *American Family Physician.* 2004;69(3):548-556. https://www.aafp.org/afp/2004/0201/p548.html.

110. Breteler MHM, Arns, M., Peters, S., Giepmans, I., & Verhoeven, L. Improvements in spelling after qeeg-based neurofeedback in dyslexia: A randomized controlled treatment study. *Applied Psychophysiology and Biofeedback.* 2010;35(1):5-11. doi: 10.1007/s10484-009-9105-2.

111. Raesi S, Dadgar, H., Soleymani, Z., & Hajjeforoush, V. Efficacy of neurofeedback training on reading and spelling skills of 8 to 12 years old children with dyslexia. *Journal of Modern Rehabilitation.* 2016;10(4):177-184. doi: 10.18869/nirp.jmr.10.4.177.

112. Medicine CfE-B. Oxford centre for evidence-based medicine – levels of evidence. 2009; https://www.cebm.net/2009/06/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/.

113. Zannikos ME, McCallum, E., Schmitt, A. J., & Pearson, K. E. A comparison of the taped spelling intervention and cover, copy, and compare for students with learning disabilities. *Journal of Behavioral Education.* 2018;27:301-327. doi: 10.1007/s10864-018-9293-z.

114. Zielinski K, McLaughlin, T. F., & Derby, K. M. The effect of "cover, copy, and compare" on spelling accuracy of high school students with learning disabilities. *American Secondary Education.* 2012;41(4):78–95. http://www.jstor.org/stable/43694150.

115. Chang SH, Yu NY. The effect of computer-assisted therapeutic practice for children with handwriting deficit: A comparison with the effect of the traditional sensorimotor approach. *Res Dev Disabil.* 2014;35(7):1648-1657. doi: 10.1016/j.ridd.2014.03.024.

116. Berninger VW, Yen-Ling, L., Abbott, R. D., & Breznitz, Z. Teaching children with dyslexia to spell in a reading-writer's workshop. *Annals of Dyslexia.* 2013;63(1):1–24. doi: 10.1007/s11881-011-0054-0.

117. Thompson R, Tanimoto, S., Lynam, R.D., Geseloqitz, K., Begay, K.K., Nielson, K., Nagy, W., Abbott, R., Raskind, M., Berninger, V. . Effective instruction for persisting dyslexia in upper grades: Adding hope stories and computer coding to explicit literacy instruction. *Education and Informational Technologies.* 2018;23:1043-1068. doi: https://doi.org/10.1007/s10639-017-9647-5.

118. Schlesinger NW, Gray S. The impact of multisensory instruction on learning letter names and sounds, word reading, and spelling. *Ann Dyslexia.* 2017;67(3):219-258. doi: 10.1007/s11881-017-0140-z.

119. Verma M, Begum R, Kapoor R. To develop an occupational therapy kit for handwriting skills in children with dysgraphia and study its efficacy: A single-arm interventional study. *The Indian Journal of Occupational Therapy.* 2019;51(3). doi: 10.4103/ijoth.ijoth_20_18.

120. Fusco N, Germano GD, Capellini SA. Efficacy of a perceptual and visual-motor skill intervention program for students with dyslexia. *Codas.* 2015;27(2):128-134. doi: 10.1590/2317-1782/20152014013.

121. McLaughlin Gray J. Putting occupation into practice: Occupation as ends, occupation as means. *American Journal of Occupational Therapy.* 1998;52(5):354-364. doi: 10.5014/ajot.52.5.354.

122. Tears HW. Research review: Handwriting without tears, k-5. (2015). 2015. https://www.lwtears.com/resources/handwriting-without-tears-research-review.

123. Education IfM-S. What is orton-gillingham? 2018; https://journal.orton-gillingham.com/what-is-orton-gillingham/.
124. Tears LW. The screener of handwriting proficiency. n.d.; www.lwtears.com/resources/screener-handwriting-proficiency.
125. Donica DKH, S. Examining validity of the print tool compared with test of handwriting skills-revised. *OTJR: Occupation, Participation & Health.* 2018;39(3):10. doi: https://doi.org/10.1177/1539449218804529.
126. Lam SST, Au, R. K. C., Leung, H. W. H., & Li-Tsang, C. W. P. Chinese handwriting performance of primary school children with dyslexia. *Research in Developmental Disabilities.* 2011;32(5):1745–1756. doi: 10.1016/j.ridd.2011.03.001.
127. Leung MMP, Lam, C. S. Y., Lam, S. S. T., Pao, N. W. Y., & Li-Tsang, C. W. P. The effect of a combined visual efficiency and perceptual-motor training programme on the handwriting performance of children with handwriting difficulties. *Optometry & Visual Performance.* 2016;4(2):76–89. http://www.ovpjournal.org/ovp—volume-4—issue-2.html.
128. Ashburner J, Vickerstaff, S., Beetge, J., & Copley, J. Remote versus face-to-face delivery of early intervention programs for children with autism spectrum disorders: Perceptions of rural families and service providers. *Research in Autism Spectrum Disorders.* 2016;23:1-14. doi: https://doi.org/10.1016/j.rasd.2015.11.011.
129. Hines M, Bulkeley K, Dudley S, Cameron S, Lincoln M. Delivering quality allied health services to children with complex disability via telepractice: Lessons learned from four case studies. *Journal of Developmental and Physical Disabilities.* 2019;31(5):593-609. doi: 10.1007/s10882-019-09662-8.
130. Utidjian LA, E. Pediatric telehealth: Opportunities and challenges. *Pediatr Clin North Am.* 2016;63(2):367-378. doi: https://doi.org/10.1016/j.pcl.2015.11.006.
131. Rortvedt DJ, K. Perspectives on the use of a telehealth service-delivery model as a component of school-based occupational therapy practice: Designing a user-experience. *Work.* 2019;62:125-131. https://onlinelibrary.wiley.com/doi/epdf/10.1002/hbm.21105.
132. Little LMP, E.; Wallisch, A.; Dunn, W. Occupation-based coaching by means of telehealth for families of young children with autism spectrum disorder. *American Journal of Occupational Therapy.* 2018;72(2):7202205020p7202205021-7202205020p7202205027. doi: https://doi.org/10.5014/ajot.2018.024786.
133. Aranki J, Wright P, Pompa-Craven P, Lotfizadeh AD. Acceptance of telehealth therapy to replace in-person therapy for autism treatment during covid-19 pandemic: An assessment of patient variables. *Telemed J E Health.* 2022. doi: 10.1089/tmj.2021.0397.
134. Criss MJ. School-based telerehabilitation in occupational therapy: Using telerehabilitation technologies to promote improvements in student performance. *International Journal Of Telerehabilitation.* 2013;5(1):39-46. doi: https://doi.org/10.5195/ijt.2013.6115.
135. Hoel VvZ, C.; Ledgerd, R.; World Federation of Occupational Therapy. The impact of covid-19 for occupational therapy: Findings and recommendations of a

global survey. *World Federation of Occupational Therapists Bulletin.* 2021;77(2):69-76. doi: https://doi.org/10.1080/14473828.2020.1855044.

136. Benham SG, V. Exploration of the effects of telerehabilitation in a school-based setting for at-risk youth. *International Journal Of Telerehabilitation.* 2017;9(1):39-46. doi: https://doi.org/10.5195/ijt.2017.6215.

137. Langbecker DH, Caffery, L., Taylor, M., Theodoros, D., & Smith, A. Impact of school-based allied health therapy via telehealth on children's speech and language, class participation, and educational outcomes. *Journal of Telemedicine and Telecare.* 2019;25(9):539-565. doi: https://doi.org/10.1177/1357633X19875848.

138. Golomb MR, Warden SJ, Fess E, et al. Maintained hand function and forearm bone health 14 months after an in-home virtual-reality videogame hand telerehabilitation intervention in an adolescent with hemiplegic cerebral palsy. *J Child Neurol.* 2011;26(3):389-393. doi: 10.1177/0883073810394847.

139. Ferre CL, Brandao M, Surana B, Dew AP, Moreau NG, Gordon AM. Caregiver-directed home-based intensive bimanual training in young children with unilateral spastic cerebral palsy: A randomized trial. *Dev Med Child Neurol.* 2017;59(5):497-504. doi: 10.1111/dmcn.13330.

140. Surana BK FC, Dew AP et al. Effectiveness of lower-extremity functional training (lift) in young children with unilateral spastic cerebral palsy: A randomized controlled trial. *Neurorehabil Neural Repair.* 2019;33(10):862-872. doi: https://doi.org/10.1177/1545968319868719.

141. Edelstein H, Schippke J, Sheffe S, Kingsnorth S. Children with medical complexity: A scoping review of interventions to support caregiver stress. *Child Care Health Dev.* 2017;43(3):323-333. doi: 10.1111/cch.12430.

142. Skar GB, Lei P-W, Graham S, Aasen AJ, Johansen MB, Kvistad AH. Handwriting fluency and the quality of primary grade students' writing. *Reading and Writing.* 2021;35(2):509-538. doi: 10.1007/s11145-021-10185-y.

143. Olson RK, Hulslander J, Christopher M, et al. Genetic and environmental influences on writing and their relations to language and reading. *Ann Dyslexia.* 2013;63(1):25-43. doi: 10.1007/s11881-011-0055-z.

144. Townsend EW, A. Occupational justice and client-centred practice: A dialogue in progress. *Candadian Journal of Occupational Therapy.* 2004;71(2):75-87. doi: https://doi.org/10.1177/000841740407100203.

145. Pierce DE. *Occupation by design: Building therapeutic power.* Philadelphia, PA: F.A. Davis Company; 2003.

146. Rapoport JL, Gogtay N. Brain neuroplasticity in healthy, hyperactive and psychotic children: Insights from neuroimaging. *Neuropsychopharmacology.* 2008;33(1):181-197. doi: 10.1038/sj.npp.1301553.

147. Berninger VW, Rutberg JE, Abbott RD, et al. Tier 1 and tier 2 early intervention for handwriting and composing. *Journal of School Psychology.* 2006;44(1):3-30. doi: 10.1016/j.jsp.2005.12.003.

148. Julien K. Loving care and funky pens: Motivating young writers. *The Reading Teacher.* 2017;71(6):659-668. doi: https://doi.org/10.1002/trtr.1670.

149. Engel-Yeger B, Nagauker-Yanuv, L., & Rosenblum, S. . Handwriting performance, self-reports, and perceived self-efficacy among children with

dysgraphia *American Journal of Occupational Therapy.* 2009;63(2):182-192. doi: 10.5014/ajot.63.2.182

150. Flack CB, Walker, L., Bickerstaff, A., Earle, H. & Margetts, C. Educator perspective of the impact of covid-19 on teaching and learning in australia and new zealand. 2020; https://pivotpl.com/wp-content/uploads/2020/04/Pivot_StateofEducation_2020_White-Paper-1.pdf.

151. Dorn E, Hancock, B., Sarakatsannis, J., & Viruleg, E. Covid-19 and learning loss-disparities grow and students need help. 2020; https://www.mckinsey.com/industries/public-and-social-sector/our-insights/covid-19-and-learning-loss-disparities-grow-and-students-need-help#.

152. Cason J. Health policy perspectives—telehealth and occupational therapy: Integral to the triple aim of health care reform. *American Journal of Occupational Therapy.* 2015;69:6902090010. doi: http://dx.doi.org/10.5014/ajot.2015.692003.

153. Graham S, Harris, K. R., & Hebert, M. It is more than just the message: Presentation effects in scoring writing. *Focus on Exceptional Children.* 2011;44(4):1-12. doi: https://doi.org/10.17161/foec.v44i4.6687.

154. Seo SM. The effect of fine motor skills on handwriting legibility in preschool age children. *Journal of Physical Therapy Science.* 2018;30(2):4. https://doi.org/10.1589/jpts.30.324.

155. Doug R. Handwriting: Developing pupils' identity and cognitive skills. *International Journal of Education and Literacy Studies.* 2019;7(2). doi: 10.7575/aiac.ijels.v.7n.2p.177.

156. Wollscheid S, Sjaastad J, Tømte C. The impact of digital devices vs. Pen(cil) and paper on primary school students' writing skills – a research review. *Computers & Education.* 2016;95:19-35. doi: 10.1016/j.compedu.2015.12.001.

157. Mayer C, Wallner S, Budde-Spengler N, Braunert S, Arndt PA, Kiefer M. Literacy training of kindergarten children with pencil, keyboard or tablet stylus: The influence of the writing tool on reading and writing performance at the letter and word level. *Front Psychol.* 2019;10:3054. doi: 10.3389/fpsyg.2019.03054.

158. Rogers J, & Case-Smith, J. Relationships between handwriting and keyboarding performance of sixth-grade students. *American Journal of Occupational Therapy.* 2002;56:34-39. doi: https://doi.org/10.5014/ajot.56.1.34.

159. Feng L, Lindner A, Ji XR, Malatesha Joshi R. The roles of handwriting and keyboarding in writing: A meta-analytic review. *Reading and Writing.* 2017;32(1):33-63. doi: 10.1007/s11145-017-9749-x.

160. Berninger VWA, R.D.; Augsburger, A.; Garcia, N. Comparison of pen and keyboard transcription modes in children with and without learning disabilities. *Learning Disability Quarterly.* 2009;32(3). doi: https://doi.org/10.2307/27740364.

161. Malpique AA, Pino-Pasternak D, Roberto MS. Writing and reading performance in year 1 australian classrooms: Associations with handwriting automaticity and writing instruction. *Reading and Writing.* 2019;33(3):783-805. doi: 10.1007/s11145-019-09994-z.

162. Montgomery D. Identifying and remediating dyslexia in the reception year, a new possibility? *Support for Learning.* 2017;32(1):60-84. doi: 10.1111/1467-9604.12150.

163. Preminger F, Weiss, P.L.T., & Weintraub, N. Predicting occupational performance: Handwriting versus keyboarding. *American Journal of Occupational Therapy.* 2004;58:193–201. doi: https://doi.org/10.5014/ajot.58.2.193.
164. De R, Pandey N, Pal A. Impact of digital surge during covid-19 pandemic: A viewpoint on research and practice. *Int J Inf Manage.* 2020;55:102171. doi: 10.1016/j.ijinfomgt.2020.102171.
165. Shigekawa E, Fix, M., Corbett, G., Roby, D. H., & Coffman, J. . The current state of telehealth evidence: A rapid review. *Health Affairs.* 2018;37(12):1975–1982. doi: https://doi.org/10.1377/hlthaff.2018.05132.
166. Tears LW. State adoption. n.d., https://www.lwtears.com/state-adoption.
167. Vygotsky LS. *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press; 1978.
168. Almasi JFF, S.K. *Teaching strategic processes in reading* second ed. New York: Guilford; 2012.
169. Donica DK. Handwriting without tears®: General education effectiveness through a consultative approach. *American Journal of Occupational Therapy.* 2015;69:6906180050. doi: http://dx.doi.org/10.5014/ajot.2015.018366.
170. Randall BS. Collaborative instruction and handwriting without tears: A strong foundation for kindergarten learning. *Journal of Occupational Therapy, Schools & Early Intervention.* 2018;11(4):14. doi: https://doi.org/10.1080/19411243.2018.1476200.
171. Schneck C, Shasby S, Myers C, DePoy Smith ML. Handwriting without tears versus teacher-designed handwriting instruction in first grade classrooms. *Journal of Occupational Therapy, Schools, & Early Intervention.* 2012;5(1):31-42. doi: 10.1080/19411243.2012.675759.
172. Grindle CF, Cianfaglione R, Corbel L, et al. Teaching handwriting skills to children with intellectual disabilities using an adapted handwriting programme. *Support for Learning.* 2017;32(4):313-336. doi: 10.1111/1467-9604.12178.
173. Meyers C, McLaughlin, T.F., Derby, M., Weber, K.P., & Robison, M. . The effects of "handwriting with tears" on the handwriting skills of appropriate size, form, and tool for a four year-old boy with a developmental delay. *Journal of Special Education Apprenticeship.* 2015;4(2):1-12. https://scholarworks.lib.csusb.edu/josea/vol4/iss2/1.
174. Larsen SC, Hammill, D.D., & Moats, L.C. *Test of written spelling, fifth edition.* Pro-ed; 2013.
175. Olsen JZK, E.F. *Handwriting without tears the print tool: The tool to evaluate and remediate.* Author; 2016.
176. Bourassa DCT, R. . Spelling development and disability: The importance of linguistic factors. *Language, Speech, and Hearing Services in Schools.* 2001;32:172-181. doi: https://doi.org/10.1044/0161-1461(2001/016).
177. Jenick CAH, D.G. Test review: Larsen, s.C., hammill, d.D., & moats, l.C. (1999). "Test of written spelling" (4th ed.; tws-4). Austin, tx: Pro-ed. . *Journal of Psychoeducational Assessment.* 2005;32(2):189-195. doi: https://doi.org/10.1177/073428290502300209.

178. Flanigan K, Hayes, L., Templeton, S., Bear, D.S., Invernizzi, M., & Johnston, M. *Words their way with struggling readers: Word study for reading, vocabulary, and spelling instruction, grades 4-12.* Pearson Education; 2011.
179. Zoom. About. 2021; https://explore.zoom.us/en/about/.
180. Olsen JZK, E.F. . *Handwriting without tears 1st grade printing teacher's guide.* Author; 2008.
181. Clark F, Park DJ, Burke JP. Dissemination: Bringing translational research to completion. *Am J Occup Ther.* 2013;67(2):185-193. doi: 10.5014/ajot.2013.006148.
182. Graham S, Harris KR, Adkins M. The impact of supplemental handwriting and spelling instruction with first grade students who do not acquire transcription skills as rapidly as peers: A randomized control trial. *Reading and Writing.* 2018;31(6):1273-1294. doi: 10.1007/s11145-018-9822-0.
183. Clark GJ. The relationship between handwriting, reading, fine motor and visual-motor skills in kindergarteners. *Graduate Theses and Dissertations.* 2010:91. https://lib.dr.iastate.edu/etd/11399.
184. Covert LT, Slevin, J.T., & Hatterman, J. The effect of telerehabilitation on missed appointment rates. *International Journal of Telerehabilitation.* 2018;10(2):65-72. doi: https://doi.org/10.5195/ijt.2018.6258.
185. Hurschler Lichtsteiner S, Wicki W, Falmann P. Impact of handwriting training on fluency, spelling and text quality among third graders. *Read Writ.* 2018;31(6):1295-1318. doi: 10.1007/s11145-018-9825-x.
186. Mehta P, Nandgaonkar H. Visual-perceptual training for handwriting legibility and speed in children with handwriting difficulties: A single-arm interventional study. *The Indian Journal of Occupational Therapy.* 2019;51(1). doi: 10.4103/ijoth.IJOTH_11_18.
187. Glasgow REE, K.M. How can we increase translation of research into practice? Types of evidence needed. *Annual Review of Public Health.* 2007;28:413-433. doi: https://doi.org/10.1146/annurev.pubhealth.28.021406.144145
188. Tears LW. Educational materials. n.d.
189. Wagner DA. Literacy. In: Bornstein M, ed. *The sage encyclopedia of lifespan human development* SAGE Publications, Inc.; 2018:1297-1298.
190. Davenport DJ, J.M. The politics of literacy. *Policy Review.* 2005:45-57.
191. Lea MR, & Street, B.V. The "academic literacies" model: Theory and applications. *Theory into Practice.* 2010;45(4):11. doi: https://doi.org/10.1207/s15430421tip4504_11.
192. Berninger VW. Development of language by hand and its connections with language by ear, mouth, and eye. *Topics in Language Disorders.* 2000;20(4):20.
193. Morgan CM, G.; Stephens, T.L.; Gardner, R.L. Understanding the importance of handwriting instruction: Implications on student cognitive and academic development. *Journal of the Texas Educational Diagnosticians' Association.* 2021;50(1):11-16.
194. Ray K, Dally K, Rowlandson L, Tam KI, Lane AE. The relationship of handwriting ability and literacy in kindergarten: A systematic review. *Reading and Writing.* 2021;35(5):1119-1155. doi: 10.1007/s11145-021-10224-8.

195. Berninger VWF, F.; Whitaker, D. A process model of writing development across the life span. *Educational Psychology Review.* 1996;8:193-218. doi: https://doi.org/10.1007/BF01464073.
196. Gosse C, Parmentier M, Van Reybroeck M. How do spelling, handwriting speed, and handwriting quality develop during primary school? Cross-classified growth curve analysis of children's writing development. *Front Psychol.* 2021;12:685681. doi: 10.3389/fpsyg.2021.685681.
197. Cahill SM, Beisbier S. Occupational therapy practice guidelines for children and youth ages 5-21 years. *Am J Occup Ther.* 2020;74(4):7404397010p7404397011-7404397010p7404397048. doi: 10.5014/ajot.2020.744001.
198. Santangelo T, Graham S. A comprehensive meta-analysis of handwriting instruction. *Educational Psychology Review.* 2015;28(2):225-265. doi: 10.1007/s10648-015-9335-1.
199. Shimel K, Candler C, Neville-Smith M. Comparison of cursive handwriting instruction programs among students without identified problems. *Phys Occup Ther Pediatr.* 2009;29(2):170-181. doi: 10.1080/01942630902784738.
200. Donica DK. Handwriting without tears((r)): General education effectiveness through a consultative approach. *Am J Occup Ther.* 2015;69(6):6906180050p6906180051-6906180058. doi: 10.5014/ajot.2015.018366.
201. Sayre JW, Toklu HZ, Ye F, Mazza J, Yale S. Case reports, case series - from clinical practice to evidence-based medicine in graduate medical education. *Cureus.* 2017;9(8):e1546. doi: 10.7759/cureus.1546.
202. Meyer K, Willis R. Looking back to move forward: The value of reflexive journaling for novice researchers. *J Gerontol Soc Work.* 2019;62(5):578-585. doi: 10.1080/01634372.2018.1559906.
203. Carcary M. The research audit trail: Methodological guidance for application in practice. *Electronic Journal of Business Research Methods.* 2020;18(2). doi: 10.34190/jbrm.18.2.008.
204. Milone ME. *Test of handwriting skills–revised.* Novato, CA: Academic Therapy Publications; 2007.
205. Milone M. *Test of handwriting skills, revised.* Academic Therapy Publications; 2007.
206. McHugh ML. Interrater reliability: The kappa statistic. *Biochemia Medica.* 2012;22(3):276-282.
207. Razali NM, & Wah, Y. B. Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. *Journal of Statistical Modeling and Anlytics.* 2011;2:21-33.
208. Ghasemi A, Zahediasl S. Normality tests for statistical analysis: A guide for non-statisticians. *Int J Endocrinol Metab.* 2012;10(2):486-489. doi: 10.5812/ijem.3505.
209. Mishra P, Pandey CM, Singh U, Gupta A, Sahu C, Keshri A. Descriptive statistics and normality tests for statistical data. *Ann Card Anaesth.* 2019;22(1):67-72. doi: 10.4103/aca.ACA_157_18.
210. Mowery BD. The paired t-test. *Pediatric Nursing.* 2011;37(6):320-321.

211. Skar GBL, P.W.; Graham, S.; Aasen, A.J.; Johansen, M.B.; Kvistad, A.H. Handwriting fluency and the quality of primary grade students' writing. *Reading and Writing.* 2022;35:509-538. doi: https://doi.org/10.1007/s11145-021-10185-y.
212. Medwell J, Strand S, Wray D. The links between handwriting and composing for y6 children. *Cambridge Journal of Education.* 2009;39(3):329-344. doi: 10.1080/03057640903103728.
213. Barlett ND, Gentile DA, Barlett CP, Eisenmann JC, Walsh DA. Sleep as a mediator of screen time effects on us children's health outcomes. *Journal of Children and Media.* 2012;6(1):37-50. doi: 10.1080/17482798.2011.633404.
214. He S, Shuai L, Wang Z, et al. Online learning performances of children and adolescents with attention deficit hyperactivity disorder during the covid-19 pandemic. *Inquiry.* 2021;58:469580211049065. doi: 10.1177/00469580211049065.
215. Becker SP, Breaux R, Cusick CN, et al. Remote learning during covid-19: Examining school practices, service continuation, and difficulties for adolescents with and without attention-deficit/hyperactivity disorder. *J Adolesc Health.* 2020;67(6):769-777. doi: 10.1016/j.jadohealth.2020.09.002.
216. Limone P, Toto GA. Psychological and emotional effects of digital technology on children in covid-19 pandemic. *Brain Sci.* 2021;11(9). doi: 10.3390/brainsci11091126.
217. Campbell KLM, J.B.; Bartholomew, J.B. The importance of publishing null results: Editorial guidelines to contribute to the reduction of publication bias in translational exercise research. *Translational Journal of the ACSM.* 2020;5(11):1. doi: 10.1249/TJX.0000000000000141.
218. Statistics NCfE. Private school enrollment. 2020; https://nces.ed.gov/programs/coe/indicator/cgc.
219. Cole MBT, R. . *Applied theories in occupational therapy: A practical approach. Second edition.* Slack Incorporated; 2020.
220. Gerde HK, Wright TS, Bingham GE. Preschool teachers' beliefs about and instruction for writing. *Journal of Early Childhood Teacher Education.* 2019;40(4):326-351. doi: 10.1080/10901027.2019.1593899.
221. Molesh KKO, C.; McFarland, C.; Griffin, J. . The impact of salient naming targets during aphasia therapy. *ScholarWorks at University of Montana.* 2019.
222. De Smedt F, Merchie, E., Barendse, M., Rosseel, Y., De Naeghel, J., & Van Keer,. Cognitive and motivational challenges in writing: Studying the relation with writing performance across students'gender and achievement level. *Reading Research Quarterly.* 2017;53(2):249-272. doi: https://doi.org/10.1002/rrq.193.
223. Ehri LC. Learning to read and learning to spell: Two sides of a coin. *Topics in Language Disorders.* 2000;20(3):19-36. doi: https://doi.org/10.1097/00011363-200020030-00005.
224. Westwood P. Arguing the case for a simple view of literacy assessment. *Australian Journal of Learning Difficulties.* 2009;14(1):3-15. doi: 10.1080/19404150902783401.
225. Law M. *Canadian occupational performance measure.* Toronto: CAOT; 1991.
226. Kolehmainen N, MacLennan, G., Tement, L., Duncan, E. A S..,Duncan, E. M., Ryan, S. B., McKee, L., & Francis, J.J. Using shared goal setting to improve

access and equity: A mixed method study of the good goals intervention in children's occupational therapy. *Implementation Science,*. 2012;76:1-11. http://www.implementationscience.com/content/7/1/76.

VITA

Laura Moore Parrish Bray, MS, OTR/L

Education

Masters of Science in Occupational Therapy

University of North Carolina, Chapel Hill, NC, 2004-2006.

Bachelor of Science in Biology

University of Virginia, Charlottesville, VA, 1997-2001.

Professional Positions

Eastern Kentucky University. Richmond, KY.

Department of Occupational Science and Occupational Therapy.

Assistant Faculty. August 2021-Present.

Part-Time Faculty. January 2019-Spring 2020

Wilson Pediatric Therapy. Lexington, KY.

Occupational Therapist. 2018-2019

The Speech Network. Lexington, KY.

Occupational Therapist. 2017-2018

Village Therapy Works. Houston, TX.

Occupational Therapist. 2010-2015

Neurodevelopment Therapy Services. Houston, TX.

Occupational Therapist. 2010-2011

Hollywood Presbyterian Hospital. Los Angeles, CA.

Therapy Services Supervisor. 2009-2010

Innovative Senior Care. Los Angeles, CA.

Occupational Therapist. 2009-2009

Cardinal Hill Rehabilitation Hospital. Lexington, KY.

Occupational Therapist. 2006-2008

Professional Publications

Bray, L. & Skubik-Peplaski, C. Handwriting Without Tears® via Telehealth Delivery: A Case Study of Feasibility and Effectiveness for Handwriting and Spelling Outcomes [Manuscript submitted for publication]

Bray, L. & Capilouto, G. (2021). Self-Determined Occupational Performance model for children from economically disadvantaged backgrounds. *Canadian Journal of Occupational Therapy*, *88*(4), 285-293. https://doi.org/10.1177/00084174211035627

Bray, L., Skubik-Peplaski, C., & Ackerman, K. (2021). A systematic review of the

effectiveness of interventions to improve handwriting and spelling in children with specific learning disabilities. *Journal of Occupational Therapy, Schools, and Early Intervention*. https://doi.org/10.1080/19411243.2021.1934227

Lauer, O. & Bray, L. (2020). Prescription drug abuse. *Kentucky Journal of Undergraduate Scholarship, 4*(1), 20-23**.** https://encompass.eku.edu/kjus/vol4/iss1/5

Professional Presentations

Bray, L. (2022, March). The role of handwriting in literacy. KOTA Eastern District Meeting. Virtual.

Skubik-Peplaski, C. Hight, J., Bray, L., & Rushing Carr, C. (2021, October). The effects of occupation-based interventions versus handwriting interventions on children's handwriting [Paper Presentation]. PREPaRE Conference, Lexington, KY, United States.

Bray, L. (2021, April). Systematic review of the effectiveness of handwriting interventions for children with specific learning disabilities [Paper Presentation]. Kentucky. http://louisville.edu/education/keep

Bray, L. (2020, May). Systematic review of the effectiveness of handwriting interventions for children with specific learning disabilities. Poster, KEEP Summit, Louisville, KY, United States. http://louisville.edu/education/keep (Conference cancelled).

Skubik-Peplaski, C. Hight, J., Bray, L., & Rushing Carr, C. (2020, March). The effects of occupation-based interventions versus handwriting interventions on children's handwriting. PREPaRE Conference, Lexington, KY, United States.

https://www.uky.edu/chs/pt/research/prepare/register (Conference cancelled).

Bray, L., Skubik-Peplaski, C., & Hight, J. (2019, May). The effects of occupation-based interventions versus handwriting interventions on children's handwriting research plan. Poster, College of Health Sciences Research Day, Lexington, KY, United States.

Bray, L. (2018, May). Is there evidence to suggest that visual perceptual and visual motor interventions improve handwriting outcomes with children who have handwriting difficulties? Poster, College of Health Sciences Research Day, Lexington, KY, United States.