

PARENTS AS TEACHERS: TOWARD IMPROVING THE PRINT HANDWRITING  
OF ADOLESCENTS WITH AUTISM

by

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A Dissertation  
Submitted to the  
Graduate Faculty  
of  
George Mason University  
in Partial Fulfillment of  
The Requirements for the Degree  
of  
Doctor of Philosophy  
Education

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Date: \_\_\_\_\_ Fall Semester 2015  
George Mason University,  
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## **Dedication**

To my sons, Evan, Jack, and Lucas, you inspire me at every turn and are the reasons for everything that I do; and to their dad, Jim, you made this journey possible through your support, encouragement, and friendship.

## **Acknowledgements**

I would like to thank Michael Behrmann, Anna Evmenova, Anastasia Kitsantas, Joan Stahle, Susan Evans, and all others at GMU that made this project possible. Thank you Susan Burns and Kristy Park for your personal and professional support that gave me strength, friendship and guidance throughout this process. I would like to thank Bill and Anne Grab for their commitment and donation of time to our family that made this journey possible during a difficult time. I would like to thank my sons Evan, Jack and Lucas for their assistance and help on this project. Thank you Angie McClevey for all your hard work, dedication, and assistance with data analysis and research of this study and for your undying friendship and emotional support, without which this project would not be possible.

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## **List of Abbreviations**

Centers for Disease Control .....	CDC
The Childhood Autism Rating Scale .....	CARS
Differential Reinforcement of Other Behavior .....	DRO
Discriminative Stimulus.....	sD
Free Appropriate Public Education.....	FAPE
Individual's with Disabilities Education Act.....	IDEA
Individual Education Program .....	IEP
National Association for the Education of Young Children .....	NAEYC
National Institutes for Health.....	NIH
Percent of Non-overlapping Data .....	PND
Theory of Mind .....	ToM
Vineland Adaptive Behavior Scales .....	VABS
Visual-Motor Integration .....	VMI

## **Abstract**

### **PARENTS AS TEACHERS: TOWARD IMPROVING THE PRINT HANDWRITING OF ADOLESCENTS WITH AUTISM**

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George Mason University, 2018

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The purpose of this dissertation was to determine if parent-mediated handwriting instruction using behavioral principles and procedures with components of the Handwriting Without Tears® curriculum would increase acquisition of pencil grip, posture, writing position, orientation, placement, size, start, sequence, control, legibility, and spacing for adolescents with autism. Previous research indicates that individuals with autism often demonstrate significant delays in motor control, visual perception, and kinesthesia that may contribute to illegible and inefficient handwriting; parents can be effective teachers to their children after receiving sufficient quality instruction; and handwriting is a functional skill that improves academic achievement for the child and quality of life for both the child and the child's family. Data were collected on 80-100 sessions across four phases (Baseline, Acquisition, Maintenance and Generalization) within a multiple-baseline design across the behaviors including pencil grip, posture, and

paper position, and four letter sets. Three 3 adolescents with autism participated in the instruction and data collection sessions conducted within their homes. A gradual increase in each handwriting dimension was anticipated for the adolescents with autism. The results of this study indicated that legibility increased, the rate of legibility acquisition appeared to increase across all three subjects.

**Keywords:** parent instruction, parent teachers, autism, pervasive developmental delay, handwriting, Handwriting Without Tears®, alphabet, print, motor control, dysgraphia, visual perception, visual-motor integration, kinesthesia, adolescent, middle school, high school, academic achievement, quality of life

## **Chapter One**

### **Importance of Handwriting**

In today's age of computer science, handwriting remains instrumental in classroom activities and daily life (Crook & Bennett, 2007). There is a continued need for handwriting instruction due to the volume of daily written work (Feder & Majnemer, 2007; Graham et al., 2007). Students need to write throughout their school day (Engel-Yeger, Nagauker-Yanuv, & Rosenblum, 2009; Feder & Majnemer, 2007); yet, handwriting instruction has been deemphasized in favor of test-oriented academic instruction (Cahill, 2009). Though there is a trend toward decreasing handwritten responses in standardized testing, interdisciplinary classroom computer access remains relatively low. Ironically, handwriting instruction may increase academic achievement since fluent handwriting skills increase access to working memory (Berninger, 1999; Kushki, Chau, & Anagnostou, 2011).

When working memory is available, there is decreased competition between the generative aspects of learning and the mechanical aspects of text production (Graham & Weintraub, 1996; Jones & Christensen, 1999; Kushki, Schwellnus, Ilyas, & Chau, 2011). The disparity that exists between the need for students to write fluently and their ability to do so may very well hinder their acquisition of the academic subjects targeted for standardized tests (Graham, Weintraub, & Berninger, 2001) Tseng & Cermak, 1993.

Even when students acquire academic skills, their poor penmanship may adversely affect their composition scores (Erhardt & Meade, 2005; Graham & Weintraub, 1996; Markham, 1976). Researchers have demonstrated that essay graders made negative qualitative judgments on student essays when handwriting quality was poor but composition skills were good. Conversely, graders made positive qualitative judgments on student essays when handwriting quality was good and composition skills were poor (Erhardt & Meade, 2005; Markham, 1976).

Academic achievement and handwriting quality can also be tied to proficiency in foundational skills, such as visual-motor integration (Bara & Gentaz, 2011; Feder & Majnemer, 2007; Kushki, Chau, et al., 2011), motor control (Feder & Majnemer, 2007) (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008) and kinesthesia (Erhardt & Meade, 2005; Kushki, Chau, et al., 2011). Early education previously supported these developmental skills through play-based learning (Adi-Japha & Freeman, 2001; Bonoti, Vlachos, & Metallidou, 2005); but, with the changing directions in education policy, children are thrust into the realm of academic learning without first fluently learning to transfer visual input to motor output (Cahill, 2009). Previously, practicing visual-motor integration taught children to plan their activities, perform them, and monitor the outcome of their performance (Adi-Japha & Freeman, 2001; Bergen, Reid, & Torelli, 2009; Bodrova & Leong, 2007; Bonoti et al., 2005; Bredekamp, Copple, & NAEYC, 1997). Furthermore, gross and fine motor control is a predictor of academic achievement (Westendorp, Hartman, Houwen, Smith, & Visscher, 2011) and kinesthesia is the sense of position, weight, tension, and movement through which motor control is improved.



Pen-based digitized writing systems may provide detailed information about pressure, segmentation, and other features of writing to increase handwriting skills (Djeziri, Guerfali, Plamondon, & Robert, 2002). Together, these skills represent a base of learning upon which all other learning can occur. They are precursors to good quality handwriting and high academic achievement (Graham et al., 2007).

### **Statement of the Problem**

Handwriting is a common practice in the school, home, and community; yet, inadequate or insufficient handwriting instruction globally contributes to decreased motor skills, working memory, academic achievement, and quality of (Graham et al., 2008) Furthermore, students with autism often have significant motor control, kinesthetic, and visual-motor integration difficulties that exacerbate handwriting deficits (Kushki, Chau, et al., 2011). With high caseloads and costs for special needs services, educational systems have been unable to meet the learning needs for the majority of students with autism (“Individuals With Disabilities Education Act, Pub. L. 94-142 as amended, 20 U.S.C. § 1400 et seq. Individuals with Disability Education Act Amendments of 1997 [IDEA}.,” 2007) Parents may be able to help alleviate foundational deficits through home-based skill interventions (Cappe, Wolff, Bobet, & Adrien, 2011).

## **Background of the Problem**

**Autism Spectrum Disorder (ASD).** According to the 4th version of the Diagnostic and Statistical Manual of Mental Disorders, autism is characterized descriptively (i.e., by features presented rather than explanations for the features) by impairments in socialization, communication, and behavior. The very term autism is derived from the Greek “Aut-” meaning “same” or “self,” indicating social isolation as a common feature of the disorder (Baron-Cohen, 2004; Ciaranello & Ciaranello, 1995). Social deficits include at least two symptoms in the range of reduced eye gaze, limited facial expression, unusual body postures, failure to develop peer relationships, decreased joint attention, and a lack of or reduced social or emotional reciprocity. Communication deficits in autism include at least one feature in the range of a delay in or total lack of spontaneous language, decreased initiations, stereotyped or repetitive language, and a lack of or limited pretend play. Behavioral deficits include at least one feature in the range of unusual preoccupation with stereotyped and/or restricted patterns and interests, rigid routines or rituals, and interests in parts of objects, rather than the whole.

The spectrum that arises from various combinations of the aforementioned features produces what is referred to as autism spectrum disorders APA, 2000, (Baron-Cohen, 2004; Ciaranello & Ciaranello, 1995). As defined in the (American Psychiatric Association, American Psychiatric Association, & Task Force on DSM-IV, 2000), each diagnosis under the autism spectrum disorder (ASD) umbrella presents with similar but slightly different manifestations and intensities of socialization, communication, and behavioral difficulties. The Center for Disease Control estimates the incidence of all

autism spectrum disorders has grown from 1 in 150 in 2007 to 1 in 88 in 2012 (Baio, 2012). The fact that ASD's occur five times more often in boys than girls suggests a genetic component, but an environmental component must also exist given that the disorder was almost unheard of prior to the 1950's and the 78% increase in autism cannot be accounted for through genetics alone. With this dramatically increasing incidence comes a corresponding need for services in areas that directly impact the child's learning (Baio, 2012).

### **Incidence of Autism**

The education system's position on the increased prevalence of autism is that there is increased: a) Awareness and diagnosis of autism, staff training, advocacy efforts, and availability of programs and services; b) improved identification procedures and data collection systems; and c) expansion of state definitions of autism ("Individuals With Disabilities Education Act, Pub. L. 94-142 as amended, 20 U.S.C. § 1400 et seq. Individuals with Disability Education Act Amendments of 1997 [IDEA}.,” 2007). However, if that were the case, a corresponding percentage of increase in identification would be seen at the same level across the entire age range of school age children, rather than the restricted age range of 6 to 11 years old. Furthermore, the unexplained gradual and steady decline in enrollment of students with autism in IDEA, part B services from ages 12 to 21 may imply alternative explanations for the increase in autism (e.g., that it is a real phenomenon), since it isn't accounted for by the reported average number of enrolled 6-11 year old students with autism compared to the average number of enrolled 12-21 year-old students with autism (IDEA, 2007). To the point, if the educational

proclamation that the increase in autism prevalence is a result of improved identification across the school years were true, it should also account for the lower prevalence rates in students who are ages 12 to 21 as well.

Two federal health organizations have offered their positions on the current estimated incidence of autism. The Center for Disease Control (CDC) states that the incidence is somewhat tied to increased access to school records, alludes to other potential causes for the increase, and concedes that the current figures may represent a true increase (Baio, 2012). A more declarative statement has been issued from the director of the National Institutes of Health (NIH), Dr. Tom Insel, who states, "As far as I can tell, the burden of proof is upon anybody who feels that there is NOT a real increase here in the number of kids affected (Kirby, 2009, p. 1)." Dr. Insel also states that the huge increase in autism incidence should be taken very seriously, as it cannot be accounted for by better diagnosis or ascertainment. To illustrate this point, as part of his medical training in the mid-1980's, he spent a year training in child psychology, during which time he noted a complete lack of autism cases. "I wanted to see children with autism. I couldn't find them," he said. "Now, I wouldn't have to go any further than the block where I live to see kids with autism today." As for the cause of autism, Dr. Insel states, "There is no question that there has got to be an environmental component here. I don't think anybody is arguing that it is 100 percent genetic. And I don't think in those terms, exactly, that it's either genetic or it's environmental. From my perspective, it's almost always going to be both (Kirby, 2009, p. 2)." Furthermore, ("CDC Online Newsroom - Press Release-CDC estimates 1 in 88 children in United States has been

identified as having an autism spectrum disorder March 29, 2012,” n.d.) states, “The data tell us one thing with certainty—there are more children and families that need help.”

With the dramatic rise in autism, educational institutions need to prepare effective, efficient, and efficacious practices in order for all future children to have an opportunity to learn since the cost of educating students with autism is so high.

### **Disabilities Education Act (IDEA)**

Legislation, such as the Individuals with Disabilities Education Act (IDEA) and Free Appropriate Public Education (FAPE), ensure that children with disabilities receive educational services; yet, the increasing incidence of ASD has inundated the educational system with the need for costly special programs and autism classrooms. In the 1999 to 2000 school year, autism education cost three times more than regular education students, at \$18,000 per capita (Shaul, Edwards, El-Hodiri, & Merriam, n.d.); however, educational institutions are still unable to attain a good outcome for most children with autism spectrum disorders. Specifically, over 96% of the restricted range of students with autism who qualified for a functional assessment performed more than two standard deviations below the mean, over 25% of students with autism ages 14 to 21 left high school with a certificate, and almost 11% dropped out rather than graduated with a high school diploma (“Individuals With Disabilities Education Act, Pub. L. 94-142 as amended, 20 U.S.C. § 1400 et seq. Individuals with Disability Education Act Amendments of 1997 [IDEA}.,” 2007). The type of participation that students with autism have within high stakes testing may provide some insight. Only 5% of students with autism take standardized tests without requiring accommodations or modifications

and a hefty 58% take alternative assessments or do not participate in any type of testing or assessment (“Individuals With Disabilities Education Act, Pub. L. 94-142 as amended, 20 U.S.C. § 1400 et seq. Individuals with Disability Education Act Amendments of 1997 [IDEA},,” 2007), which may indicate student learning deficits in basic skills that prevent typical testing conditions.

A contributing factor for learning deficits may be that finding qualified teachers to work with children with autism is particularly difficult, with evidence of 46% district shortages across the United States (*National Assessment of IDEA Overview. NCEE 2011-4026*, 2011). Without the direction and guidance of qualified instructors, students with autism are unlikely to get the academic exposure or rigor necessary to achieve academically. Moreover, programs for students with autism are likely to target goals designed for optimal classroom functioning rather than the specific needs of the child, as identified in the Individual Education Program.

### **Components of a Successful Educational Programs**

The intensity and extensity required within consistent and efficient programs necessitates highly qualified teachers who care about the students, believe in them, and are willing to extend themselves to help the students reach their students’ developed goals (“Bronfenbrenner 1977,” n.d.); (Erhardt & Meade, 2005); (Feder & Majnemer, 2007); (Graham, Harris, Fink, & MacArthur, 2001); (Tschannen-Moran & Johnson, 2011). Ideally, committed instruction requires consistency and efficiency across educational school years (“Bronfenbrenner 1977,” n.d.). As students acquire and maintain skills and knowledge, they need simultaneous support in progressing just beyond their

level of current functioning (Alberto & Troutman, 2009); (Cooper, Heron, & Heward, n.d.); (Kozulin, 2003); (Miltenberger, 2012). Instructors who have continuity with prior learning history can seamlessly teach at that zone of proximal development (Kozulin, 2003); (Newman, Griffin, & Cole, 1989). In the absence of sufficient high quality teachers, student to teacher ratios may increase, effectively blocking all but the most accessible student goals (“Bronfenbrenner 1977,” n.d.); (Feder & Majnemer, 2007); (Graham, Harris, et al., 2001); (Tschannen-Moran & Johnson, 2011). Alternatively, less qualified instructors are unlikely to be able to provide the necessary depth of instruction using established principles and procedures that have shown demonstrable effectiveness and efficiency in increasing substantive goal acquisition (e.g., (Alberto & Troutman, 2012); (Cooper et al., n.d.); (Sundberg & Partington, 1998).

From an instructional standpoint, the most important component in a great program is to have a teacher who is able to manipulate the instructional variables to meet the specific needs of an individual student (Howard, Sparkman, Cohen, Green, & Stanislaw, 2005); (McClannahan, MacDuff, & Krantz, 2002). Behavioral and cognitive principles and procedures show instructional support within the autism and related literature (e.g., (Kozulin, 2003); (Skinner, 1991); (Sundberg & Partington, 1998); (Winokur, 1976). To name a few, shaping, prompt-fade, and differential reinforcement procedures provide students with greater degrees of independent functioning under increasingly naturalistic conditions in specifically chosen tasks that are representative goals in the student’s Individual Education Program (Sundberg & Partington, 1998). An effective cognitive strategy that is in alignment with behavioral principles and procedures

is working at or just beyond the level of current functioning, called the zone of proximal development (Kozulin, 2003). Reinforcement and punishment are examples of principles that provide contingencies for the emergence of the desired behaviors, including acquisition of desirable skills and knowledge and the extinction of undesirable behaviors to increase optimal learning opportunities (Alberto & Troutman, 2012); (Cooper et al., n.d.). For every behavior change procedure that an effective and efficient instructor undertakes, from student's writing their names to sitting appropriately with joint attention to a task, aspects of behavioral principles and procedures may effectively and efficiently shape the behaviors (Sundberg & Partington, 1998).

### **Significance of Handwriting**

**Historical significance.** Historically, handwriting developed as a means to communicate rituals and stories. The printed work ensured that the story remained the same, rather than as interpretive storytelling over time. In Ancient Mesopotamia and nearby Egypt, two cultures developed handwriting nearly simultaneously. In the 4th millennium BC, the Sumerians, with ample resources of clay to make tablets, developed Cuneiform (Daniels & Bright, 1996); (Fischer, 2003); (Harris & Semiotic Society of American, in cooperation with the Philosophy Documentation Center, 1986); (Sacks, 2003); (Tschichold, n.d.). They inscribed wet clay with abstract symbols using a stylus and then dried the tablet. Around 3,200 BC, the Egyptians carved hieroglyphs into stone, followed by papyrus and ink writings shortly thereafter. Royalty and priests primarily wrote with hieroglyphs around 1500 BC; though, writing became more commonly used following simplification of hieroglyphs (i.e., hieratics) around 500 BC (Harris &



Semiotic Society of American, in cooperation with the Philosophy Documentation Center, 1986) for use in everyday life.

Phoenician traders developed a 22-symbol phonetic capital-letter alphabet written on papyrus or parchment around 1000 BC, based on Canaanite writing (Daniels & Bright, 1996). After its adoption by the Greeks using stone, metal, clay, and papyrus, it traveled back to Egypt and to surrounding trade routes in Persia and India. The rise of the Roman Empire allowed the Phoenician alphabet to spread beyond the hand of Rome, itself. As it became increasingly used in everyday life, lowercase letters were developed to aid in writing speed and to decrease the required space on the writing surface (Daniels & Bright, 1996) (Sacks, 2003). Handwriting has progressively changed across the ages, but it developed into an art form when good handwriting quality raised a person's level of prestige in society. This phenomenon has been evident throughout history and within the United States at least since the signing of famous historic documents, including the Declaration of Independence and The Constitution (Daniels & Bright, 1996) (Fischer, 2003);(Harris & Semiotic Society of American, in cooperation with the Philosophy Documentation Center, 1986);(Sacks, 2003);(Tschichold, n.d.).

**Modern significance.** Today, three modern handwriting forms represent the major source of handwriting curricula within the United States: Zaner-Bloser, D'Nealian, and Handwriting Without Tears (Ailie & Jutila, 2010); (Cahill, 2009). Zaner-Bloser, developed in the early 1900's, occupies 40% of the handwriting curricula market. It is a fairly simple font that requires relatively little complexity to print; however, the added flourishes when transitioning to cursive increase the handwriting task difficulty.

D'Nealian, introduced in 1978, also occupies 40% of the handwriting market. It purportedly serves as a means to efficiently transition from print to cursive handwriting. However, it presents many flourishes that may pose difficulties in handwriting acquisition (Graham, Harris, et al., 2001). It also presents higher-order handwriting skills too early in development. In both Zaner-Bloser and D'Nealian materials, too many distracting pictures, colors, and inadequate practice opportunities exist within a variety of handwriting workbooks and the cursive curriculum unnecessarily increases the task difficulty. They also use triple line instruction, which may confuse early learners in letter and number placement.

Handwriting Without Tears® (HWT®), developed in 1977, presents handwriting instruction from an occupational therapy mindset. It is most similar to the Zaner-Bloser print font; however, significant differences exist in the manner of instruction and presentation of all the letters and numbers. HWT® is a comprehensive system of handwriting instruction that takes into account the physical position of the writer, writing media, and writing utensils. Additionally, it provides a task analysis of handwriting strokes with descriptive words that specify the exact movements necessary to write every uppercase and lowercase letter of the alphabet, along with numbers 0-9. The writing workbooks minimize distractions, provide practice directly below the model, and optimize workbooks for accessibility for both right- and left-handed writers. The letter formations are simple, easily transfer from print to cursive handwriting, and are taught in groups according to similar stroke movements. Website access provides further customizable printing options for expanded learning opportunities beyond the variety of

workbooks available at each instructional level. Beyond the efficiency and efficacy of the writing program, major benefits to HWT® are that parents and educators can easily acquire effective handwriting materials at reasonable costs, website support exists through newsletters and online communities, and each level of handwriting builds incrementally toward the next (Cahill, 2009).

In the United States today, most educational programs don't specify handwriting goals after 4<sup>th</sup> grade and some districts have removed it entirely from the school curriculum. This general apathy toward handwriting instruction is also evidenced by a lack of teacher training at the university level in handwriting instruction. In (Graham et al., 2008), 79% of elementary school teachers confirmed that their schools had established handwriting goals. However, even though the vast majority of teachers taught handwriting at least once per week using a variety of materials and methods, only 12% of those teachers felt that their education had prepared them to teach handwriting. Moreover, when working with students who had difficulty with writing, only 20% of teachers allowed the students to dictate written assignments, whereas 22% allowed students to complete assignments on the computer (Graham et al., 2008). Initially, withholding computer keyboarding under the circumstances might seem imprudent; however, students who are deficient in handwriting skills but also lack fluency in keyboarding may produce even slower text production when given that accommodation (Cahill, 2009);(Crook & Bennett, 2007) However, it isn't an all or nothing proposition.

Computer programming has its use, as does handwriting. Computer use enhances the complexity of written language, the number and variability of words used, and

cohesive transitional elements (Dupuy, 2001). However, as evidenced on mRI analysis, a formidable argument to retain handwriting in the general curricula is evidence that long-term memory is enhanced through in-hand manipulation of a writing instrument when compared to computer typing (Longcamp et al., 2008). When considering the topographic similarity within keyboarding, each keystroke generates the same neural response. It thereby doesn't initiate specific memory of the typed word, phrase, or sentence. However, with handwriting, each stroke has a unique topography that generates distinct neural impulses. Long-term memory may arise from the topographic dissimilarity within the handwriting task.

Parents may best provide opportunities for consistent learning over time, when their positive expectancies (Conley, 2012); (Wigfield & Eccles, 2000); values (Hulleman, Godes, Hendricks, & Harackiewicz, 2010), and beliefs (Conley, 2012); (Mayes & Calhoun, 2003); (Tschannen-Moran & Johnson, 2011); (Wigfield & Eccles, 2000), in conjunction with their detailed knowledge of their child and a desire to teach their child, lead to measurable and steady progress (Cappe et al., 2011); (Schultz, Schmidt, & Stichter, 2011). Perhaps in adolescence, when the sense of urgency in acquiring and maintaining early intervention services for their children with autism largely subsides, parents may be able to step into an instructional role that might have previously felt alien or undesirable. Given the state of education that the child probably received up until this transitional point, it is likely that many goals in education still need to be introduced and mastered. In fact, in the absence of a maintenance program, many skills may have been

lost. One foundation skill that is introduced in early childhood, but not maintained over time is handwriting.

**Autism deficits.** Students with autism typically have several handwriting deficits that may prompt teachers to provide accommodations. Sources of the deficits include deficient motor control, visual-motor integration, and kinesthesia (Kushki, Chau, et al., 2011). Conversely, students with autism have been found to possess keen visual performance skills that seem to support the handwriting task (Caron, Mottron, Rainville, & Chouinard, 2004), but weak central coherence may cause them to divide letter segments, thereby decreasing the quality of handwriting tasks (Shah & Frith, 1993). Previous research in handwriting with children with autism has specifically focused on testing legibility, formation, placement, size, control, spacing, and speed (Fuentes, Mostofsky, & Bastian, 2009); (Fuentes, Mostofsky, & Bastian, 2010); (Graham et al., 2008). The aim of research and instruction in handwriting for typically developing students with dysgraphia and students with autism is to provide access to higher academic achievement through fluency acquisition. Those aims may be achieved through effective and efficient instruction that produces automaticity, thereby freeing working memory to focus on the academic learning task (Graham et al., 2008); (Kushki, Chau, et al., 2011).

## **Logic Model**

**Current state of handwriting in education.** Handwriting is an undervalued academic task as evidenced by the general lack of teacher training in handwriting and the nationwide absence of handwriting goals past fourth grade. Some contend that

handwriting is or will soon be obsolete given that standardized tests are moving to a computerized model and eliminating the handwritten portions of the test (Graham & Weintraub, 1996). However, workplaces, homes, and communities still require handwriting to communicate ideas and information (Engel-Yeger et al., 2009); (Feder & Majnemer, 2007). With limited classroom technology availability, the fact is that the majority of students are still writing their assignments by hand. Yet, many students have difficulty with handwriting throughout the school years and the longer handwriting delays persist, the more it impacts other areas of their education (Nelson & Van Meter, 2007) This also causes a decrease in academic achievement given that students with handwriting difficulties split their attention between the mechanical aspects of text production and the writing task itself (Graham & Weintraub, 1996); (Jones & Christensen, 1999); (Kushki, Chau, et al., 2011). When handwriting reaches automaticity (i.e., the student no longer has to attend to the handwriting aspect of the writing task), students can then develop higher-order skills to promote academic achievement (Bara & Gentaz, 2011); (Feder & Majnemer, 2007); (Kushki, Chau, et al., 2011).

Parent-mediated instruction of print handwriting of lowercase letters may help adolescent students with autism gain many useful skills. Parental instruction with simple, effective, and efficient instructional materials may increase consistency in daily instruction of print handwriting, effectively increasing motor control, visual-motor integration, and kinesthesia. These skills may increase the student's level of academic ability and quality of life and may increase parental quality of life as well (see Figure 1) (Cappe et al., 2011); (Schultz et al., 2011). Teachers' expectations of students may play a

meaningful role in how well students learn (Fives & Buehl, 2005); (Hauser-Cram, Sirin, & Stipek, 2003); Turner, et al., 2004). Students react to teacher behavior that either increases or decreases skill and knowledge acquisition based upon how the student perceives the teacher feels about him or her (Hauser-Cram et al., 2003). This is true for regular education but it may be even more crucial in special education (Kaderavek & Rabidoux, 2004).

**Handwriting towards a greater quality of life.** In special education, students have less ability to advocate for themselves, to self regulate, to form valid or concrete self-assessments, or to acquire skills and knowledge incidentally (Burack, Root, & Zigler, 1997; (Gerhardt & Holmes, 2005). It is therefore necessary to have a strong support system, not only in terms of beliefs, but also of quality instruction that focuses on goals that will increase the quality of life for special education students (Julie K. Ivey, 2007); (Zascavage & Keefe, 2004). The precepts of the Individuals with Disabilities Education Act (IDEA) and the corresponding mandate for a Free and Appropriate Public Education (FAPE) support the notion that individuals with disabilities have the right to receive public education services. Indeed, lawmakers worldwide acknowledge an appropriate education as a right of children with disabilities. Nonetheless, the variability in how “appropriate” is defined may largely determine how well services are delivered and what is taught.

Acquiring a good quality of life for special needs students through educational instruction is a worthwhile pursuit (*Handbook of Autism and Pervasive Developmental*

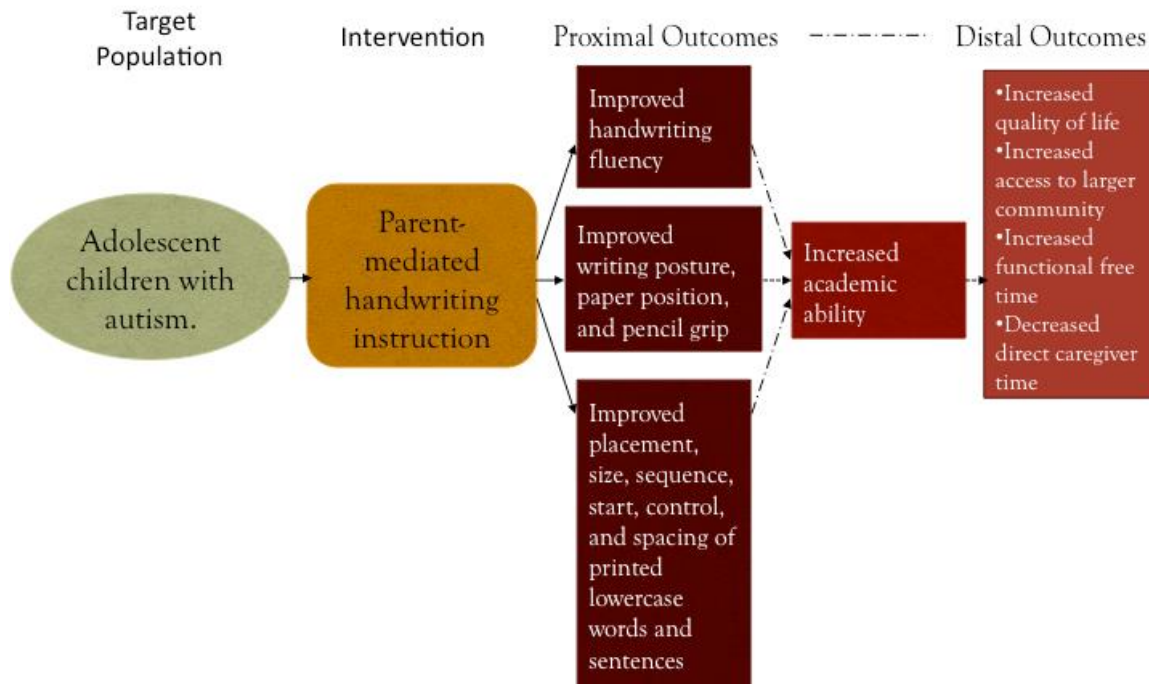
*Disorders, Fourth Edition*, n.d.); (Julie K. Ivey, 2007). Quality of life can be equated to the degree to which a person acquires and maintains self-determination (Nirje, 1972).

One major facet of the normalization principle is to create conditions through which a handicapped person experiences the normal respect to which any human being is entitled. Thus the choices, wishes, desires, and aspirations of a handicapped person have to be taken into consideration as much as possible in actions affecting him. To assert oneself with one's family, friends, neighbors, coworkers, other people, or vis -à-vis an agency is difficult for many persons. It is especially difficult for someone who has a disability or is otherwise perceived as devalued. But in the end, even the impaired person has to manage as a distinct individual, and thus has his identity defined to himself and to others through the circumstances and conditions of his existence. Thus, the road to self-determination is both difficult and all-important for a person who is impaired (Nirje, 1972).

With the deinstitutionalization movement that began in the 1970's and has continued up to the last decade, more adults with disabilities are residing in alternative living environments including living independently, in the family home, with other relatives, or in group homes (Gerhardt & Holmes, 2005); Young, 2003). With the increasing prevalence of autism, the financial burden to society continues to climb. In an effort to alert policymakers to the need to allocate resources to autism research, (Ganz, 2007) cited the cost to society for each individual with autism to be \$3.2 million dollars or more across the individual's lifetime. An effective way to increase quality of life for the affected individuals (Julie K. Ivey, 2007) and to decrease the financial burden to



society (Ganz, 2007) is to increase quality of educational services to raise student functional levels. To increase the ability to functionally and effectively negotiate daily living, increase effective communication, to promote socialization, and to alleviate the pressures on the people who are largely responsible for the person's care as students age, it is important to teach skills and knowledge to students that are more likely to increase the opportunities to meaningfully and independently engage with people in the community where the person resides (Gerhardt & Holmes, 2005)



*Figure 1. Handwriting instruction logic and flowchart.*

**Components of effective instruction.** Environmental and child-specific considerations may need to be taken into account during handwriting instruction for the adolescent child with autism (see Appendix C). Appropriate seating type and height, adequate size of the writing surface, instructor location determination based upon handedness and required prompt level, reduction of potential auditory or visual distractions, adequate temperature of the instructional environment, and appropriate lighting may facilitate optimal learning (Rosenblum, Goldstand, & Parush, 2006) (Smith-Zuzovsky & Exner, 2004) therefore, these factors must be evaluated prior to instruction and accounted for while the child learns a new skill. Furthermore, checking medical/health, sleep, and biological needs prior to starting daily instruction may increase the child's ability to engage in sustained and focused joint attention to task. Also, placing all necessary materials within the instructional area prior to beginning instruction may maintain joint attention to task. Systematic antecedent prompt-fade procedures may efficiently bring responding under the control of the materials rather than instructor prompts. Additionally, visual availability of preference-based reinforcers may increase the child's motivation to remain on task for increasing durations with increasing compliance (O'Neill, 1997).

“Teachers can increase success when they provide explicit and systematic self-regulation and writing instruction, view children as collaborators in the process, provide scaffolding that gradually shifts the responsibility to the children, and adapt instruction to meet the abilities and interests of the children.” (Julie K. Kidd M. Susan Burns & Tamara Genarro, 2010:175-204). With instructor-determined introduction of targets, parents

ensure that the child receives repeated and systematic instruction for particular targets across time as the child meets specified criteria to mastery for each targeted goal (Sundberg & Partington, 1998). This strategy may improve acquisition rates and maintenance thereby facilitating efficient goal acquisition. Ensuring that each instructional component is taught within each session may help the child learn a self-check strategy to increase similar independent task performance (McClannahan et al., 2002). Additionally, interspersing targets within and across sessions will decrease the child's ability to predict the next target, thereby increasing joint attention to task, motivation to write consistently over time, and memory skills (Charlop, Kurtz, & Milstein, 1992).

Consequence management is critical in producing effective child learning. Using child-specific variable rates of reinforcement increases the likelihood that the child will acquire joint attention to task and increase the length of time on task since the child will be unable to predict the next instance of reinforcement (Touchette & Howard, 1984). Furthermore, differential reinforcement of high-rate responses provides access to the most-preferred reinforcers. Finally, when mistakes occur, error-correction procedures reset the instance of the learning opportunity. Types of error-correction include: antecedent prompt then test, antecedent prompt then fade, simultaneous prompting (i.e., also known as 0-second prompting), most-to-least prompting, least-to-most prompting, least intrusive prompting, constant time delays, progressive time delays, and graduated guidance. Allowing errors to occur without planned error-correction procedures simply allows the child to practice a mistake in relation to a given direction, resulting in variable

future responding when presented with the same learning task and discriminative stimulus (Bailey, Aytch, Odom, Symons, & Wolery, 1999) .

### **Purpose Statement and Research Questions**

The purpose of this study was to examine the functional relation between parent-mediated handwriting instruction using behavioral principles and procedures with components of the Handwriting Without Tears® curriculum and the acquisition of placement, size, sequence, start, control, and spacing of printed lowercase words and sentences, in addition to speed, writing posture, paper position, and pencil grip for adolescent children with autism. Previous research indicates that individuals with autism often demonstrate significant delays in motor control, visual perception, and kinesthesia that contribute to illegible and inefficient handwriting; parents can be effective teachers to their children after receiving sufficient quality instruction; and handwriting is a functional skill that improves academic achievement for the child and quality of life for both the child and the child's family. Specific research questions included:

1. Will parent-mediated instruction using Handwriting Without Tears® materials gradually improve percent correct of legibility while copying English printed lowercase letters on double-spaced paper across randomly presented word sets for adolescents with autism within their home program?
2. Will parent-mediated instruction using Handwriting Without Tears® materials gradually improve the legibility rate in copying English printed lowercase letters on double-spaced paper across randomly presented word sets for adolescents with autism within their home program?

3. Will parent-mediated instruction using Handwriting Without Tears® materials gradually improve percent correct of child posture and paper position, a while printing English lowercase letters for adolescents with autism within their home program?
4. Following the treatment phase, will writing skills generalize to single- and triple-lined paper in two new locations with two new instructors?

### **Definitions**

In the fields of applied behavior analysis and social-cognitive psychology, researchers use terms to define specific behaviors, constructs, thoughts, and feelings. Additionally, terms used within the field of autism refer to precise idiosyncratic and symptomatic behaviors, interventions, or brain research, while terms used in occupational therapy are used to define motoric behaviors. An alphabetical listing of the most pertinent terms, grouped by field of study, is listed below.

**Abative effect.** An abative effect is a component of the motivational operation, resulting in a decrease in motivation to respond, as evidenced by decreased responding (Jack Michael, Palmer, & Sundberg, 2011).

**Ability beliefs.** Ability beliefs are defined as task-specific self-beliefs about an individual's current competence in a task (Wigfield & Eccles, 2000).

**Antecedent.** An antecedent is a stimulus that precedes a response and signals the availability of reinforcement or punishment (Cooper et al., n.d.).

**Behavior.** Behavior is defined as an interaction between an organism and the environment (Cooper et al., n.d.). It encompasses the interaction of a living organism with its environment. Behaviors may be anything an organism does, thinks, or believes.

**Consequence.** A consequence is defined as any event following a behavior that either increases or decreases the future likelihood of that behavior (Cooper et al., n.d.).

**Control.** According to the handwriting script, accurate control must include rounding letter strokes that require roundings, pointing letter strokes that require points, keeping any within-letter gaps to less than 1/16", constraining overstrokes to no greater than 1/16" beyond the stopping point in the script, refraining from within-letter retracing that is not demonstrated in the script, writing the midpoint of the letter within 1/16" either above or below the vertical midpoint (i.e., for letters b, d, h, g, p, q, k, f, t, e, x, s, and y), and writing any mirror image letter stroke at less than or equal to twice the size of its identical part (i.e., for letters f, k, m, n, t, u, v, w, x, and z) (Olsen, 2008).

**Differential reinforcement of high-rate behaviors (DRH).** DRH is defined as the delivery of a highly preferred, higher magnitude, or higher amount of reinforcement following rates of a behavior that are equal to or above a set criterion (Gast, 2010).

**Discriminative stimulus (sD).** A discriminative stimulus is defined as a condition or event in the presence of which a particular response will be reinforced ((Cooper et al., n.d.).

**Duration.** Duration is defined as the total amount of time occupied by the occurrence of a behavior (Cooper et al., n.d.).

**Dysgraphia.** Dysgraphia is defined as a condition of difficulty in writing (Stedman, 1990) and in the context of handwriting means difficulties, including lack of fluency, with writing movement.

**Dyspraxia.** Dyspraxia is defined as a condition of difficulty in the performance of an action (Stedman, 1990) and in the context of handwriting means difficulties, including lack of fluency, with motor control coordination (Kushki, Chau, et al., 2011).

**Error-correction procedure.** An error-correction procedure is defined as the immediate re-presentation of the last target discriminative stimulus, combined with a least intrusive prompt, following a student response error for the target.

**Errorless teaching.** Errorless teaching is defined as instruction in a domain of learning using a combination or subset of prompt-fade procedures, shaping procedures, differential reinforcement, variable rates of reinforcement, and error-correction procedures to efficiently teach skills or knowledge, as required for the learning situation (Bailey et al., 1999).

**Evocative effect.** An evocative effect is a component of the motivational operation, resulting in an increase in motivation to respond, as evidenced by increased responding (Jack Michael et al., 2011).

**Executive control.** Executive control is defined as the ability of the brain to give multiple concurrent directions to cue perceptions, thoughts, actions, and possibly emotions, thereby aiding in self-regulation (“Wiley,” n.d.).s

**Fine-motor control.** Fine motor control in the context of handwriting is defined as the in-hand manipulation of a writing instrument with manual dexterity, a grip that

maintains normal skin tone and moderate muscle tension, and control of the writing instrument for both movement and pressure, at the correct time (Kushki, Chau, et al., 2011).

**Graphomotor.** Graphomotor is defined as the motor control movements used in the writing process (Stedman, 1990).

**Interspersal training.** Interspersal training, also known as “mixing and varying” instruction, is defined as the unpredictable presentation of target and reinforced maintenance discriminative stimuli and their related materials across a training session, rather than the presentation of discriminative stimuli in discrete-trial training (Charlop et al., 1992).

**Kinesthesia.** Kinesthesia is defined as the sense perception of movement (Stedman, 1990) and in the context of handwriting refers to the awareness and control of speed, extent, and force of body and arm movements in the writing process, for error-correction purposes (Kushki, Chau, et al., 2011).

**Latency.** Latency is defined as the time that occurs between the onset of a discriminative stimulus and the beginning of a response (Cooper et al., n.d.).

**Legibility.** Legibility is defined as the out-of-context readability of written numbers, letters, words, and sentences.

**Motivation expectancy-values.** Expectancy beliefs and values that affect the likelihood that an individual will choose, perform well on, and persevere in a task (Wigfield & Eccles, 2000)

**Motivational operation.** A motivational operation is the establishment or



abolishment of effectiveness of a reinforcer or punisher, which results in a respective increase or decrease of motivation to respond (Jack Michael et al., 2011).

**Orientation.** Orientation is defined at all grade levels as facing letters and numbers in the correct direction, resulting in fluency, legibility, and accurate spelling. Accurate orientation must include writing all within-letter strokes in the correct direction, according to the letter script and written model.

**Paper position.** Paper position is defined as the right-handed child positioning the worksheet to the right of body midline, rotating the paper counterclockwise 30-45 degrees such that the right upper corner is higher than the left upper corner, and placing the left hand on the left upper corner to steady the page. The left-handed child will position the worksheet to the left of body midline, rotate the paper clockwise 30-45 degrees such that the left upper corner is higher than the right upper corner, and place the right hand on the left upper corner to steady the page.

**Pencil grip.** Pencil grip is defined as holding the pencil in a tripod grip (i.e., thumb, index, and middle fingers) within 1" of the writing tip or quadropod grip (i.e., thumb and the index, middle, and ring fingers) within 1" of the writing tip that maintains normal skin color and moderate muscle tension.

**Placement.** Placement is defined at the 1<sup>st</sup> grade level as the ability to accurately place all within-letter strokes that should touch the lower line within 1/16" either above or below that line, according to the letter script and written model.

**Posture.** Writing posture is defined as sitting on a chair, feet flat on the floor, body initially in a seated upright position, head in alignment with the spine, arms resting

on the writing surface at a height such that the shoulders remain in a neutral position, wrists in a neutral position, stomach one hands-width from the writing surface, and a forward-body lean of 15-30 degrees.

**Prompt-fade procedure.** A prompt-fade procedure includes verbal, gestural, modeling, physical, or environmental prompts that are sequentially faded to bring the behavior under the control of the associated discriminative stimuli (Alberto & Troutman, 2012).

**Punishment.** Punishment is anything that, when delivered, decreases the future likelihood of a behavior (Cooper et al., n.d.).

**Reinforcement.** Reinforcement is anything that, when delivered, increases the future likelihood of a behavior (Cooper et al., n.d.).

**Self-efficacy beliefs.** Self-efficacy beliefs are defined as task-specific self-beliefs about an individual's future competence in a task (Wigfield & Eccles, 2000).

**Sequence.** Sequence is defined at all grade levels as writing the strokes in the correct order, as written in the script; writing each stroke in the correct direction (i.e., without producing an orientation error); accurately angling each stroke at no greater than 1/16" off angle; and writing with a continuous stroke sequence (i.e., no pencil pick-ups, except as required).

**Shaping procedure.** A shaping procedure is defined as the sequential change in a behavior toward increasingly more accurate approximations of the target behavior, brought about by changes in the reinforcement schedule or magnitude of reinforcement (Alberto & Troutman, 2012).

**Size.** Size is defined at the 1<sup>st</sup> grade level as vertically sizing tall (i.e., b, d, f, h, k, l, and t) and descending (i.e., g, j, p, q, and y) letters no smaller than 9 mm and no larger than 16 mm, and vertically sizing small letters (i.e., a, c, e, i, m, n, o, r, s, u, v, w, x, and z) no smaller than 5 mm and no larger than 8 mm.

**Start.** Start is defined at the 1<sup>st</sup> grade level as beginning the first stroke of tall letters (i.e., b, f, h, k, l, and t) between 4 mm and 8 mm above the upper line and beginning the first stroke of tall, small, or descending letters (i.e., a, c, d, g, i, j, m, n, o, p, q, r, s, u, v, w, x, y, and z) at or within 1/16" above or below the upper line; and beginning the first stroke of letter "e" within 1/16" above or below the midpoint between the double lines

**Theory of mind (ToM).** Theory of mind is defined as a failure to understand the beliefs and intentions of social partners, such that individuals cannot predict behaviors, motivations, or non-literal meanings within social exchanges (Loth, Gómez, & Happé, 2008).

**Variable ratio of reinforcement (VR).** A variable ratio of reinforcement is a reinforcement schedule in which the number of responses required to receive reinforcement changes unpredictably within a range (Alberto & Troutman, 2012).

**Visual-motor integration (VMI).** Visual-motor integration is defined as the combination of visual perception, a relative strength in children with autism spectrum disorders, and motor control, a relative weakness in children with autism spectrum disorders, during the writing process (Kushki, Chau, & Anagnostou, 2011).

**Weak central coherence.** Weak central coherence is defined as a brain account for visual attention to a part, rather than the whole, of an object (Happe & Frith, 2006).

## Chapter Two

### Literature Search Procedures

The principle sources of information for this dissertation for locating research included Educational Resources Information Center (ERIC), Dissertations and Theses, PsycInfo, PubMed, Sage Publications, Science Direct, and ancestry and descendant searches of reference lists of relevant articles. Hand searches of relevant journals included *American Journal of Occupational Therapy*, *Australian Occupational Therapy Journal*, *Autism*, *Brain*, *The Canadian Journal of Occupational Therapy*, *Journal of Applied Behavior Analysis*, *Journal of Autism and Developmental Disorders*, *Neurology*, and *Research in Developmental Disabilities*. Keyword descriptors included academic achievement, adolescent, alphabet, autism, dysgraphia, graphomotor, handwriting, high school, manuscript, middle school, parent education, parent training, and quality of life.

**Inclusion and exclusion criteria.** Since handwriting instruction usually occurs in early education, much of the research focused on instruction of pre-kindergarten, kindergarten, and elementary school typically developing students. Research in the present study included instruction in English handwriting with special needs students or typically developing elementary school students who demonstrated handwriting delays. Also included were studies of handwriting instruction for adolescents with and without

autism. Research on computer handwriting instruction is used to note optimal pencil-holding strategies that yield appropriate pressure and stroke generation.

Excluded from review were studies involving handwriting in Chinese, Arabic, or other languages, except where relevant to examine handwriting segmentation and writing instrument pressure. Articles with a participant base or focus on cerebral palsy, deafness, and Down's syndrome were excluded given their dissimilarity in diagnostic criteria from students with autism. Interventions with a pre-kindergarten and kindergarten age group were also excluded given the participant age of the current study, except where relevant to examine the developmental sequences of handwriting skills. Handwriting involving script (i.e., cursive) production was excluded given that print handwriting is the focus of this intervention.

## **Theoretical Constructs**

**Concept development.** Students with autism have difficulty learning concept development. A skill is something that a person can do; knowledge is a question that a person can answer. Conceptual knowledge arises from various tangible or intangible characteristics of a stimulus to form a response class. For example, when asked about an apple, a person may respond in a variety of ways to the apple: a) label it as “an apple,” b) state that it is round, crunchy, and/or sweet, c) state that it is a piece of fruit, something that you eat, and/or something that is used to play “dunking for apples,” etc... Those traits, taken together, represent the concept of what it means to be an apple. Concept development demonstrates that a student can respond flexibly to a variety of receptive and expressive identification of the item, characteristics of the item, functions of its use,

and the reversals of those characteristics and functions of a stimulus (Russell, Jarrold, & Henry, 1996). This differs from generalization in that the focus in concept development is on increasing the quality of experience with something (Ivar Lovaas & Smith, 1989). It is one skill to label an item as an apple or to say that the apple is red. It is a much more comprehensive skill to say, “The round, red apple tastes sweet and feels crunchy when I bite into it.” When stimulus classes and response classes grow, there is more opportunity for flexible learning and novel response production. Rote responding diminishes and novel responding increases when students acquire numerous ways to discuss skills and knowledge. A more complex example of a concept is an expectation, value, or belief.

**Motivation.** It is important to distinguish between the definitions and uses of motivation in the social-cognitive and behavioral literature. Social-cognitive theory focuses on cognitive abstractions of motivation in the form of expectancies, values, and beliefs that can be quantified, in this study, with the parents through questionnaires that include those constructs. Behavioral theory focuses on ways to identify individual motivations in the form of preferences along with principles (i.e., reinforcement and punishment) and procedures (e.g., pairing) that can modify those motivations. Also, it is important to note that each theory presents different terminology. Often, that terminology refers to the same behavior but discusses it in different ways. Nonetheless, both social-cognitive and behavioral theories contribute meaningfully to a collective understanding of the origin of motivation and what alters it.

Within social-cognitive theory, motivation occurs as a combination of expectancies, values, ability beliefs, self-efficacy beliefs, and self-regulation (“Self-

Efficacy (Bandura – 1977),” n.d.). Each of those constructs has been demonstrated to affect motivation and outcomes in a learning task. They have great utility when devising learning strategies for people with average- to high-level cognitive functioning because those populations can answer questions about their thoughts, beliefs, expectations, and values. Also, they can understand instruction in those constructs to increase their level of achievement. Finally, the terminology within those constructs is easily accessible since it is used within the standard lexicon. Nonetheless, each of the terms represents a particular definition that differs somewhat from the standard lexicon, which could cause confusion if definitional nuances specify precise meanings that differ in a significant way from the standard lexicon. Motivation from a social-cognitive perspective is included as a component in the current study with a focus on examining parents’ desire to work with their children in a therapeutic role.

***Expectancy-values.*** Expectancies and values are tied together in social-cognitive theory of achievement motivation in the field of educational psychology (Wigfield & Eccles, 2000). Expectancies are how well the individual expects to successfully acquire skills and knowledge in the learning task. Values are the value that an individual places on the learning task. These two are multiplied together to yield the product, which is the amount of motivation the individual feels in pursuing and engaging in the task. This effect of motivation on task achievement naturally affects learning outcomes and is a promising line of research to assist learners in increasing motivation in learning tasks (Eccles & Wigfield, 2002); (Wigfield & Eccles, 2000).



Analysis of teachers' expectancies for students with autism is a newly emerging research focus. Few studies have looked at this concept to assess beliefs about educating students with autism. Prior research studied parents' expectancy beliefs for important and likely outcomes for their children with autism (Ivey, 2007; Mutua, 1999) and teachers' expectancy beliefs for important and likely outcomes for students with autism (Ivey, 2007). The focus in previous work on important goals (i.e., outcomes that are perceived to be valuable to the student's future) for students with autism relates to the concept of outcome expectancies, while the focus in previous research on likely outcomes (i.e., outcomes that are perceived to be realistic based upon the student's condition, acquisition rate, and access to quality and quantity of instruction) relates to the concept of efficacy expectancies (Ivey, 2004, 2007; Mutua, 1999). Given that people are more likely to engage in behaviors that increase good outcomes if they have higher efficacy beliefs, both outcome and efficacy expectancies need to be taken into consideration to increase the likelihood of effective instruction (Ivey, 2007). Several gaps existed within previous research. Given that children with autism are increasingly in inclusive and alternative environments, it is important to assess the expectancies of the educators who could potentially affect outcomes (*Handbook of Autism and Pervasive Developmental Disorders, Fourth Edition*, n.d.); (Campbell, Gilmore, & Cuskelly, 2003).

Previous research also did not take into consideration the type of educational environment (e.g., public school vs. private school vs. charter school) that may affect student outcomes. Different school environments may provide different levels of teacher resources and support (*Handbook of Autism and Pervasive Developmental Disorders*,

*Fourth Edition*, n.d.). When resources are readily available and options exist within the resources, teachers may feel more self-efficacious in delivering services to students with disabilities (Campbell, Gilmore, & Cuskelly, 2003). Additionally, if administrative support is strong in developing and maintaining a pleasant working environment, supporting teachers in advanced and applicable continuing education training, and affirming and motivating teachers for engaging in consistent and effective practice, teachers may feel more efficacious in delivering services to students with autism (Fives & Buehl, 2005). Therefore, better student outcomes may be achieved as teacher outcome and expectancy beliefs increase in differing settings.

***Self-efficacy and ability beliefs.*** Self-efficacy beliefs are the situation-specific beliefs that an individual holds regarding their ability to acquire skills and knowledge at a particular level (Bandura, 1990). Teacher self-efficacy has been demonstrated to affect student learning. The higher teacher self-efficacy, the higher student achievement; Likewise, with low teacher self-efficacy, students have lower levels of achievement (Fives & Buehl, 2005). Motivation is also tied to self-efficacy in that high self-efficacy corresponds to higher levels of motivational beliefs, values, and goals (Eccles & Wigfield, 2002). Ability beliefs represent the competence that learners feel in broad learning domains, rather than the narrow range within self-efficacy beliefs (Wigfield, 1994). The broad feeling of competence may manifest itself by individuals' preferentially choosing to engage in particular areas of study. This demonstrates their belief that they will do well or poorly in a given domain depending on their ability beliefs within that domain (Wigfield, 1994).

The focus in previous work on important goals for students with autism relates to the concept of outcome expectancies, while the focus in previous research on likely outcomes relates to the concept of efficacy expectancies. Given that people are more likely to engage in behaviors that increase good outcomes if they have higher efficacy beliefs, both need to be taken into consideration to increase the likelihood of effective instruction (Julie K. Ivey, 2007). Several gaps existed within previous research. Given that children with autism are increasingly in inclusive and alternative environments, it is important to assess the expectancies of the educators who could potentially affect outcomes (*Handbook of Autism and Pervasive Developmental Disorders, Fourth Edition*, n.d.); (Campbell et al., 2003).

***Self-regulation.*** *Self-regulation* is an important tool within the field of educational psychology, representing the structure by which performance can be measured and monitored. (Zimmerman, 2002) proposed forethought, performance, and reflection as the three phases that cyclically provide behavioral momentum to engage in and move forward in a particular task (Schunk & Zimmerman, 1998).

***The zone of proximal development.*** Another important concept in social-cognitive theory is instructing a person at or just beyond their current functional level. This is often attributed to the incomplete work of Russian-born Lev Vygotsky but it, in fact, arose from later theorists who interpreted his work (Wertsch, 1988). Nonetheless, the theory proposes that students learn best when they are given continuous support at their outer limit of developmental skills and knowledge. Working memory is available to focus on developing a new analysis and ideas rather than requiring students to reinvent

skills and knowledge. Capitalizing on the zone of proximal development by making the writing task challenging yet attainable can keep the writer on task, increase writer confidence, and allow researchers to discern the factors that optimize writing efficiency (Crook & Bennett, 2007).

**Motivational operations.** For parents, social-cognitive motivational theories include expectancies, values, and beliefs combine with behavioral motivational theory to yield a powerful tool in explaining and enhancing parent-child cooperative learning. Expectancies, values, and beliefs may be less effective with children with autism, given lower levels of executive control (“Wiley,” n.d.) and understanding of those abstract concepts. However, parents are increasingly expected to teach their children. Since they are often not educators by trade, they need to have a rationale, strategy, and reinforcement for what they are expected to do and accomplish (Schunk & Zimmerman, 1998). Behavioral theory is included with a focus on increasing the establishing motivational operations for both parents and children. From a behavioral standpoint, the identification of specific motivational variables will increase or decrease the likelihood that parents or other caregivers will work with their children with autism (Michael et al., 2011). Motivational operations are divided into two categories called abolishing and establishing operations. Both abolishing and establishing operations can be further subdivided into abative and evocative operations (Iwata, Smith, & Michael, 2000; Laraway, Snyckerski, Michael, & Poling, 2002; Michael, 2000). Establishing operations explain how motivation works to increase the future likelihood of a behavior. Abolishing

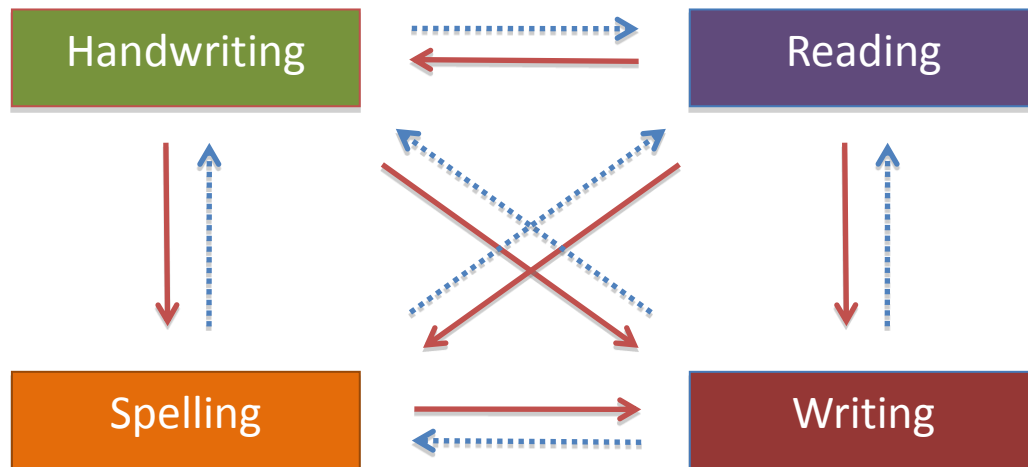
operations explain how motivation affects the decrease in the future likelihood of a behavior.

### **Applied Behavior Analysis and Autism Instruction**

Stimulus equivalence occurs when one area of learning supports and enhances a related area of learning, an equivalence between the stimuli can develop reciprocally (Sidman, 1994). Reading, writing, spelling, and handwriting can become stimulus equivalence relations when one area of learning overlaps with the other. For example, if students were asked to read a text and write a plot summary, both of those domains of learning would support the enhancement of handwriting ability since the student would have the opportunity to practice the act of handwriting in responding to the text and writing assignment. Correspondingly, better spelling skills can develop if a student not only reads the words but must also write them.

In the stimulus equivalence relation depicted in Figure 2, each of the red arrows denote specific instruction in that task to acquire skills and knowledge in another learning domain. For instance, handwriting instruction would be implemented to increase learning in spelling and writing. Reading instruction would be implemented to increase learning in handwriting, spelling, and writing. Spelling instruction would be implemented to increase learning in writing. The decisions made in developing the instructional targets depend upon the strengths, weaknesses, and needs of the learner. The blue arrows represent learning that may occur incidentally. Conceptual knowledge is easier to achieve when a variety of stimuli produce a similar response. Often, students with autism do not easily

acquire incidental learning targets, but research shows promise in developing better implementation strategies to increase learning acquisition rates.



*Figure 2.* Language arts stimulus equivalence relations. Solid red lines denote direction of instruction that can be selectively chosen by the instructor; dashed lines denote direction of learning that may be acquired incidentally. Incidental learning may require fewer or more directly taught concepts, depending on the learner's history and skill set.

At the beginning of any instructional program, pairing procedures should be done to increase motivation within the learning task. Pairing is the process of increasing the number of reinforcers through presentation in time of a neutral or non-motivating item with a motivating item. Respondent conditioning is used to acquire a conditioned reinforcer. In early learning instructional programs, development of secondary reinforcers via classical conditioning is necessary to avoid satiation of potential reinforcers. This is where a primary or previously established secondary reinforcer is presented concurrently

with the targeted secondary reinforcer to produce a conditioned reinforcer (Alberto & Troutman, 2012; Cooper et al., n.d.).

Joint attention (Anderson et al., 2007) is the ability for an instructor to gain student attention to the instructional or interactive activity. It is a basic prerequisite to any learning opportunity since learning requires student discrimination training, interspersal training, errorless teaching, and shaping through differential reinforcement are procedures used within applied behavior analysis to produce faster acquisition rates and stronger stimulus control, decrease inadvertent reinforcement, and increase independent responding. Discrimination training is the presentation of learning material in conjunction with a verbal stimulus to produce Contextual interference is an instructional practice that randomly presents related and unrelated tasks, rather than sequential repetition of the same task (Ste-Marie, Clark, Findlay, & Latimer, 2004). This is the cognitive equivalent to interspersal training, also known as mixing and varying instruction.

### **Handwriting Approaches**

Different curricula have been developed for and occupy the handwriting market; however, many aspects of handwriting programs are used based upon instructor's perceptions of effectiveness rather than research-validated approaches (Ailie & Jutila, 2010) Sensorimotor, cognitive, kinesthetic, and eclectic handwriting approaches are the main curricular components in handwriting programs. Handwriting Without Tears is a response-to-intervention handwriting program that provides a sensorimotor approach. The materials are designed to limit distractions, provide simple and consistent instructions, group letters according to topographic similarity, and provide multisensory

materials to be used or omitted as needed. Most handwriting programs have multisensory tools available. The main drawback to multisensory programs is the limited and inconsistent research to support their use. One omission in the HWT program is the lack of a cognitive component. The main cognitive approach introduced into a few handwriting interventions is to have students circle the best example of their own handwriting after writing a letter repeatedly. Circling represents the reflection component of self-regulated learning. This strategy may be used to bring the best exemplar in contact with the greatest degree of reinforcement to increase the likelihood that future writing of that letter will more closely approximate the previous best sample.

Kinesthetic approaches to handwriting instruction include movement that simulates writing without use of actual writing materials. Students may be asked to “air write” letters while listening to and/or following a model or receptively following directions while listening to an air writing handwriting song. Finally, an eclectic handwriting program contains an arbitrary combination of handwriting approaches including sensorimotor, cognitive, and kinesthetic materials and approaches (Ailie & Jutila, 2010; Feder & Majnemer, 2007; Feder et al., 2005).

## **Handwriting and Autism**

Few authors have specifically studied handwriting with children with autism. In (Fuentes et al., 2009), using a blind scoring system with the Minnesota Handwriting Assessment (MHA), the authors sought to determine the types of handwriting difficulties that students with autism experience compared to typically developing peers in this case-control design. Twenty-eight mixed-gender participants were divided into two groups: 1)



14 students with documented autism (mean age = 10.2) had a mean full-scale IQ of 99.3 ( $SD = 18.8$ ) and 2) 14 typically developing students (mean age = 11.1) had a mean full-scale IQ of 112.7 ( $SD = 9.2$ ). Perceptual Reasoning IQ for children with autism was an average of 108.3 ( $SD = 13.3$ ) and for controls was an average of 107.3 ( $SD = 7.2$ ). The Minnesota Handwriting Assessment (MHA), the Physical and Neurological Examination for Subtle (Motor) Signs (PANESS), and the WISC-IV Block Design test, age, gender, and full-scale IQ were used for t-tests and stepwise multiple regressions.

The MHA was used to assess legibility, form, alignment, size, spacing, and a rate score on triple-lined paper for all participants using a pangram (i.e., a sentence that contains all of the letters of the alphabet) that was scrambled to reduce the confounding variable of fluent reader advantage. Two raters graded each handwriting sample and achieved a minimum of 97.5% interrater reliability across handwriting measures. Form was the only discrete variable that had statistical significance between the groups ( $p = 0.004$ ). Students with autism had difficulty with incorrect points and incorrect roundings, which negatively affected form scores. Next, the PANESS assessed gait, balance, and timed movements. Students with autism took longer to complete these measures relative to their peers ( $p = 0.002$ ). This result supported previous research that demonstrated weaknesses in motor skills for students with autism relative to typically developing controls. Finally, the WISC-IV Block Design test assessed visual-spatial pattern recognition. This test did not have statistical significance between students with autism and controls ( $p = 0.13$ ). All of the study participants were fluent readers who could decode letter features quickly while reading, a skill that may have supported the visual

segmentation and manual reproduction of the target letters. That observation supports prior research that stimulus equivalence relations may yield incidental interdisciplinary learning.

Several implications arose from the outcomes of this study. First, participants in this study who had ASD also had average IQ scores; therefore, skill within legibility ( $p = 0.25$ ), alignment ( $p = 0.12$ ), size ( $p = 0.24$ ), and spacing ( $p = 0.21$ ) may be accounted for by relatively high cognitive ability. Secondly, as a result of low motor control demonstrated in the PANESS total score ( $p = 0.002$ ), in gait ( $p = 0.003$ ), and timed movements ( $p = 0.009$ ), form may be the main source of handwriting difficulty for students with autism who have average IQ's. Third, size ( $p = 0.24$ ) may have been accounted for in this study by the initial instruction to write the letter the same size as the sample; since, in previous research, enlarged size (i.e., macrographia) was evident for adults with autism who were not given that direction. Fourth, although gender was not a statistically significant factor in handwriting for students with autism, its failure to be evident may have been a result from effects of autism overshadowing gender effects. Fifth, analysis within this study was limited to the handwriting product; handwriting process analysis may have provided additional useful information on how students with autism start and sequence lowercase letters. Finally, a suggestion for future research included a rate measure in letters per minute since almost all participants were able to finish within the predetermined timeframe.

Another study presented a similar analysis of handwriting for students with autism. (Fuentes et al., 2010), using a blind scoring system with the Minnesota

Handwriting Assessment (MHA), sought this time to determine the types of handwriting difficulties that adolescent students with autism experience compared to typically developing peers in this case-control design. Twenty-four mixed-gender participants were divided into two groups: 1) 12 students with documented autism (mean age = 14.4) had a mean full-scale IQ of 111.7 ( $SD = 16.7$ ) and 2) 12 typically developing students (mean age = 13.8) had a mean full-scale IQ of 116.7 ( $SD = 12.1$ ). Perceptual Reasoning IQ, which measures cognitive organization and perceptual reasoning, for children with autism was an average of 108.7 ( $SD = 10.5$ ) and for controls was an average of 112.9 ( $SD = 11.6$ ). The MHA, the PANESS, PRI, age, gender, and full-scale IQ were used for t-tests and within- and across-group stepwise multiple regressions.

Again, MHA was used to assess legibility, form, alignment, size, spacing, and a rate score on triple-lined paper for all participants using a pangram that was scrambled to reduce the confounding variable of fluent reader advantage. Two raters graded each handwriting sample but inter-rater reliability percentages across handwriting measures weren't documented. Spacing was the only discrete variable that had statistical significance between the groups on the MHA; nonetheless, both form ( $p = 0.06$ ) and alignment ( $p = 0.08$ ) had decreasing trends that are suggestive of borderline skill deficits.

On the PANESS, the students with autism demonstrate that they took longer to complete the tasks relative to their peers. This result supports previous research that demonstrated weaknesses in these skills for students with autism relative to controls; however, a multiple regression analysis demonstrated no effect of the PANESS on MHA total handwriting scores. Instead, the PRI predicted legibility ( $R^2 = 0.39$ ,  $p = 0.04$ ), size

( $R^2 = 0.79$ ,  $p < 0.001$ ), and handwriting total score ( $R^2 = 0.59$ ,  $p = 0.006$ ) for students with autism. There was no mention of how fluently the study participants were able to read. The omission of that information may present a confound; since, prior research suggested that students with autism who could decode letter features quickly while reading may have supportive strategies for the visual segmentation and manual reproduction of the target letters in handwriting. For students with autism: PRI predicted legibility ( $R^2 = 0.39$ ,  $p = 0.04$ ), size ( $R^2 = 0.79$ ,  $p < 0.001$ ), and MHA handwriting total score. For control students: PANESS total scores predicted MHA handwriting total performance ( $R^2 = 0.39$ ,  $p = 0.03$ ). Across the groups, PANESS total score predicted legibility ( $R^2 = 0.17$ ,  $p = 0.048$ ), form ( $R^2 = 0.25$ ,  $p = 0.02$ ), and MHA total scores ( $R^2 = 0.59$ ,  $p = 0.006$ )

The second study included the introduction of WISC-IV Verbal Comprehension Index and PANESS overflow movements measures (Fuentes et al., 2010). In that study, form ( $p = 0.057$ ) appeared to be less difficult for adolescent children with autism than for younger children in previous research (Fuentes et al., 2009). Within the multiple regression, although PANESS did not account for handwriting deficits in adolescents; PRI predicted handwriting skills for them ( $R^2 = 0.61$ ,  $p = 0.007$ ).

Key implications that arose from this study include increased evidence that motor control deficits for students with autism negatively affect their ability to handwrite well. This result is true for each sub-measure of the PANESS. Spacing, form, and alignment are the most problematic features of handwriting for students with autism. Furthermore, the two main predictors between groups are total handwriting ( $p = 0.02$ ) and spacing ( $p = 0.04$ ). Multiple regression of PANESS did not predict total handwriting scores though

PRI demonstrates that adolescent students with autism who present with scattered motor control skills may compensate through organization and perceptual logic to achieve high PRI scores. Although suggestions to add a rate measure were introduced in prior research, it was not done in this study. Likewise, a suggestion to include process analysis in addition to product analysis was not heeded. Nonetheless, age ( $p = 0.32$ ) is less of a factor in explaining difficulties in handwriting (Fuentes et al., 2010) than age ( $p = 0.13$ ) in previous research (Fuentes et al., 2009) This may indicate that adolescent children with autism may benefit from a handwriting program.

The current study replicated and extended prior research. Randomized presentation of five randomly assigned scrambled pangrams accounted for test-retest errors with adolescent students with autism in a multiple baseline study across topographies of handwriting. A letter per minute rate measure accounted for changes in fluency rather than a fixed duration measure. This intervention interspersed daily training targets to decrease fluent reader confounds and to increase joint attention and on-task motivation through continuous unpredictable letter- and word-presentation within and across sessions. Worksheets were developed with separate testing and training models written on two-line paper. Participants were instructed to circle the best approximation.

## **Chapter Three**

The overall purpose of the methods section is to provide an overview, in sufficient detail, so that research is replicable. First, this chapter includes the description of the study design, participant inclusion and exclusion criteria, and information about study participants and settings. Second, operational definitions are provided for dependent and independent variables, along with information about: materials for parents and children during training and testing, parent and child measures; procedures for participant recruitment, parent training, child training, and child testing. Finally, information on interobserver agreement, procedural fidelity, internal and external validity, and social validity is included to establish the integrity of this study.

### **Research Design**

The design used in this study was a multiple baseline design across multiple subjects and behaviors for three dependent variables. This design was chosen to provide replication of the emergence of behavior across three participants given continuous implementation of the independent variables, including maintenance and generalization of the behaviors. It accounts for the irreversibility of target behaviors and has sensitivity to the application of differential reinforcement to optimally increase the accuracy and rate of responding. Moreover, since the participants' traits were functionally similar, the

dependent variables should have been similarly affected by the intervention.

A multiple baseline design was used to provide replication of the emergence of handwriting across four letter sets when analyzing fluency of legible letters per minute across sessions (Gast, 2010). The design standards for a multiple-based design include: (a) Researcher-driven systematic replication of the independent variable; (b) consistent measurement of interobserver agreement across each study phase; (c) continuous data measurement in a minimum of six phases to demonstrate three basic effects at three different points in time of the independent variable on the dependent variables; and (d) data measurement with at least three data points per phase (in order to meet standards with reservation) or five data points per phase in order to meet standards (Kratochwill et al., 2010). Other standards for multiple baseline designs included establishing the stability of trend and variability in baseline prior to the introduction of the intervention, then establishing stability of trend and variability in treatment prior to the introduction of the intervention for the next person (Gast, 2010).

### **Participant Recruitment**

This study, including the associated documents, was approved through George Mason University human subject research board prior to recruitment or acceptance of any participant into the study. Participant inclusion and exclusion criteria may affect the extent to which this study has internal and external validity. They are included here to inform the reader of the breadth of considerations governing decision points early in the research process and of potential bias that may limit the ability to generalize the findings.

**Inclusion criteria.** Parents were chosen based upon convenience or snowball sampling of English-speaking families known to the researcher who had an adolescent child with autism who had handwriting difficulties. The children were included if they: 1) spoken English as a first language; 2) scored at a mild-moderate autism level on the Childhood Autism Rating Scale (CARS); 3) scored at a non-significant or intermediate maladaptive behavior level on the Vineland Adaptive Behavior Scales (VABS); and 4) reached 10 years old by the onset of the study. Additionally, families were chosen if the parent: a) believed he/she could learn how to teach his/her child; b) believed the child could learn how to handwrite accurately and fluently; and c) could commit to a maximum of 86 sessions of acquisition training and testing for 15-30 minutes daily, plus 3-5 sessions of maintenance for 5-7 minutes daily, and 9 sessions of parent generalization testing for 5-7 minutes daily. Parents were also asked to extend the data collection during 18 generalization sessions to two additional people. Prior to acceptance into the study, parents read and signed informed consent, while parents and children both read and signed informed assent for child participation (see Appendix A). Out of eight potential child/parent dyads, three met the inclusion criteria and were included into the study.

**Exclusion criteria.** Families were excluded from participation 1) if the primary language for the child or parent-mediator was other than English; 2) if the children received a score of 37 or greater on the Childhood Autism Rating Scale (CARS), which placed them in the severe autism category; 3) if the children received a Vineland Adaptive Behavior Scales maladaptive behavior age-dependent score that identified them as having significant maladaptive behaviors; or 4) if they were younger than 10 years old.



Additional exclusion criteria included families who: a) did not believe they could learn how to teach their child; b) did not believe their child could learn how to handwrite accurately and fluently; c) had personally taught their children with autism systematically across domains of learning; d) lived outside of a one-hour driving distance of the researcher; e) responded to the recruitment inconsistently or disinterestedly, f) did not agree to have the sessions videotaped, and g) families who did not sign both informed consent and assent forms.

### **Participants and Settings**

Participants and settings are grouped below into their respective case studies to unite their data. Parent data include demographics. Child data include demographics, recent scores on the Childhood Autism Rating Scale (CARS), and recent Vineland Adaptive Behavior Scales scores (VABS). Information on participant settings includes a brief ecological inventory and potential environmental distractors.

**Case number one.** Case number one was the case that was randomly selected to enter treatment first. Information contained in this section includes parent, child, and setting characteristics.

**Parent one.** Keane's dad was an English-speaking 47-year-old divorced Caucasian male. He had earned a bachelor's degree in electrical engineering, a master's degree in physics, and a second master's degree in applied mathematics. He worked as a scientist, grossing an annual income of \$180,000. He had three adolescent boys with special needs that included autism, seizures, ADHD, Asperger syndrome, dyspraxia, and ADD. Subsequent to his children's diagnoses, his parental training included limited

aspects of neurology, speech therapy, applied behavior analysis, verbal behavior, and physical therapy. He had no plans to acquire certification in teaching children with autism and had not previously received training in providing handwriting instruction.

***Child one.*** Keane was a 16-year-5-month old right-handed Caucasian male 9<sup>th</sup> grade homeschooler who had received a diagnosis of autism at age 23 months, seizure disorder at age 10, and ADHD at age 11. At the start of the study, Keane received a score of 33.5 on the Childhood Autism Rating Scale (CARS), which fell at the mild-moderate autism range. Keane's father responded to the Vineland Adaptive Behavior Scales Interview Edition Expanded Form (VABS) to provide information regarding Keane's adaptive behavior. The Vineland is a norm-referenced test that evaluates three domains of adaptive behavior in the areas of communication, daily living skills, and socialization. Keane received a VABS adaptive behavior composite of 35, which fell below the 0.1 percentile, in the low range, and at a 5 year and 11 months age equivalent. There was a 95 percent probability that his true adaptive behavior composite fell between 29 and 41. Keane received a communication domain composite standard score of below 20 (estimated at 18), which fell below the 0.1 percentile, in the low range, and at a 3 year and 7 months age equivalent. His ratings on one communication subdomain fell in the adequate range, while two communication subdomains fell in the low range. There was a 95 percent probability that his true communication domain composite standard score fell between 8 and 28. Keane received a daily living skills domain composite standard score of 43, which fell below the 0.1 percentile, in the low range, and at a 6 year and 11 months age equivalent. His ratings on two daily living skills subdomains fell in the moderately

low range, while one daily living skills subdomain fell in the low range. There was a 95 percent probability that his true daily living skills domain composite standard score fell between 35 and 51. Keane's socialization domain composite standard score of 53 fell at the 0.1 percentile, in the low range, and at a 7 year and 3 months age equivalent. Among socialization subdomains, one of his ratings fell in the moderately low range, while two socialization subdomains fell in the low range. There was a 95 percent probability that his true socialization domain composite standard score fell between 45 and 61. Keane received a maladaptive behavior, part 1, domain score of 5, which fell in the middle of the intermediate range for his age (see Table 1).

Table 1

*Vineland Adaptive Behavior Scale Summary Results for Keane*

	Standard/Raw Score	Percentile Rank	Adaptive Level	Age Equivalent
Communication	18 *	Below 0.1	Low	3 - 7
Receptive	46		Adequate	7 - 10
Expressive	94		Low	2 - 6
Written	28		Low	6 - 7
Daily Living Skills	43	Below 0.1	Low	6 - 11
Personal	173		Mod Low	10 - 2
Domestic	60		Mod Low	9 - 8
Community	43		Low	5 - 1
Socialization	53	0.1	Low	7 - 3
Interpersonal Relationships	63		Low	3 - 8
Play and Leisure Time	81		Low	8 - 9
Coping Skills	61		Mod Low	10 - 10
Adaptive Behavior Composite	35	Below 0.1	Low	5 - 11

*Note.* Standard Scores of Domains of the VABS are at the 95% confidence interval. Raw scores are listed for Subdomains. Mod Low = Moderately Low. Age equivalents are listed as years followed by months.

\*Estimated Standard Scores.

***Setting one.*** Keane lived part-time with his father in a single-family home and part-time with his mother in a nearby townhouse. From his birth until 2006, he lived with both of his parents and his two brothers in his dad's current home. Since 2006, he spent most of his time with his mother, who homeschooled him. Handwriting instruction was conducted at his mother's house at her rectangular 40" x 65" wood dining room table. Participants sat on standard-height high-back leather-cushioned chairs. The 14' x 21' dining room had 10' ceilings with an approximately 7.5' x 10' area rug placed over the carpet. During training, Keane's father stood directly behind Keane or 12" to the right of him to model or physically prompt writing, as needed. During testing, Keane's dad sat perpendicular to Keane within 24" of Keane's left. The room was lit with incandescent and natural lighting and was maintained at an average temperature of 70 degrees. The main level of the home had extensive interior decorating, with multiple potential points of distraction including a large fruit plate on the table, decoratively painted walls, a floor-length tri-fold mirror, activity in the nearby kitchen, and some audible exterior road noise. Usually, small items that could pose a distraction were removed prior to beginning training or testing. Videotaping occurred at a distance of 6' from the table to include the parent and child interactions.

**Case number two.** Case number two was the case that was randomly selected to enter treatment second. Information contained in this section includes parent, child, and setting characteristics.

***Parent two.*** Tony's mom was an English-speaking 43-year-old married Caucasian female. She had earned a bachelor's degree in nursing and worked full-time at a Northern

Virginia suburb hospital as a registered nurse, while Tony's dad earned a bachelor's degree and served in law enforcement in the District of Columbia/Metro area. Their estimated combined gross income was \$150,000. They had four children, two of whom had special needs. Tony's mom did not have prior training in education, had not previously received training in providing handwriting instruction, and did not plan to acquire certification to teach children with autism.

***Child two.*** Tony was a 13-year-3-month old right-handed Caucasian male 7<sup>th</sup> grade public school student who had received a diagnosis of ADHD at age 5 and pervasive developmental delay at age 10. At the start of the study, Tony received a score of 32 on the Childhood Autism Rating Scale (CARS), which fell at the mild-moderate autism range. Tony's mother responded to the Vineland Adaptive Behavior Scales, Interview Edition Expanded Form (VABS) to provide information regarding Tony's adaptive behavior. The Vineland is a norm-referenced test that evaluates three domains of adaptive behavior in the areas of communication, daily living skills, and socialization.

Tony received a VABS Adaptive Behavior Composite of 45, which fell below the 0.1 percentile, in the low range, and at a 5 year and 9 months age equivalent. There was a 95 percent probability that his true adaptive behavior composite fell between 39 and 51. Tony received a communication domain composite standard score of 59, which fell at the 0.3 percentile, in the low range, and at a 7 year and 11 months age equivalent. His ratings on one communication subdomain fell in the adequate range, while two communication subdomains fell in the low range. There was a 95 percent probability that his true communication domain composite standard score fell between 49 and 69. Tony received

a daily living skills domain composite standard score of 42, which fell below the 0.1 percentile, in the low range, and at a 6 year and 1 month age equivalent. Among daily living skills subdomains, his ratings fell in the low range. There was a 95 percent probability that his true daily living skills domain composite standard score fell between 36 and 48. Tony's socialization domain composite standard score of 44 falls below the 0.1 percentile, in the low range, and at a 3 year and 4 months age equivalent. Among socialization subdomains, his ratings fell in the low range. There was a 95 percent probability that his true socialization domain composite standard score fell between 34 and 54. Tony received a maladaptive behavior, part 1, domain score of 9, which fell at the high end of the intermediate range for his age (see Table 2).

Table 2

*Vineland Adaptive Behavior Scales Summary Results for Tony*

	Standard/Raw Score	Percentile Rank	Adaptive Level	Age Equivalent
Communication	59	0.3	Low	7 - 11
Receptive	46		Adequate	7 - 10
Expressive	146		Low	6 - 6
Written	44		Low	8 - 3
Daily Living Skills	42	Below 0.1	Low	6 - 1
Personal	146		Low	5 - 2
Domestic	40		Low	5 - 11
Community	71		Low	7 - 2
Socialization	44	Below 0.1	Low	3 - 4
Interpersonal Relationships	64		Low	3 - 9
Play and Leisure Time	47		Low	2 - 8
Coping Skills	27		Low	4 - 3
Adaptive Behavior Composite	45	Below 0.1	Low	5 - 9

*Note.* Standard Scores of Domains of the VABS are at the 95% confidence interval. Raw scores are listed for Subdomains. Age equivalents are listed as years followed by months.

***Setting two.*** Tony lived full-time with his mother, father, two sisters, and one brother in their single-family home, where they had lived for the previous 4 years. Handwriting instruction was conducted at their oblong 48” x 75” wood dining room table while sitting on standard-height high-back wooden dining room chairs. The approximately 10’ x 14’ dining room had 9’ ceilings and a cream-tone carpeted floor. Tony’s mother sat perpendicular to him within 24” to his right while training and testing. The room was lit with incandescent and natural lighting and was maintained at an average temperature of 70 degrees. The dining room had two different light-colored wallpapers on the upper and lower halves of the walls. Multiple potential points of distraction included the use of half the table as a desk and/or activity center, toys on the floor, television noise in the living and/or family rooms, adjacent kitchen activity, interest and questions from his little sister and brother, and the occasional appearance of one of the family pets. Usually, small items that could pose an immediate distraction were removed prior to beginning training or testing. Videotaping occurred at a distance of 6’ from the table to include the parent and child interactions.

**Case number three.** Case number three was the case that was randomly selected to enter treatment third. Information contained in this section includes parent, child, and setting characteristics.

***Parent three.*** Owen’s mom was an English-speaking 46-year-old married Caucasian female. She had taken approximately 100 hours of college courses in general studies and communication. Her primary profession was a stay-at-home mom, while Owen’s dad worked as a government-contracted intelligence analyst in the District of

Columbia. Their household gross income was \$135,000. They had two children, one of whom had special needs. Owen's mom didn't have prior training in education, but had hired a reading therapist for Owen in 3<sup>rd</sup> grade. She did not plan to acquire certification to teach children with autism and had not previously received training in providing handwriting instruction.

***Child three.*** Owen was a 10-year-11-month old right-handed Caucasian male 5<sup>th</sup> grade public school student who had received a diagnosis of Asperger syndrome, pervasive developmental delay, and sensory disorder in November 2006. At the start of the study, Owen received a score of 32 on the Childhood Autism Rating Scale (CARS), which fell at the mild-moderate autism range. Owen's mother responded to the Vineland Adaptive Behavior Scales, Interview Edition Expanded Form (VABS) to provide information regarding Owen's adaptive behavior. The Vineland is a norm-referenced test that evaluates three domains of adaptive behavior in the areas of communication, daily living skills, and socialization. Owen received a VABS adaptive behavior composite of 56, which fell at the 0.2 percentile, in the low range, and at a 6-year age equivalent. There was a 95 percent probability that his true adaptive behavior composite fell between 49 and 63. Owen received a communication domain composite standard score of 70, which fell at the 2nd percentile, in the moderately low range, and at a 7 year and 9 months age equivalent. Among communication subdomains, his ratings ranged from adequate to low. There was a 95 percent probability that his true communication domain composite standard score fell between 60 and 80. Owen received a daily living skills domain composite standard score of 61, which fell at the 0.5 percentile, in the low range, and at a



6 year and 9 months age equivalent. Among daily living skills subdomains, his ratings fell in the low range. There is a 95 percent probability that his true daily living skills domain composite standard score falls between 53 and 69. Owen's socialization domain composite standard score of 52 fell at the 0.1 percentile, in the low range, and at a 3 year and 9 months age equivalent. Among socialization subdomains, his ratings fell in the low range. There was a 95 percent probability that his true socialization domain composite standard score fell between 42 and 62. Owen received a maladaptive behavior, part 1, domain score of 11, which fell at the high end of the intermediate range for his age

Table 3

*Vineland Behavior Scale Summary Results for Owen*

	Standard/Raw Score	Percentile Rank	Adaptive Level	Age Equivalent
Communication	70	2 <sup>nd</sup>	Mod Low	7 - 9
Receptive	46		Adequate	7 - 10
Expressive	140		Low	5 - 2
Written	48		Mod Low	8 - 9
Daily Living Skills	61	0.5	Low	6 - 9
Personal	154		Low	5 - 11
Domestic	42		Low	6 - 2
Community	76		Low	7 - 6
Socialization	52	0.1	Low	3 - 9
Interpersonal Relationships	63		Low	3 - 8
Play and Leisure Time	54		Low	3 - 5
Coping Skills	30		Low	4 - 7
Adaptive Behavior Composite	56	0.2	Low	6 - 0

*Note.* Standard Scores of Domains of the VABS are at the 95% confidence interval. Raw scores are listed for Subdomains. Age equivalents are listed as years followed by months.

**Setting three.** Owen lived full-time with his mother, father, and older sister in their single-family home. Handwriting instruction was conducted at their rectangular 36” x 60” wood kitchen table while sitting on standard-height high-back wooden chairs. The approximately 9’ x 9’ eating area had 8’ ceilings and a linoleum floor. Tony’s mother sat 12” to his right while training and testing. The room was lit with incandescent and natural lighting and was maintained at an average temperature of 70 degrees. The kitchen had light-colored walls and multiple potential points of distraction including the use of one-half of the table as a desk and activity center, household supplies and items on the floor, television noise in the adjacent living room, adjacent kitchen activity, and the occasional appearance of the family cat. Usually, small items that could pose an immediate distraction were removed prior to beginning training or testing. Videotaping occurred at a distance of 4’ from the table to include the parent and child interactions and was an occasional distraction prior to testing and during training.

### **Independent Variables**

This study used parent-mediated HWT® materials, strategies, and modified letter formation scripts to determine if handwriting skills for adolescents with autism would improve. Parents also used principles and procedures of applied behavior analysis to increase handwriting proficiency, while relying on the researcher for instructional support. Each of those instructional aspects is listed below.

**Handwriting Without Tears® materials.** HWT® training materials included: Individual slate chalkboards for parents and children for writing numbers in baseline; individual blackboards for parents and children while writing letters during acquisition

training; 1” chalk bits for writing on slates and blackboards in baseline and acquisition; and ½” sponges for use during the Wet-Dry-Try activity on slates and blackboards during baseline and acquisition (see Figure 5).

**Strategy instruction.** Strategy instruction included HWT® The Hand Activity, Wet-Dry-Try, and The Three P’s. The Hand Activity was used to teach the location of tall, small, and descending letters relative to double-lined writing surfaces (e.g., individual blackboards and double-lined training sheets during acquisition, and double-lined testing sheets throughout the study; see Figure 5). The Wet-Dry-Try sequence provided a strategy to transfer the generative aspects of learning to mechanical practice of handwriting scripts on the slate chalkboard in baseline and on the lowercase blackboard in acquisition (see Figure 5). The Three P’s were foundational skills of handwriting: Posture, paper position, and pencil grip. Three P’s instruction included a forward-chain task analysis of each skill during acquisition.



*Figure 3.* HWT® blackboard, slate chalkboard, sponge cubes, and chalk bits. Reproduced with permission of Handwriting Without Tears®.

**Letter scripts.** Scripted lessons included HWT® scripts for letter formations for each of the four letter sets. These scripts represented a forward-chain task analysis of letter formation (see Figures 12 – 15 in Appendix B Handwriting without tears material).

**Instructional support.** Instructional support included researcher-developed instructional protocol for interspersing letter instruction using errorless teaching with the

HWT® materials, strategies, and scripts, along with additional researcher contact, as needed and/or desired.

***Errorless teaching.*** Errorless teaching is defined as instruction in a domain of learning (e.g., handwriting) using a combination of prompt-fade procedures (i.e., a shaping procedure), differential reinforcement (e.g., social reinforcement), a fixed rate of reinforcement (e.g., plastic counting tokens), and error-correction procedures to efficiently teach skills or knowledge, as required for the learning situation.

***Interspersal training.*** Interspersal training is defined as the unpredictable presentation of target stimuli and their related materials across a training session, rather than the presentation of discriminative stimuli in discrete-trial training (Neef, Iwata, & Page, 1980).

## **Materials**

Parent and child participants were introduced to a variety of training and testing materials across six dependent variables. Materials specific to parent or child use as well as materials for various phases of the study are described below.

**Parents.** HWT® instructional sheets included Number Formation Instructions, The Hand Activity, Wet-Dry-Try, the Three P's task analysis sheet, and letter set 1-4 scripts. HWT® materials included one slate chalkboard, one blackboard, a quantity of 10 - 1" chalk bits, a quantity of 10 - ½" sponges (see Figure 5), 100 - 2" x 2" paper towel squares, 20 Learning Resources® plastic counting tokens (i.e., 4 each of red, blue, yellow, orange, and green), and one Avery® heavy-duty 2" D-ring binder to hold activity, training, and testing sheets. Duration data were collected with a Polder Model

898-90 3-in-1 clock, timer, & stopwatch on a Three P's data collection form (see Appendix D Checklists and Data Collection Forms). One Panasonic HC-V500 or Panasonic HC-V700 video camera, one SanDisk Model SDSDU-032G-AFFP Ultra 32gb SDHC class 10 flash memory card 30mg/S, and one Ravelli Model APLT4 tripod were used for procedural reliability and interobserver agreement data for each household.

**Children.** Child participants were introduced to one of four 6-7 letter subdivisions of the English alphabet during legibility acquisition. Baseline materials and legibility acquisition instruction materials are listed below. No independent variable instruction occurred within maintenance or generalization. Posture and paper position instruction were identical across acquisition, but required no materials. Legibility rate and generalization were probed for as a byproduct of differential instruction; therefore, no materials were required to teach them.

**Baseline.** One slate chalkboard for writing numbers, a quantity of 10 - 1" chalk bits, a quantity of 10 - 1/2" sponges (see Figure 2), and a quantity of 100 - 2" x 2" paper towel squares were used to establish stimulus-stimulus pairing in baseline.

**Acquisition training.** One slate blackboard for writing letters, a quantity of 10 - 1" chalk bits, a quantity of 10 - 1/2" sponges (see Figure 2), a quantity of 100 - 2" x 2" paper towel squares, a quantity of 5 - 4" pencils, and up to three letter set sheets for each training session were used for legibility acquisition training (See Appendix B).

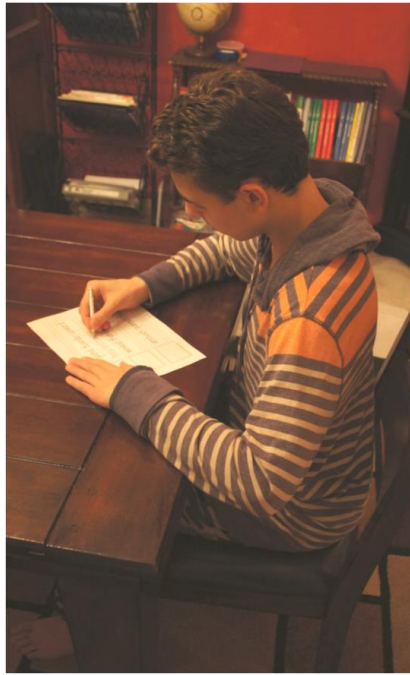
### **Dependent Variables**

The dependent variables targeted in this study were chosen to replicate and extend previous research. Specifically, legibility, legibility rate, posture, paper position, and

pencil grip were targets of instruction. Each variable is operationally defined below. The detail description of the data recording sheets is provided in the Procedures section.

**Legibility, including legibility rate.** Given an 11" x 8 ½" worksheet with double lines containing randomly assigned words and the discriminative stimulus, "Write these words in your best handwriting, as quickly as you can," the child would: 1) start writing within 3 seconds of receipt of the discriminative stimulus; 2) accurately write all strokes for at least 3 letters in the set according to the letter script and written model in terms of orientation, placement, size, start, sequence, and control; and 3) complete the entire worksheet with gradually decreasing writing durations during the first-of-the-day cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs (see Appendix B).

**Posture.** Given the discriminative stimulus, "It's time to do some writing," in the presence of the handwriting testing materials, within 10 seconds of receipt of the discriminative stimulus the child would: 1) sit on the chair directly in front of the writing materials with feet flat on the floor; 2) body held in a seated upright position; 3) head held in alignment with the spine; 4) arms resting on the writing surface at a height such that the shoulders remain in a neutral position; 5) wrists in a neutral position; 6) stomach one hands-width from the writing surface; and 7) a forward-body lean of 15-30 degrees during the first-of-the-day cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs (see **Error! Reference source not found.**).



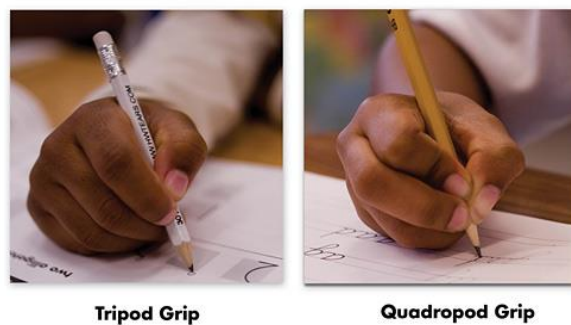
*Figure 4.* Correct right-handed handwriting posture and paper position. © 2014 Tamara J. Genarro.

**Paper position.** Given the discriminative stimulus, “It’s time to do some writing,” in the presence of the handwriting testing materials, within 10 seconds of receipt of the discriminative stimulus the right-handed child would: 1) position the worksheet to the right of body midline; 2) rotate the paper counterclockwise 30-45 degrees such that the right upper corner is higher than the left upper corner; and 3) place the left hand on the left upper corner to steady the page during the first-of-the-day cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs. The left-handed child would position the worksheet to the left of body midline, rotate the paper clockwise 30-45 degrees such that the left upper corner is higher than the right upper corner, and place the right hand on the left upper corner to steady the page during the first-of-the-day



cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs.

**Pencil grip.** Given the discriminative stimulus, “It’s time to do some writing,” in the presence of the handwriting testing materials, within 10 seconds of receipt of the discriminative stimulus the child would: 1) pick up the pencil in a tripod (i.e., thumb, index and middle fingers) or quadropod (i.e., thumb and the index, middle, and ring fingers) grip; 2) maintain normal skin color; and 3) maintain moderate muscle tension during the first-of-the-day cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs (see **Error! Reference source not found.**4).



*Figure 5.* Handwriting tripod and quadropod pencil grip for left- or right-handed writers. Reproduced with permission of Handwriting Without Tears®.

**Stimulus generalization.** Given an 11” x 8 ½” worksheet with double lines containing randomly assigned words and the discriminative stimulus, “Write these words in your best handwriting, as quickly as you can,” the child would: 1) start writing within 3 seconds of receipt of the discriminative stimulus; 2) accurately write all strokes for at

least 3 letters in each set according to the letter script and written model in terms of orientation, placement, size, start, sequence, and control; 3) correctly complete the worksheets when delivered by three different people, in three different locations, and with three different materials; and 4) complete the entire worksheet with gradually decreasing writing durations during the first-of-the-day cold probe with 100% accuracy across 2 consecutive days on which the opportunity occurs (see Appendix B).

### **Additional Measures**

Parents and children needed separate measures to collect demographic data to determine the effect of intervention on the dependent variables. As such, three measures were included for parent participants. Child participants included demographics and data collection on all dependent variables.

**Parent.** Standard demographic data were collected on parents. Procedural reliability data were collected on parent implementation of the intervention as described later. Social validity data were collected at the conclusion of the study as described later.

**Child.** Standard demographic data, The VABS®, and The CARS® were collected on children. The child handwriting measures were developed based upon suggestions in recent literature and measures in The Print Tool™ (see examples in Appendix C Randomization of Letter Sets, figures 16-24). Neither the Print Tool™ measures nor the modifications to them conducted herein have been tested for reliability or validity. One test sheet containing all letters of the alphabet in a scrambled pangram was provided per test session (see Appendix C Randomization of Letter Sets). In addition, a reinforcer

preference survey was used to identify items that could raise child motivation to engage in handwriting.

## **Procedures**

Many aspects of this study required a task analysis and procedural compliance. First, university protocol required informed consent and assent. Second, parents needed to be taught consistently. Third, a reinforcer preference survey was needed to identify items that could raise child motivation to engage in handwriting. Fourth, a pairing procedure was introduced to increase the likelihood of children enjoying handwriting as a conditioned reinforcer. Fifth, children needed to be trained consistently. Finally, children needed consistency in testing procedures. Each of those procedures is discussed below.

**Informed consent and assent.** Prior to instruction, the researcher discussed and obtained informed consent from the parent. The researcher also discussed and obtained informed assent from the child and the parent, as follows. The child was asked if the researcher and parent could work with him to teach him to write. The researcher and the parent noted a confirmatory response. A confirmatory response for a nonvocal student was recognized as the child's positive affect, remaining at the table, and/or looking at the materials and/or researcher. A negative response was recognized as the child removing himself/herself from the table or displaying signs of dissatisfaction or distress (e.g., crying, frowning, etc). For a vocal student, a confirmatory response was recognized as the child giving an affirmative response (e.g., "Yes, it's ok."). Following a positive response, the researcher and parent signed their names on the assent form. The child signed his name, as skill allowed.

**Intake assessments.** Two assessments were used in this study to establish a general baseline across the participants. After the parents and children agreed to participate in the study and signed the consent and assent forms, the researcher interviewed the parents with two standardized measures, The VABS and the CARS. The VABS was used to assess the children's developmental level across four domains, communications, daily living skills, socialization, and maladaptive behavior. The researcher had used the VABS for over six years and was knowledgeable about scoring and interpretation with that assessment. She had also used the CARS for two years to assess a child's degree of features of autism. Participants were given the option to meet at a coffee house, library, or within their home. Each parent was asked to arrange for childcare during the meeting, since the VABS interview takes approximately 90 minutes to conduct. Keane's dad chose to conduct the interview at a coffee house. Tony's mom opted to hold the interview in her home. Owen's mom also chose to conduct the interview within her home.

During the assessment meeting, the researcher sat opposite the individual parents, turned at a 90-degree angle to maintain an open-body posture while still being able to collect data during the interview. None of the interviews were video- or audiotaped. To minimize observational effects, the researcher brought only the necessary paperwork to complete the interview, the laptop computer, and a 1" 3-ring binder to hold notepaper. Each interview was completed within 90 minutes. At the end of the interview, each parent was told that they would receive a copy of the results at the end of the study. That decision was made to avoid treatment effects based upon altered expectations, beliefs,

values, and motivation in teaching their children. Any parents who were not eligible to enter the study were offered the results, upon request. No parent who was ineligible to join the study requested the results.

**Parent training.** The researcher set up the training environment per antecedent strategy instructions as listed on the data collection form (see Appendix D Checklists and Data Collection Forms). With all materials, instructions, and parental considerations attended to, the researcher began intake of parent and child demographics. These data were collected at a date after the intake assessments were scored since they requested more personal information. If families were found ineligible, collecting that sensitive information would be unnecessary. The parents were informed that the surveys would take approximately 10 minutes to complete.

Following collection of participant and setting demographics, the researcher instructed parents in a 90-minute workshop on how to teach handwriting to their adolescent children with autism using the HWT® activities including: The Hand Activity, Wet-Dry-Try, the Three P's task analysis, and Letter Formation scripts. Concurrently, the researcher presented the HWT® slate chalkboards, lowercase blackboards, chalk bits, sponges, pencils, Learning Resources® plastic counting tokens, and the paper towel squares.

The researcher began the practical teaching by demonstrating (a) how to set up, angle, and charge the video camera (i.e., with a requisite downward angle to capture child posture, paper position, pencil grip, and parent/child interactions); (b) set up the handwriting environment with all requisite materials; (c) start the video camera; (d)

signal the child to prepare for handwriting (e.g., “It’s time to do some writing.”); (e) use and display the procedural checklist in view of the video camera at the beginning of the session; (f) ask the child to begin writing (e.g., “Write these words in your best handwriting, as quickly as you can.”); (g) start the duration timer; and (h) collect Three P’s data for daily sessions.

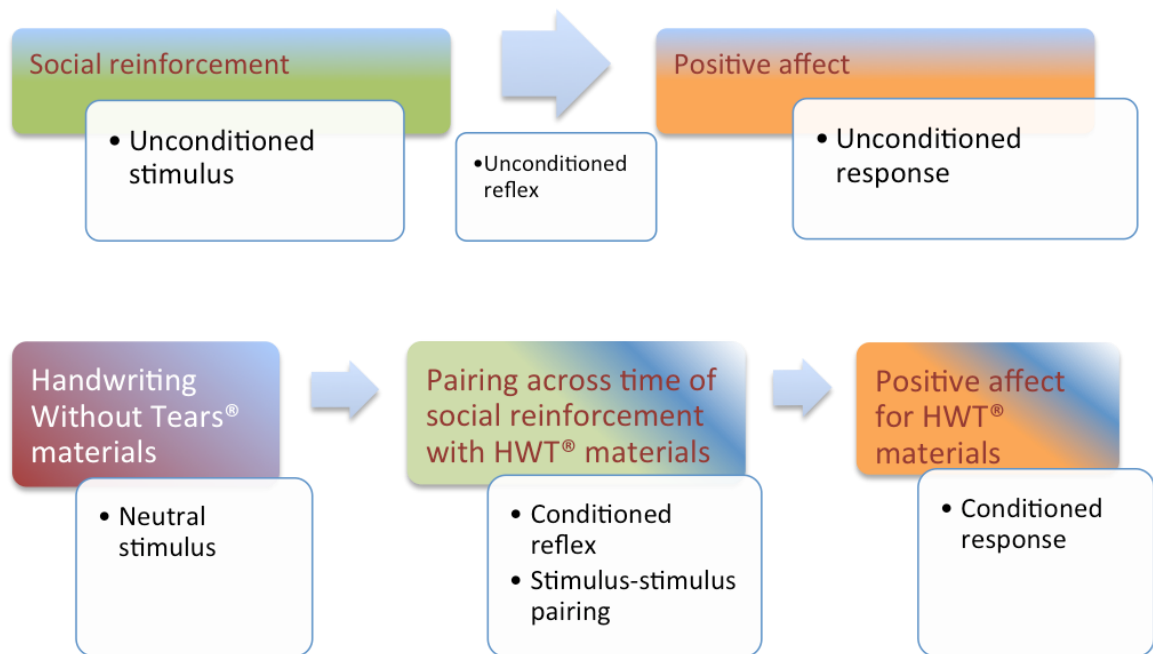
Following the workshop, the parent practiced the above teaching procedure with the researcher (i.e., with the researcher serving as the child role model) until the parent could consistently perform each step of the training and testing conditions fluently. The researcher was available to answer parent questions and provide additional future training via email, phone, or in person, as needed. Parent training was provided during each phase of intervention for new targets and to revisit criteria for data collection and procedural reliability instructions, as needed. Parents did not receive instruction on how to score their children’s writing.

**Reinforcement preference survey.** A reinforcement preference survey is defined as an identification tool for potentially reinforcing foods, toys, activities, and social interactions (Fisher, Piazza, Bowman, & Amari, 1996). Parents were asked to note their children’s five most-preferred toys, foods, activities, and social interactions for a total of 20 potential reinforcers. Each parent was asked to reserve the top four most-preferred items for handwriting instruction.

The pairing procedure was repeated during the introduction of each letter set to ascertain and ensure effectiveness of the top four most-preferred reinforcers. New reinforcers were determined if the child demonstrated satiation for initial reinforcers.

While the researcher created a preference token board for three participants, one mother chose to make her own based upon the researcher's model. The token boards were printed on 8½" x 11" cardstock paper. They were kept in sight to remind the child participants of what they were earning while doing handwriting. Long-term goals for the participants included a day trip to the Virginia Safari Park, to Richmond Lego Kidsfest, and to ride the DC metro.

**Pairing procedure.** In order to increase the motivation to use the handwriting materials and therefore increase the likelihood of handwriting success, the HWT® materials were paired with known reinforcers (e.g., child-specific social reinforcement) to evoke the materials as conditioned reinforcers through stimulus-stimulus pairing (see Figure 6) (Alberto & Troutman, 2009; Cooper, Heron, & Heward, 1987; Miltenberger, 2012). Praise was provided to the child when he interacted with the HWT® materials. For example, when the child approached, touched, or picked up the materials, the researcher commented on their activity (e.g., "That's awesome."). The ratio of reinforcement was decreased as the child increasingly engaged with the HWT® materials until the materials served as conditioned reinforcers. All child participants were found to be sensitive to the delivery of social praise; however, Owen had a threshold of social praise as a reinforcer before it turned into a punisher for him. Since a long-term goal of parent-mediated instruction was to establish a positive affect for handwriting for the child, the parent and researcher decided to withhold social praise, except to differentially reinforce particularly unique responses.



*Figure 6.* Pairing procedure of an unconditioned stimulus with a neutral stimulus.

**Child training.** Beyond the initial intake and instruction, the researcher served as either a consultant or a collaborator to parents during child training. She did not serve as a teacher to the children themselves. During each phase of training, the researcher provided the materials, instructions, and follow-up training to the parents so that they could implement each phase of instruction. The researcher provided instruction to the parents in the same order as listed below. The researcher visited the homes every 1-3 days to provide direct support and to pick up training and testing products. She was also available daily via text messaging, phone, and email for questions or support, as needed.



**Baseline.** Prior to instruction, parents set up the video camera with adequate available memory. The parent ensured the child: (a) had 15-30 minutes of uninterrupted time available for instruction; (b) had any special needs met; (c) was adequately fed; (d) had a good general state of health and arousal; and (e) had used the restroom immediately prior to instruction. Room temperature and lighting were set to the child's comfort level prior to instruction and parents were asked to reduce competing environmental noises. Primary reinforcers (e.g., small bites of cucumber for Keane) and secondary reinforcers (e.g., a paused movie for Keane, a computer game for Tony, and a cookie for Owen) were visually available but out of direct reach of the child. Parents placed the antecedent prompting and discriminative stimuli sheet at the instruction location. The parent called the child to the handwriting environment when all materials, instructions, child considerations, and reinforcers were ready. Appropriate prompt-fade and error-correction procedures were used to increasingly promote independent responding and to differentially reinforce better approximations of writing. Finally, the parent provided noncontingent reinforcement with a plastic counting chip every 30 seconds.

Participants used the HWT® Number Formations for numbers 0-9 (see Appendix B Handwriting Without Tears Material.), Wet-Dry-Try instructions, slate chalkboards, chalk bits, wet sponge cubes that were gently squeezed of excess water, and paper towel squares. All materials were positioned within two feet of the instruction location. Then, number instruction began. First, the parent wrote a number model on his or her slate board with a chalk bit while reciting the number script. Second, the parent used a damp sponge to trace over the written number. Third, the parent modeled drying the wet tracing

while using a pincer grip to hold the scrunched paper towel square. Fourth, the parent rewrote the number with a chalk bit while reciting the number script. Fifth, the parent prompted the child through the same four steps, recited the script as the child wrote the numbers, and encouraged the child to recite the script as the child wrote it.

***Acquisition phase: Letter set 1.*** As in baseline, parents set up the video camera with adequate available memory. The parent ensured the child (a) had 15-30 minutes of uninterrupted time available for instruction; (b) had any special needs met; (c) was adequately fed; (d) had a good general state of health and arousal; and (e) had used the restroom immediately prior to instruction. Room temperature and lighting were set to the child's comfort level prior to instruction and parents were asked to reduce competing environmental noises. Primary reinforcers (e.g., small bites of cucumber for Keane) and secondary reinforcers (e.g., a paused movie for Keane, a computer game for Tony, and a cookie for Owen) were visually available but out of direct reach of the child. Parents placed the antecedent prompting and discriminative stimuli sheet at the instruction location. The parent called the child to the handwriting environment when all materials, instructions, child considerations, and reinforcers were ready. The parent used appropriate prompt-fade and error-correction procedures to increasingly promote independent responding and to differentially reinforce better approximations of all variables across the duration of the study. The parent also provided noncontingent reinforcement with a plastic counting chip every 30 seconds throughout training for the child's engagement in handwriting.

The seven letters in set 1 did not have similar features. They were described as “miscellaneous” letters: e, f, i, j, l, t, and u. Parents and children used the HWT® Letter Formations scripts, HWT® Wet-Dry-Try instructions, The HWT® Hand Activity, slate blackboards, chalk bits, wet sponge cubes that were gently squeezed of excess water, and paper towel squares, 4” pencils, and three letter set 1 training sheets. All materials were positioned within two feet of the instruction location. Posture, paper position, and pencil grip instruction were added into treatment.

Instruction began with the delivery of a vocal discriminative stimulus (e.g., “It’s time to do some writing.”) and directions (e.g., “Sit in writing position.”) In the presence of the handwriting training materials and a point prompt, within 10 seconds of receipt of the discriminative stimuli the parent prompted the child at the required level to sit on the chair directly in front of the writing materials with feet flat on the floor, to sit in an upright position, and to align the head with the spine. The parent prompted at the required level for the child’s arms to rest on the writing surface at a height such that the shoulders were in a neutral position, wrists were in a neutral position, stomach was one fist-width from the writing surface, and with a forward-body lean of 15-30 degrees (see Figure 3).

After being seated correctly at the testing table and given the discriminative stimulus, “Position your paper,” in the presence of the handwriting training materials and a point prompt, the parent prompted the child at the required level within 3 seconds of receipt of the discriminative stimulus. Since all child participants were right-handed, they were prompted to position the worksheet to the right of body midline, rotate the paper counterclockwise 30-45 degrees such that the right upper corner was higher than the left

upper corner, and placed their left hand on the left upper corner to steady the page. If the children had been left-handed, they would have been prompted to position the worksheet to the left of body midline, to rotate the paper clockwise 30-45 degrees such that the left upper corner was higher than the right upper corner, and to place their right hand on the left upper corner to steady the page (see Figure 3).

After being seated with correct posture at the testing table, correctly positioning the paper, and given the discriminative stimulus “Get ready to write,” in the presence of the handwriting training materials and a parent gesture (e.g., pointed to where the child should write) or physical prompt (e.g., hand-over-hand or touching the wrist) to the child: within 3 seconds of receipt of the discriminative stimulus the child picked up the pencil in a tripod (i.e., thumb, index and middle fingers) or quadropod (i.e, thumb and the index, middle, and ring fingers) grip that maintained normal skin color and moderate muscle tension (i.e., the absence of overgripping the writing instrument).

Then, given an 8 ½” x 11” worksheet with double lines containing randomly assigned letters and/or words (see Appendix C) and a discriminative stimulus (e.g., “Copy the letter” or “Copy the word”), the parent prompted the child at the required level to start writing within 3 seconds of receipt of the discriminative stimulus. The child received instruction on how to accurately orient, place, size, start, sequence, and control training letters and words (i.e., on blackboards and double-lined paper in acquisition).

First, the parent demonstrated the location of a randomly chosen letter, based upon the Hand Activity. Second, the parent wrote a model of the randomly chosen set 1 letter with chalk on his or her blackboard while reciting the letter script. Third, the parent

used a damp sponge to trace over the written letter. Fourth, the parent dried the wet tracing while using a pincer grip to hold a scrunched paper towel square. Fifth, the parent rewrote the letter with a chalk bit while reciting the letter script. Sixth, the parent prompted the child through the above steps 1-5 on the child's blackboard, recited the script as the child wrote the letters, and encouraged the child to recite the script as the child wrote it. Parents faded the vocal, gestural, and physical prompts to promote independent responding as the child acquired greater accuracy in handwriting. Error-correction procedures included preventing the child from continuing to write when an error had occurred by quickly erasing the error with a moistened paper towel, flipping over the blackboard, or replacing it with the parent's board. Then, instruction resumed at a higher prompt level (e.g., parent would restart the letter script at the second parental step) until the child accurately wrote the letter at a lower prompt level. Parents were asked to conclude all instruction on a good note by ending only when the student wrote at their lowest prompt level while maintaining the best to-date accuracy.

In addition to blackboard letter writing (i.e., the first 10-minute session), three double-lined training sheets were introduced to shape the child's production of printed letters on paper (i.e., for the second 10-minute session). Only the child received training sheets. The parent read and/or prompted the child to say the letter location based upon the HWT® Hand Activity. The parent either sat to the right of the child (i.e., since each was right-handed) or stood behind and to the right of the child in order to physically prompt letter writing at the hand, wrist, or forearm. Posture, paper position, and pencil grip were also prompted during training sheet writing. Instruction began with the training sheet

targeted at the letter level. The parent prompted the letter formation scripts as the child wrote. Instruction on the two word-level training sheets followed the same sequence.

Letter presentation was based on the daily letter sheet randomized order in which they were generated. Physical prompts were used to produce correct letter formations, as necessary. Error-correction procedures included preventing the child from continuing to write when an error had occurred by quickly erasing the error or having the child erase it, then instruction resumed at a higher prompt level (e.g., requiring the child to say the script prior to and during letter writing) until the child accurately wrote the letter at a lower prompt level. Parents were asked to conclude all instruction on a good note by ending only when the student wrote at their lowest prompt level while maintaining the best to-date accuracy. The children were asked to circle their best sample of each written letter to reinforce correct letter formation in the future.

***Acquisition phase: Letter set 2.*** The parent continued antecedents (i.e., all events that preceded instruction), behaviors (i.e., letter instruction on blackboards and training sheets), and consequences (e.g., prompt-fade and error-correction procedures) as in letter set 1. The seven letters in set 2 had similar features that were based on “magic c”: c, a, d, g, o, q, and s. Word-level training sheets for letter set 2 contained both letter set 1 (e.g., as continual training) and letter set 2. As such, fewer opportunities existed for practicing letters in the current set than opportunities that existed for set 1.

***Acquisition phase: Letter set 3.*** The parent continued antecedents (e.g., all events that preceded instruction), behaviors (e.g., letter instruction on blackboards and training sheets), and consequences (e.g., prompt-fade and error-correction procedures) as in letter

sets 1 and 2. The six letters in set 3 had similar features that were based on “diver letters” and specifically letters that contain the letter “r”: r, b, h, m, n, and p. Word-level training sheets for letter set 3 contained letters from sets 1 and 2 (i.e., as continual training) and letter set 3. As such, fewer opportunities existed for practicing letters in the current set than opportunities that existed for sets 1 or 2.

***Acquisition phase: Letter set 4.*** The parent continued antecedents (e.g., all events that preceded instruction), behaviors (e.g., letter instruction on blackboards and training sheets), and consequences (e.g., prompt-fade and error-correction procedures) as in letter sets 1-3. The six letters in set 4 have similar features that were based on “diagonals”: k, v, w, x, y, and z. Word-level training sheets for letter set 4 contained letters from sets 1-3 (i.e., as continual training) and letter set 4. As such, fewer opportunities existed for practicing letters in the current set than opportunities that existed for sets 1-3.

**Child testing.** Child participants were introduced to four phases of testing across six dependent variables. Each phase is outlined below.

***Baseline.*** Testing sheets were administered to each participant based upon random assignment (see Appendix C Randomization of Letter Sets) using cold probe data collection (i.e., testing occurred prior to training). Parents set up the video camera with adequate available memory. The parent ensured the child: (a) had at least 5 minutes of uninterrupted time available for testing; (b) had any special needs met; (c) was adequately fed; (d) had a good general state of health and arousal; and (e) had used the restroom immediately prior to instruction. Room temperature and lighting were set to the child’s comfort level prior to instruction and parents were asked to reduce competing

environmental noises. Parents placed the antecedent prompting and discriminative stimuli sheet at the instruction location. The parent called the child to the handwriting environment when all materials, instructions, and child considerations were ready. Testing occurred under extinction conditions (e.g., no reinforcement was given for any response) and no prompting or error-correction procedures were used in testing sessions.

After delivery of a vocal discriminative stimulus (e.g., “Write these words in your best handwriting, as quickly as you can”), the parent started the timer to collect duration data. Then, parents used time sampling for posture, paper position, and pencil grip on a 15-second rotating interval (i.e., posture = 5 sec, paper = 10 sec, pencil = 15 sec, posture = 20 sec, etc.), recording it within session on a time sampling data sheet. They placed the timer on the table such that they could read it and watch the child simultaneously. At the end of each 5-second interval, the parent wrote on the time sampling Three P’s data collection form (see Appendix D Checklists and Data Collection Forms). If the child’s behavior met all of the accuracy requirements in the behavior being measured, the parent wrote Y, indicating Yes, on the data collection sheet in the appropriate time sampling interval. If the child’s behavior did not meet all of the accuracy requirements in the behavior being measured, the parent wrote N, indicating No, on the data collection sheet in the appropriate time sampling interval. When the child stopped writing and put the pencil down, the parent stopped the timer. Either the parent or the child wrote the duration, date, and their participant number on the permanent product. If the child wrote the duration, the parent checked that it was accurately recorded. Time sampling data



collection was calculated as percent correct by dividing the number of correct responses by the number of correct plus incorrect responses and multiplying by 100.

***Acquisition.*** The main requirement for testing administration was the presentation of a training session on the preceding day. Random assignment of testing sheets, cold probe data collection, antecedent preparation, and reinforcement extinction conditions continued from baseline. No prompting or error-correction procedures were used in testing sessions. Parents conducted the testing session as in baseline.

***Maintenance.*** Unlike in acquisition, there was no presentation of a training session on the preceding day. Random assignment of testing sheets, cold probe data collection, antecedent preparation, and reinforcement extinction conditions continued from baseline and acquisition. No prompting or error-correction procedures were used in testing sessions. Parents conducted the testing session as in baseline.

***Generalization.*** Unlike in acquisition, there was no presentation of a training session on the preceding day. Cold probe data collection, antecedent preparation, and reinforcement extinction conditions continued from baseline and acquisition. No prompting or error-correction procedures were used in testing sessions. Parents conducted the testing session as in baseline.

Random assignment of testing sheets in this condition included generalization across three different people, locations, and testing materials (i.e., double-, triple-, and single-lined paper. To simplify the generalization process for the researcher, the last nine sheets randomly assigned to Keane were also assigned to Tony and Owen. Parents were asked to present from one to nine test sheets per day since there was no pre-training

requirement. Three of the nine sentences were randomly assigned to the three teachers. Each sentence for each teacher was assigned to the three paper types. Each teacher and paper type was assigned to three different locations that were conducive to handwriting.

### **Interobserver Agreement**

Two independent observers manually recorded session data using a data collection form and a pen during randomly selected sessions across all study phases. Observers were taught the response definitions prior to the study and were calibrated actively within training sessions or with videotape examples of a similar intervention until agreement was 100%. Reviewing response definitions in each treatment phase controlled for observer drift (Kennedy, 2005). Videotaped sessions allowed for the observers to review the children's responses. That was particularly useful to evaluate potential orientation and sequencing errors. Observers included the researcher, parents, one hired female observer, and one hired male observer. Additionally, the researcher and each parent collected data on his (or her) child's posture, paper position, pencil grip, and handwriting duration. Data was collected either within session or from a videotape of the session and was written directly onto data sheets for posture, paper position, pencil grip, and duration.

The researcher, female observer, and male observer scored participant permanent products that resulted in IOA for legibility throughout the study. Permanent products were used for legibility handwriting analysis. Interobserver agreement was calculated point-to-point by dividing the number of agreements by the total number of agreements plus disagreements and multiplying by 100. Observers collected data across a minimum

of 29% (i.e., 2 out of 7 sessions) of sessions in all study phases. Agreement was targeted between 80-100% agreement across each phase. Agreement was greater than 93% across all research questions and phases for all participants. If agreement had fallen below 90% during any phase of study, observers would have recalibrated by reviewing a videotaped example until agreement was 100%.

### **Procedural Reliability**

**Parent instruction.** Parent procedural reliability was measured across eleven antecedent, five instructional, and three consequence management procedures. The child instruction procedural reliability checklist that was used in this study (a) noted the title of the study; (b) stated that the form was a procedural reliability checklist; (c) had a space for the child's code; and (d) contained blank areas to be filled in for date, time of day, and duration. It also had areas to write notes of special consideration, number of features complete and correct, number of features incomplete or incorrect, strength areas, areas to improve before the next observation, and boxes to be checked for within-session or videotape observation (see Appendix I Procedural Reliability).

Two independent observers collected data on procedural reliability on the described data collection form. The researcher conducted procedural reliability on antecedent, instructional, and consequence strategies via videotape analysis for a minimum of 43% (i.e., 3 out of 7 sessions per week) of all sessions across all phases of the study. A second observer conducted procedural reliability on all three strategies via videotape analysis of 100% of sessions across all phases of the study. The researcher and second observer reviewed terminology together prior to the start of the intervention and

during each phase of treatment. Procedural reliability was calculated by dividing the number of steps completed by the number of steps planned multiplied by 100. Agreement was targeted between 80-100% agreement across each phase. Agreement between observers was greater than 96% agreement across antecedent, instructional, and consequence measures. If agreement had fallen below 90% during any phase of study, observers would have recalibrated by reviewing a videotaped example until agreement was 100%

**Data entry.** The researcher created the Microsoft® Excel databases into which legibility, duration, posture, paper position, pencil grip, generalization, parent fidelity, and social validity were entered. Then, the researcher transferred all data from the handwriting data analysis sheet to the Excel database. A second observer independently conducted data entry reliability across 100% of the data. Percentage of agreement was calculated point-to-point by dividing the number of agreements by the total number of agreements plus disagreements and multiplying by 100. Agreement was targeted between 80-100% agreement across each phase and across each dependent variable. The researcher and second observer obtained an agreement of greater than 98% across data entry for all research questions and intervention phases. If agreement had fallen below 90% during any phase of study, observers would have recalibrated by reviewing the data entry protocol until agreement was 100%.

### **Internal Validity**

Extraneous independent variables may have caused threats to internal validity, but they were controlled to the greatest possible extent. Obtaining information from parents

about the child-participant's exposure to handwriting within their educational curriculum controlled for participant history. Setting inclusion criteria to include adolescents controlled for maturation effects, since handwriting instruction ended for all participants in elementary school and they were unlikely to gain handwriting skills as a result of the study duration. Cold probe data collection controlled for training effects. Randomization of the pangram sentences controlled for test-retest errors. Setting relatively broad inclusion criteria in terms of diagnosis label within the autism spectrum, the range of acceptable maladaptive behavior, and randomizing training and testing materials controlled for selection bias. There was no attrition during this study, although one participant family chose to discontinue acquisition of four letter sets. There was potential diffusion of treatment as a result of a lack of videotaped parent training sessions and all participant parents maintaining potentially distracting items, sounds, and/or activities near the instructional area.

### **External Validity**

The results of this handwriting intervention may generalize more readily due to control for threats to external validity. Using handwriting materials that have been used extensively to teach a wide variety of children controlled for materials characteristics. Using an area of the home where students often do homework controlled for setting characteristics. Having parents instruct the participants in an activity similar to homework controlled for intervener characteristics.

## **Social Validity**

Social validity was evaluated to determine the extent to which the goals, procedures, and effects of the intervention were acceptable to the parent-participants (Cooper et al., 1987; Kennedy, 2005; Miltenberger, 2012). Five questions, modified from a BP-PBS Acceptability Questionnaire, assessed the extent to which handwriting instruction (a) improved handwriting; (b) improved handwriting at school; (c) was worth the time and effort; (d) was worth recommending to others; and (e) was easy to implement (Ross & Horner, 2013). Scores on the questionnaire were recorded on a Likert-type scale from 1 to 5, with higher scores indicating a more favorable impression (see Appendix J Social Validity).

## **Data Analysis**

Data were graphed using Microsoft® Excel® 2008 Version 12.3.0 for Mac. Normalized writing durations, graphics, mean scores, standard deviations, changes in between-phase magnitude, and percent of nonoverlapping data were generated with that program.

Within-phase, between-phase, and between-participant patterns were analyzed for each research question and participant. Within-phase patterns included: (a) the level of the data points, as determined by the mean; (b) variability range (low, medium, or high), as determined by the standard deviation; (c) and the degree of the trend line, indicating whether it was positive, negative, or flat. Between-phase patterns included: (a) the immediacy of effect, as noted by no, slow, moderate, or rapid change between the last three data points in the first phase of interest with the first three data points from the

second phase of interest (Kennedy, 2005); (b) the magnitude of change, as noted by a low, medium, or high change that was calculated by subtracting the phase one mean from the phase two mean (i.e.,  $\Delta \text{Magnitude} = M_2 - M_1$ ) and yielded a positive or negative sign that indicated the direction of change; (c) the pattern consistencies that emerged at similar points of treatment; and (d) a non-regression analysis of overlap, as noted by percent of non-overlapping data (PND) (Scruggs, Mastropieri, & Casto, 1987). Between-participant pattern analysis included vertical analysis, as determined by how or if the dependent variable changed for participants in different tiers as a result of introducing treatment. Results are described in Chapter 4 for each research question, participant, and phase in the order as listed above.

## **Chapter Four**

The focus of this chapter is on describing the results addressing four research questions across three participants. A sample of three adolescent students with autism and their parents participated in this study on parent-mediated instruction of print handwriting. The three students were similar in their VABS daily living skills and adaptive behavior composite scores. Daily living skills scores were: Keane, 6 years 11 months; Tony, 6 years 1 month; Owen, 6 years 9 months. When communication, daily living skills, and socialization were collapsed into the adaptive behavior composite, the three participants were separated by only 3 months: Keane, 5 years 11 months; Tony, 5 years 9 months; and Owen, 6 years 0 months. Participant differences were found in communication and socialization. Communication scores were: Keane, 3 years 7 months; Tony 7 years 11 months; and Owen, 7 years 9 months. Socialization scores were: Keane, 7 years 3 months; Tony, 3 years 4 months; and Owen, 3 years 9 months. All participants were right-handed; received mild-moderate autism rating on the CARS; and had intermediate levels of maladaptive behavior, with Keane having the lowest maladaptive behavior score.

Data were also collected on an additional student, Alec, who did not meet the study inclusion criteria due to his high VABS maladaptive behavior scores. Nonetheless, his mother expressed extensive interest in joining the study and their dyad was included



to ascertain the effects of maladaptive behaviors on handwriting acquisition (i.e., as validation for the study inclusion criteria). His results may be of interest to readers to determine how maladaptive behaviors may affect handwriting acquisition. Interested readers may examine his demographics, scores, and graphs in Appendix E Alec's Case Study.

### **Research Questions**

A multiple baseline design was used to determine functional relations across legibility, legibility rate, posture, paper position, and pencil grip. Generalization data were collected for each of those dependent variables.

**Research question 1 results: Legibility.** Legibility was calculated by examining the subdomain scores of handwriting. Six subdomains of legibility were evaluated: orientation, placement, size, start, sequence, and control. Definitions of those variables were included in chapter one. Four out of six of those variables needed to be correct in order for the letter to be scored as correct in legibility. If a letter was duplicated in a sentence (e.g., in pangram 2, "the quick brown fox jumps over a lazy dog," the letter "u" appears twice), any incorrectly written instance of that letter was scored as a subdomain error in the legibility composite score. These scoring criteria were modified from The Print Tool handwriting analysis.

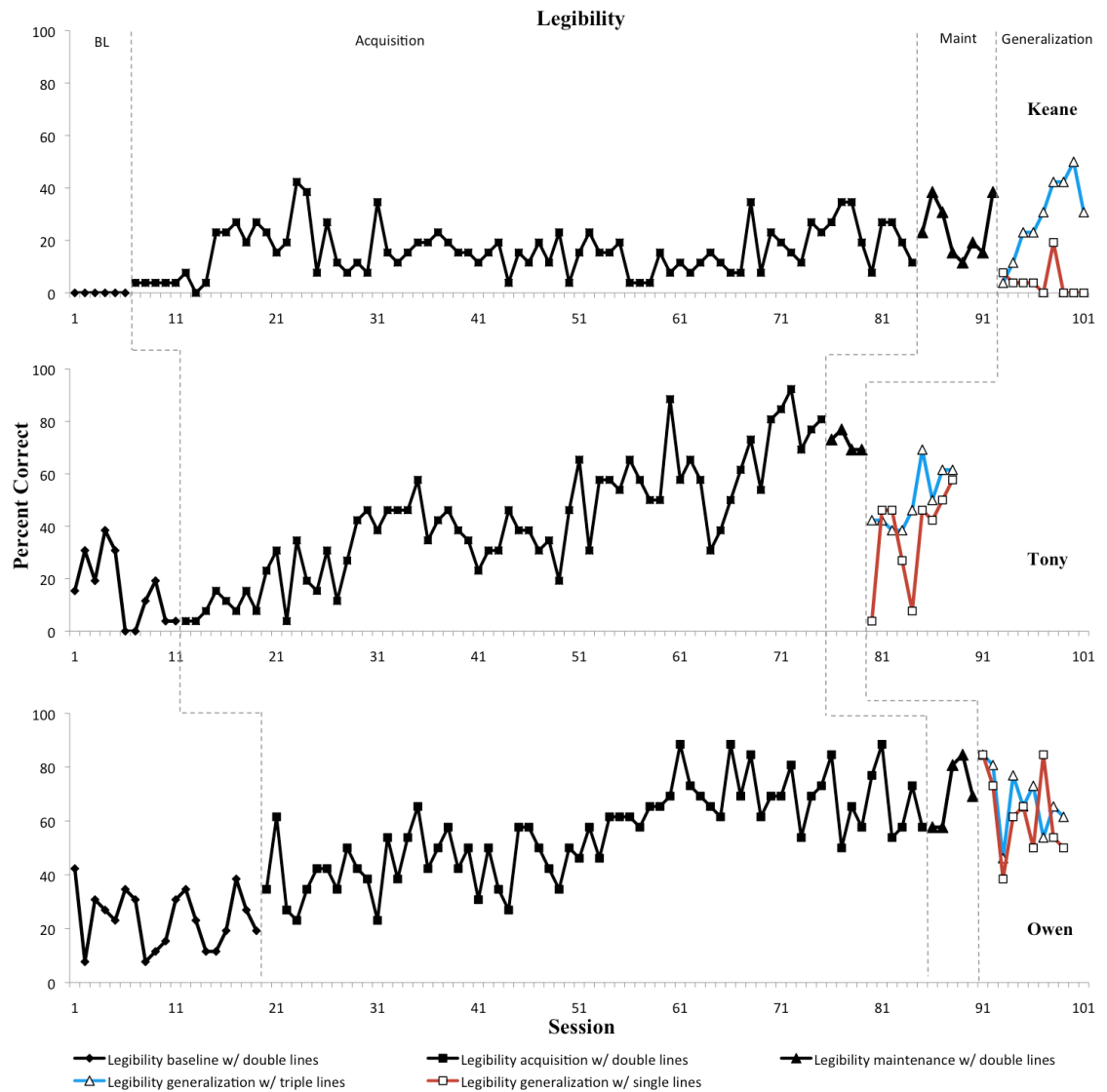


Figure 7. Legibility scores for three participants across baseline, acquisition, maintenance, and generalization phases.

**Keane.** During legibility baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a consistent baseline for Tony and Owen (see Figure 7).

During legibility acquisition domain scoring, the within-phase patterns included a mean of 16%, a medium degree of variability ( $SD = 9$ ), and a small positive trend (slope = 0.07;  $R^2 = 0.03$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +16% correct, a dissimilar pattern consistency, and a low degree of overlap with the previous phase (PND = 99%). The between-participant vertical analysis demonstrated that the independent variable introduction for Keane did not result in a change in legibility for either Tony or Owen, who had not entered treatment.

The maintenance score was compared to the legibility domain score. During legibility maintenance, the within-phase patterns included a mean of 24%, a medium degree of variability ( $SD = 11$ ), and a small negative trend (slope = -0.55;  $R^2 = 0.02$ ). The between-phase patterns included slow immediacy of effect between the last three data points in legibility acquisition and the first three data points in legibility maintenance, a low magnitude of change of +8% correct, a dissimilar pattern consistency, and a very high degree of overlap with legibility acquisition (PND 38%).

During legibility generalization on double-lined paper, the within-phase patterns included a mean of 32%, a medium degree of variability ( $SD = 10$ ), and a small positive trend (slope = 0.83,  $R^2 = 0.05$ ). The between-phase patterns included low immediacy of effect between the last three data points in maintenance and the first three data points in double-line generalization, a low magnitude of change of +8% correct, a dissimilar pattern consistency, and a very high degree of overlap with previous phase (PND = 22%).

During legibility generalization on triple-lined paper, the within-phase patterns included a mean of 29%, a medium degree of variability ( $SD = 15$ ), and a large positive trend (slope = 4.7;  $R^2 = 0.73$ ). During legibility generalization on single-lined paper, the within-phase patterns included a mean of 4%, a low degree of variability ( $SD = 6$ ), and a small negative trend (slope = -0.58;  $R^2 = 0.07$ ).

**Tony.** During legibility baseline, the within-phase patterns included a mean of 16%, a medium degree of variability ( $SD = 13$ ), and a moderate negative trend (slope = -2.3;  $R^2 = 0.32$ ). There were no between-phase patterns since the intervention had not been introduced. The between-participant vertical analysis demonstrated a consistent baseline for Owen (see Figure 7).

During legibility acquisition, the within-phase patterns included a mean of 42%, a medium degree of variability ( $SD = 22$ ), and a moderate positive trend (slope = 1.0;  $R^2 = 0.69$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +26% correct, a dissimilar pattern consistency, and a high degree of overlap with the previous phase (PND = 48%). The between-participant vertical analysis demonstrated that the independent variable introduction for Tony did not result in a change in legibility for Owen, who had not entered treatment.

The maintenance score was compared to the legibility domain score. During legibility maintenance, the within-phase patterns included a mean of 72%, a low degree of variability ( $SD = 4$ ), and a moderate negative trend (slope = -1.9;  $R^2 = 0.45$ ). The between-phase patterns included no immediacy of effect between the last three data

points in legibility acquisition and the first three data points in legibility maintenance, a medium magnitude of change of +30% correct, a similar pattern consistency, and a very high degree of overlap with legibility acquisition ( $PND = 0\%$ ).

During legibility generalization on double-lined paper, the within-phase patterns included a mean of 68%, a medium degree of variability ( $SD = 14$ ), and a large positive trend (slope = 4.2,  $R^2 = 0.071$ ). The between-phase patterns included no immediacy of effect between the last three data points in maintenance and the first three data points in double-line legibility, a low magnitude of change of -4% correct, a dissimilar pattern consistency, and a very high degree of overlap with legibility maintenance ( $PND = 22\%$ ).

During legibility generalization on triple-lined paper, the within-phase patterns included a mean of 50%, a medium degree of variability ( $SD = 11$ ), and a large positive trend (slope = 3.1;  $R^2 = 0.57$ ). During legibility generalization on single-lined paper, the within-phase patterns included a mean of 36%, a medium degree of variability ( $SD = 19$ ), and a large positive trend (slope = 4.0;  $R^2 = 0.32$ ).

**Owen.** During legibility baseline, the within-phase patterns included a mean of 23%, a medium degree of variability ( $SD = 11$ ), and a small negative trend (slope = -0.26;  $R^2 = 0.018$ ) (see Figure 7). During legibility acquisition, the within-phase patterns included a mean of 56%, a medium degree of variability ( $SD = 16$ ), and a small positive trend (slope = 0.60;  $R^2 = 0.49$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +33% correct, a dissimilar pattern

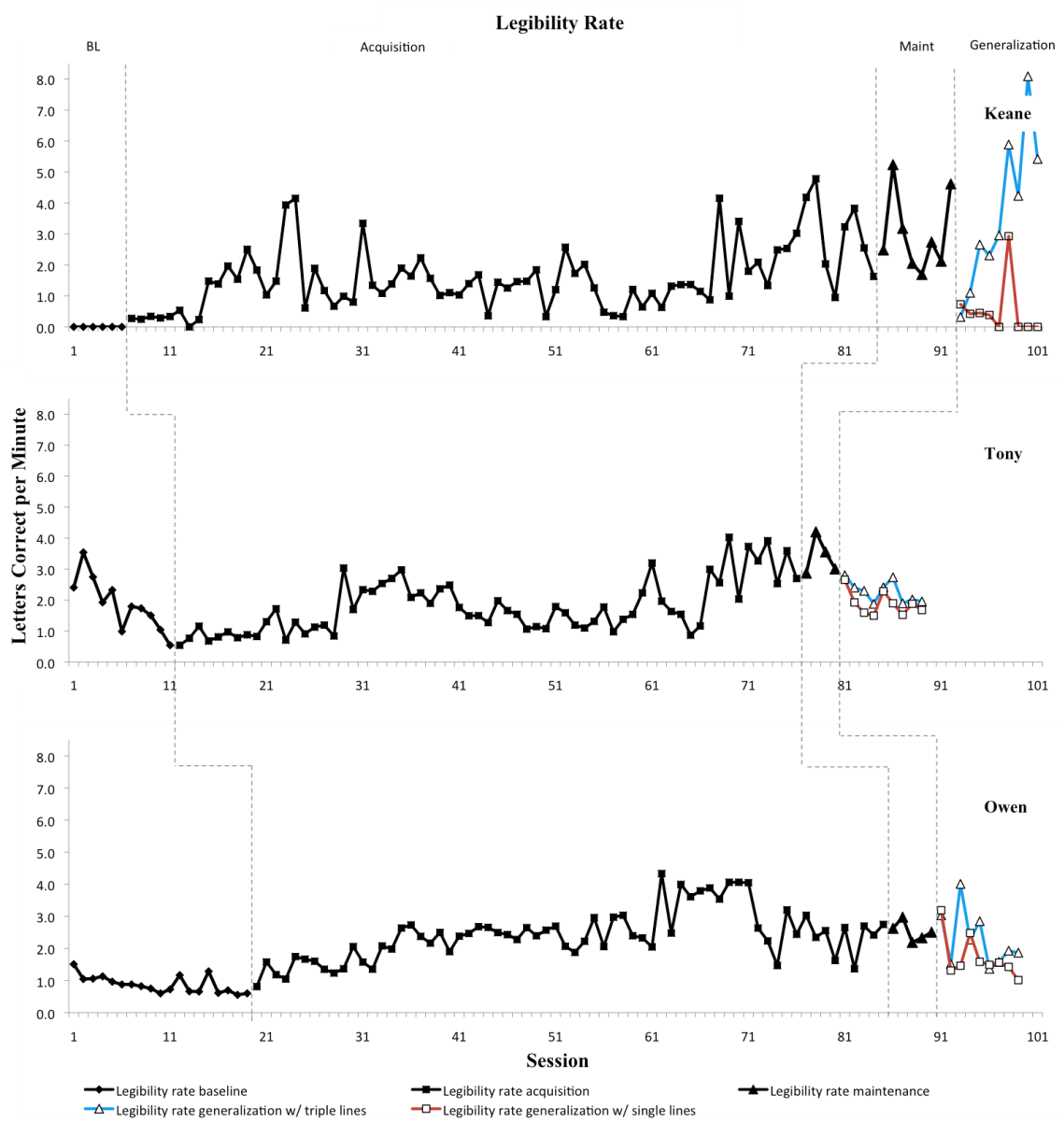
The maintenance score was compared to the legibility domain score. During legibility maintenance, the within-phase patterns included a mean of 70%, a medium degree of variability ( $SD = 13$ ), and a large positive trend (slope = 5.0;  $R^2 = 0.39$ ). The between-phase patterns included no immediacy of effect between the last three data points in legibility acquisition and the first three data points in legibility maintenance, a medium magnitude of change of +14% correct, a dissimilar pattern consistency, and a very high degree of overlap with legibility acquisition (PND = 0%).

During legibility generalization on double-lined paper, the within-phase patterns included a mean of 70%, a medium degree of variability ( $SD = 9$ ), and a moderate negative trend (slope = -1.0,  $R^2 = 0.094$ ). The between-phase patterns included no immediacy of effect between the last three data points in maintenance and the first three data points in double-line legibility, no mean magnitude of change, a dissimilar pattern consistency, and a very high degree of overlap with legibility maintenance (PND = 0%).

During legibility generalization on triple-lined paper, the within-phase patterns included a mean of 68%, a medium degree of variability ( $SD = 13$ ), and a moderate negative trend (slope = -2.1;  $R^2 = 0.21$ ). During legibility generalization on single-lined paper, the within-phase patterns included a mean of 62%, a medium degree of variability ( $SD = 16$ ), and a moderate negative trend (slope = -1.9;  $R^2 = 0.11$ ).

**Research question 2 results: Legibility rate.** The results addressing Research Question 2 are provided below.

*Keane.* During legibility rate baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a decelerating baseline for Tony and Owen (see Figure 8).



*Figure 8.* Legibility rate scores for three participants across baseline, acquisition, maintenance, and generalization phases.

During legibility rate acquisition, the within-phase patterns included a mean of 1.6 letters correct per minute, a moderate degree of variability ( $SD = 1.1$ ), and a small positive trend (slope = 0.018;  $R^2 = 0.15$ ). The between-phase patterns included a slow



immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +1.6 letters correct per minute, a similar pattern consistency, and a low degree of overlap with the previous phase (PND = 99%). The between-participant vertical analysis demonstrated that the independent variable introduction for Keane did not result in a change in legibility rate for either Tony or Owen, who had not entered treatment.

During legibility rate maintenance, the within-phase patterns included a mean of 3.0 letters correct per minute, a moderate degree of variability ( $SD = 1.3$ ), and a small negative trend (slope = -0.028;  $R^2 = 0.003$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in legibility rate acquisition and the first three data points in legibility rate maintenance, a low magnitude of change of +1.4, a dissimilar pattern consistency, and a very high degree of overlap with legibility rate acquisition (PND = 13%).

During legibility rate generalization on double-lined paper, the within-phase patterns included a mean of 4.1 letters correct per minute, a moderate degree of variability ( $SD = 1.4$ ), and a small positive trend (slope = 0.16;  $R^2 = 0.01$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in maintenance and the first three data points in double-line generalization, a high magnitude of change of +1.1 letters correct per minute, a dissimilar pattern consistency, and a very high degree of overlap with previous phase (PND = 22%).

During legibility rate generalization on triple-lined paper, the within-phase patterns included a mean of 3.7 letters correct per minute, a moderate degree of

variability ( $SD = 2.5$ ), and a small positive trend (slope = 0.80;  $R^2 = 0.79$ ). During legibility rate generalization on single-lined paper, the within-phase patterns included a mean of 0.6 letters correct per minute, a low degree of variability ( $SD = 0.9$ ), and a small negative trend (slope = -0.04;  $R^2 = 0.02$ ).

**Tony.** During legibility rate baseline, the within-phase patterns included a mean of 2.0 letters correct per minute, a moderate degree of variability ( $SD = 1.5$ ), and a small negative trend (slope = -0.22;  $R^2 = 0.70$ ). There were no between-phase patterns since the intervention had not been introduced. The between-participant vertical analysis demonstrated a decelerating baseline for Owen (see Figure 8).

During legibility rate acquisition, the within-phase patterns included a mean of 6.1 letters correct per minute, a medium degree of variability ( $SD = 2.9$ ), and a small positive trend (slope = 0.026;  $R^2 = 0.31$ ). The between-phase patterns included a slow immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a high mean magnitude of change of +4.1, a dissimilar pattern consistency, and a high degree of overlap with the previous phase (PND = 56%). The between-participant vertical analysis demonstrated that the independent variable introduction for Tony did not result in a change in legibility rate for Owen, who had not entered treatment.

During legibility rate maintenance, the within-phase patterns included a mean of 5.6 letters correct per minute, a low degree of variability ( $SD = 0.9$ ), and a small negative trend (slope = -0.025;  $R^2 = 0.003$ ). The between-phase patterns included no immediacy of effect between the last three data points in legibility rate acquisition and the first three

data points in legibility rate maintenance, a low decelerating magnitude of change of -0.5 letters correct per minute, a dissimilar pattern consistency, and a very high degree of overlap with legibility rate acquisition (PND = 0%).

During legibility rate generalization on double-lined paper, the within-phase patterns included a mean of 8.0 letters correct per minute, a medium degree of variability ( $SD = 2.7$ ), and a small negative trend (slope = -0.15;  $R^2 = 0.45$ ). The between-phase patterns included no immediacy of effect between the last three data points in maintenance and the first three data points in double-line legibility rate, a high magnitude of change of +2.4 letters correct per minute, a dissimilar pattern consistency, and a moderate degree of overlap with legibility rate maintenance (PND = 78%).

During legibility rate generalization on triple-lined paper, the within-phase patterns included a mean of 5.9 letters correct per minute, a medium degree of variability ( $SD = 1.6$ ), and a small negative trend (slope = -0.075;  $R^2 = 0.34$ ). During legibility rate generalization on single-lined paper, the within-phase patterns included a mean of 5.5 letters correct per minute, a high degree of variability ( $SD = 3.0$ ), and a small negative trend (slope = -0.063;  $R^2 = 0.20$ ).

**Owen.** During legibility rate baseline, the within-phase patterns included a mean of 0.6 letters correct per minute, a low degree of variability ( $SD = 0.8$ ), and a small negative trend (slope = -0.030;  $R^2 = 0.40$ ) (see Figure 8). During legibility rate acquisition, the within-phase patterns included a mean of 1.7 letters correct per minute, a moderate degree of variability ( $SD = 1.1$ ), and a small positive trend (slope = 0.02;  $R^2 = 0.30$ ). The between-phase patterns included a slow immediacy of effect between the last

three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +1.1 letters correct per minute, a dissimilar pattern consistency, and a high degree of overlap with the previous phase (PND = 21%).

During legibility rate maintenance, the within-phase patterns included a mean of 2.6 letters correct per minute, a low degree of variability ( $SD = 0.9$ ), and a small negative trend (slope = -0.088;  $R^2 = 0.21$ ). The between-phase patterns included no immediacy of effect between the last three data points in legibility rate acquisition and the first three data points in legibility rate maintenance, a medium magnitude of change of +0.9 letters correct per minute, a dissimilar pattern consistency, and a very high degree of overlap with legibility rate acquisition (PND = 25%).

During legibility rate generalization on double-lined paper, the within-phase patterns included a mean of 2.9 letters correct per minute, a high degree of variability ( $SD = 2.4$ ), and a small negative trend (slope = -0.077,  $R^2 = 0.14$ ). The between-phase patterns included no immediacy of effect between the last three data points in maintenance and the first three data points in double-line legibility rate, a low magnitude of change of -0.3 letters correct per minute, a dissimilar pattern consistency, and a very high degree of overlap with legibility rate maintenance (PND = 11%).

During legibility rate generalization on triple-lined paper, the within-phase patterns included a mean of 2.9 letters correct per minute, a high degree of variability ( $SD = 2.1$ ), and a small negative trend (slope = -0.15;  $R^2 = 0.23$ ). During legibility rate generalization on single-lined paper, the within-phase patterns included a mean of 2.7

letters correct per minute, a high degree of variability ( $SD = 2.4$ ), and a small negative trend (slope = -0.15;  $R^2 = 0.38$ ).

**Research question 3 results: Posture and paper position.** Posture and paper position were calculated separately by time sampling data collection on a rotating 15-second interval. The equation used for the calculation was the number of correct intervals divided by the total number of intervals multiplied by 100. Definitions of posture, paper position, and pencil grip were included in chapter three operational definitions.

**Posture: Keane.** During posture baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a consistent baseline for Tony and Owen (see Figure 9).

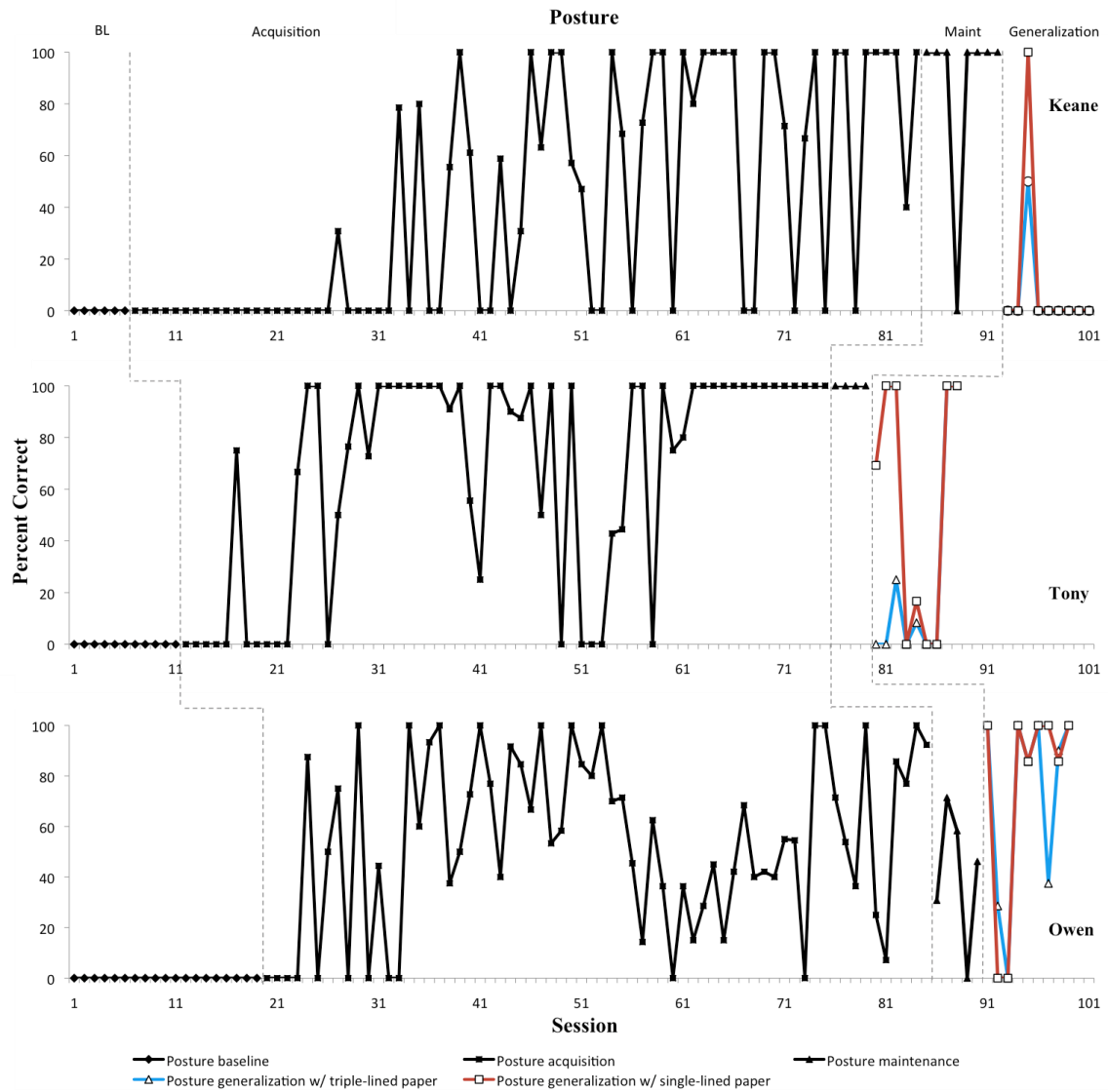


Figure 9. Posture scores for three participants for three participants across baseline, acquisition, maintenance, and generalization phases.

During posture acquisition, the within-phase patterns included a mean of 41%, a high degree of variability ( $SD = 45$ ), and a moderate positive trend (slope = 1.3;  $R^2 = 0.40$ ). The between-phase patterns included a flat immediacy of effect between the last

three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +41% correct, a dissimilar pattern consistency, and a very high degree of overlap with the previous phase ( $PND = 49\%$ ). The between-participant vertical analysis demonstrated that the independent variable introduction for Keane did not result in a change in posture for either Tony or Owen, who had not entered treatment.

During posture maintenance, the within-phase patterns included a mean of 88%, a high degree of variability ( $SD = 35$ ), and a moderate positive trend (slope = 1.2;  $R^2 = 0.007$ ). The between-phase patterns included a maintenance of effect between the last three data points in posture acquisition and the first three data points in posture maintenance, a medium magnitude of change of +47% correct, a similar pattern consistency, and a very high degree of overlap with posture acquisition ( $PND = 0\%$ ).

During posture generalization on double-lined paper, the within-phase patterns included a mean of 14%, a high degree of variability ( $SD = 28$ ), and a large negative trend (slope = -6.2,  $R^2 = 0.37$ ). The between-phase patterns included a decelerating effect between the last three data points in maintenance and the first three data points in double-line generalization, a high decelerating magnitude of change of -74% correct, a dissimilar pattern consistency, and a very high degree of overlap with previous phase ( $PND = 0\%$ ).

During posture generalization on triple-lined paper, the within-phase patterns included a mean of 6%, a medium degree of variability ( $SD = 17$ ), and a moderate negative trend (slope = -1.7;  $R^2 = 0.08$ ). During posture generalization on single-lined paper, the within-phase patterns included a mean of 11%, a high degree of variability ( $SD = 33$ ), and a large negative trend (slope = -3.3;  $R^2 = 0.08$ ).

**Posture: Tony.** During posture baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a consistent baseline for Owen (see Figure 9).

During posture acquisition, the within-phase patterns included a mean of 67%, a high degree of variability ( $SD = 42$ ), and a moderate positive trend (slope = 1.1;  $R^2 = 0.25$ ). The between-phase patterns included a flat immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a high mean magnitude of change of +67% correct, a dissimilar pattern consistency, and a moderate degree of overlap with the previous phase (PND = 75%). The between-participant vertical analysis demonstrated that the independent variable introduction for Tony did not result in a change in posture for Owen, who had not entered treatment.

During posture maintenance, the within-phase patterns included a mean of 100%, no degree of variability ( $SD = 0$ ), and a flat trend since he reached the ceiling. The between-phase patterns included a decelerating effect between the last three data points in posture acquisition and the first three data points in posture maintenance, a medium magnitude of change of +33% correct, a similar pattern consistency, and a very high degree of overlap with posture acquisition (PND = 0%), due to ceiling effects.

During posture generalization on double-lined paper, the within-phase patterns included a mean of 63%, a large degree of variability ( $SD = 43$ ), and a large negative trend (slope = -6.3,  $R^2 = 0.16$ ). The between-phase patterns included a decelerating immediacy of effect between the last three data points in maintenance and the first three data points in double-line posture, a low magnitude of change of -37% correct, a



dissimilar pattern consistency, and a very high degree of overlap with posture maintenance (PND = 0%).

During posture generalization on triple-lined paper, the within-phase patterns included a mean of 26%, a high degree of variability ( $SD = 43$ ), and a large positive trend (slope = 10.8;  $R^2 = 0.48$ ). During posture generalization on single-lined paper, the within-phase patterns included a mean of 54%, a high degree of variability ( $SD = 49$ ), and a moderate negative trend (slope = -1.3;  $R^2 = 0.005$ ).

**Posture: Owen.** During posture baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend (see Figure 9). Owen was the lowest-tier participant, therefore, vertical analysis was not warranted.

During posture acquisition, the within-phase patterns included a mean of 54%, a high degree of variability ( $SD = 35$ ), and a small positive trend (slope = 0.35;  $R^2 = 0.04$ ). The between-phase patterns included no immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +54% correct, a dissimilar pattern consistency, and a moderate degree of overlap with the previous phase (PND = 83%).

During posture maintenance, the within-phase patterns included a mean of 41%, a medium degree of variability ( $SD = 17$ ), and a large negative trend (slope = -4.1;  $R^2 = 0.05$ ). The between-phase patterns included a moderately decelerating immediacy of effect between the last three data points in posture acquisition and the first three data points in posture maintenance, a medium magnitude of change of -13% correct, a

dissimilar pattern consistency, and a very high degree of overlap with posture acquisition (PND = 0%).

During posture generalization on double-lined paper, the within-phase patterns included a mean of 85%, a high degree of variability ( $SD = 33$ ), and a large positive trend (slope = 4.6,  $R^2 = 0.15$ ). The between-phase patterns included a low immediacy of effect between the last three data points in maintenance and the first three data points in double-line posture, a medium magnitude of change of +44% correct, a dissimilar pattern consistency, and a low degree of overlap with posture maintenance (PND = 89%).

During posture generalization on triple-lined paper, the within-phase patterns included a mean of 71%, a high degree of variability ( $SD = 39$ ), and a large positive trend (slope = 4.3;  $R^2 = 0.094$ ). During posture generalization on single-lined paper, the within-phase patterns included a mean of 75%, a high degree of variability ( $SD = 43$ ), and a large positive trend (slope = 7.6;  $R^2 = 0.23$ ).

***Paper position: Keane.*** During paper position baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a consistent baseline for Tony and Owen (see Figure 10).

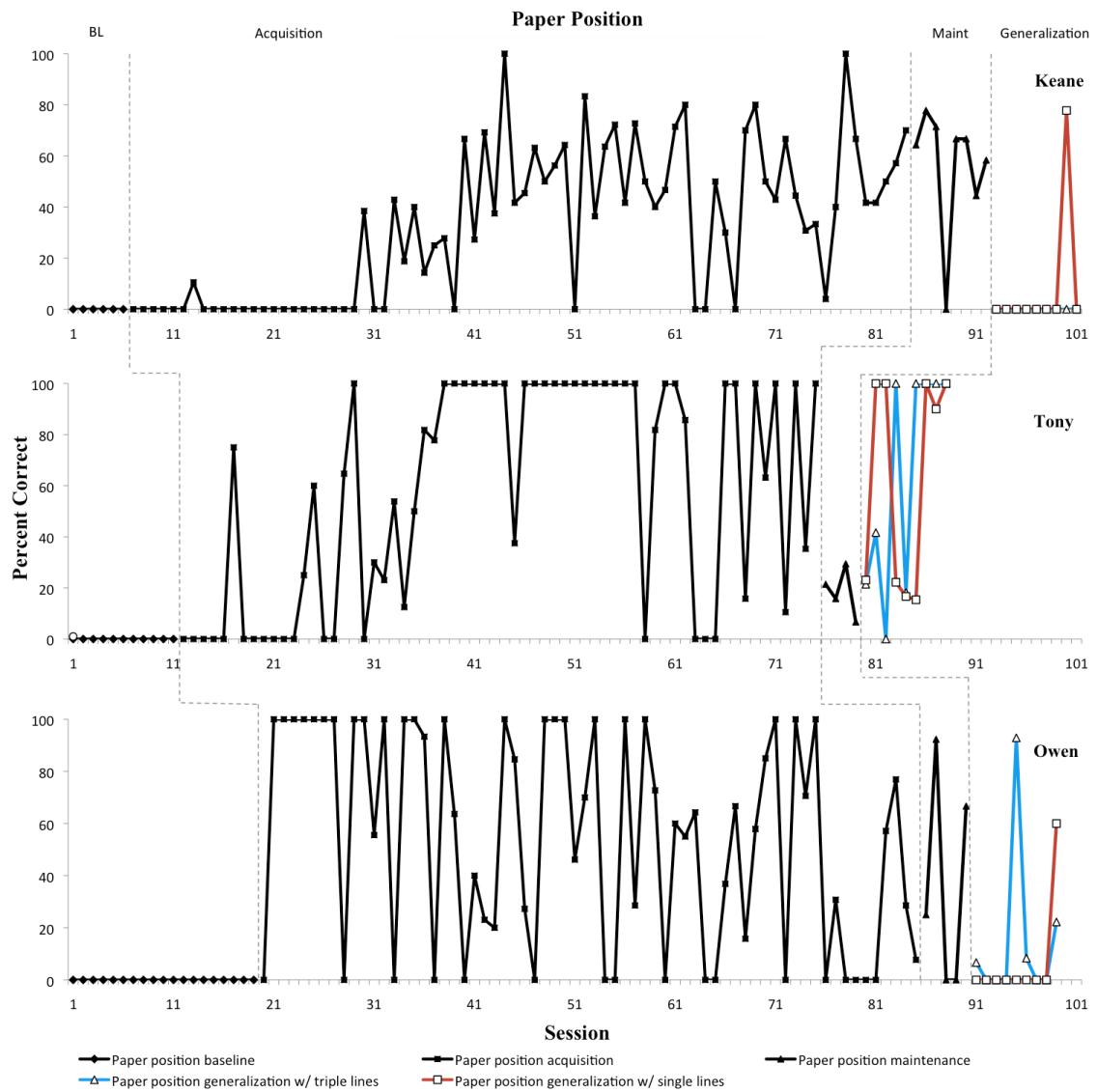


Figure 10. Paper position scores for three participants across baseline, acquisition, maintenance, and generalization phases.

During paper position acquisition, the within-phase patterns included a mean of 32%, a high degree of variability ( $SD = 31$ ), and a small positive trend (slope = 0.84;  $R^2 = 0.41$ ). The between-phase patterns included no immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean

magnitude of change of +32% correct, a dissimilar pattern consistency, and a high degree of overlap with the previous phase ( $PND = 62\%$ ). The between-participant vertical analysis demonstrated that the independent variable introduction for Keane did not result in a change in paper position for either Tony or Owen, who had not entered treatment.

During paper position maintenance, the within-phase patterns included a mean of 56%, a high degree of variability ( $SD = 25$ ), and a moderate negative trend (slope = -1.9;  $R^2 = 0.034$ ). The between-phase patterns included a gradually decelerating immediacy of effect between the last three data points in paper position acquisition and the first three data points in paper position maintenance, a low magnitude of change of +24% correct, a dissimilar pattern consistency, and a very high degree of overlap with paper position acquisition ( $PND = 0\%$ ).

During paper position generalization on double-lined paper, the within-phase patterns included a mean of 0%, no degree of variability ( $SD = 0$ ), and a flat trend. The between-phase patterns included rapidly decelerating immediacy of effect between the last three data points in maintenance and the first three data points in double-line generalization, a high magnitude of change of -56% correct, a similar pattern consistency, and a very high degree of overlap with previous phase ( $PND = 0\%$ ) due to floor effects.

During paper position generalization on triple-lined paper, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. During paper position generalization on single-lined paper, the within-phase patterns included a mean of 9%, a low degree of variability ( $SD = 26$ ), and a large positive trend (slope = 3.9;  $R^2 = 0.17$ ).

***Paper position: Tony.*** During paper position baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. There were no between-phase patterns since the intervention had not been introduced. The between-participant vertical analysis demonstrated a consistent baseline for Owen (see Figure 10).

During paper position acquisition, the within-phase patterns included a mean of 58%, a large degree of variability ( $SD = 44$ ), and a moderate positive trend (slope = 1.1;  $R^2 = 0.23$ ). The between-phase patterns included no immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a high mean magnitude of change of +58% correct, a dissimilar pattern consistency, and a moderate degree of overlap with the previous phase ( $PND = 72\%$ ). The between-participant vertical analysis demonstrated that the independent variable introduction for Tony did not result in a change in paper position for Owen, who had not entered treatment.

During paper position maintenance, the within-phase patterns included a mean of 18%, a medium degree of variability ( $SD = 10$ ), and a large negative trend (slope = -3.1;  $R^2 = 0.17$ ). The between-phase patterns included a rapidly decelerating immediacy of effect between the last three data points in paper position acquisition and the first three data points in paper position maintenance, a medium magnitude of change of -40% correct, a dissimilar pattern consistency, and a very high degree of overlap with paper position acquisition ( $PND = 0\%$ ).

During paper position generalization on double-lined paper, the within-phase patterns included a mean of 100%, no variability ( $SD = 0$ ), and a flat trend. The between-phase patterns included a rapid immediacy of effect between the last three data points in

maintenance and the first three data points in double-line paper position, a high magnitude of change of +82% correct, a similar pattern consistency, and a low degree of overlap with paper position maintenance (PND = 100%).

During paper position generalization on triple-lined paper, the within-phase patterns included a mean of 65%, a high degree of variability ( $SD = 43$ ), and a large positive trend (slope = 11.5;  $R^2 = 0.53$ ). During paper position generalization on single-lined paper, the within-phase patterns included a mean of 63%, a high degree of variability ( $SD = 42$ ), and a large positive trend (slope = 4.5;  $R^2 = 0.088$ ).

***Paper position: Owen.*** During paper position baseline, the within-phase patterns included a mean of 0%, no degree of variability ( $SD = 0$ ), and a flat trend (see Figure 10).

During paper position acquisition, the within-phase patterns included a mean of 55%, a high degree of variability ( $SD = 41$ ), and a small negative trend (slope = -0.75;  $R^2 = 0.12$ ). The between-phase patterns included a rapid immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a high mean magnitude of change of +55% correct, a dissimilar pattern consistency, and a moderate degree of overlap with the previous phase (PND = 76%).

During paper position maintenance, the within-phase patterns included a mean of 37%, a high degree of variability ( $SD = 41$ ), and a small negative trend (slope = -0.90;  $R^2 = 0.001$ ). The between-phase patterns included no immediacy of effect between the last three data points in paper position acquisition and the first three data points in paper position maintenance, a medium magnitude of change of -18% correct, a dissimilar

pattern consistency, and a very high degree of overlap with paper position acquisition (PND = 0%).

During paper position generalization on double-lined paper, the within-phase patterns included a mean of 27%, a high degree of variability ( $SD = 43$ ), and a moderate positive trend (slope = 2.9,  $R^2 = 0.04$ ). The between-phase patterns included no immediacy of effect between the last three data points in maintenance and the first three data points in double-line paper position, a low magnitude of change of -10% correct, a dissimilar pattern consistency, and a very high degree of overlap with paper position maintenance (PND = 22%).

During paper position generalization on triple-lined paper, the within-phase patterns included a mean of 14%, a high degree of variability ( $SD = 30$ ), and a moderate positive trend (slope = 1.2;  $R^2 = 0.01$ ). During paper position generalization on single-lined paper, the within-phase patterns included a mean of 7%, a medium degree of variability ( $SD = 20$ ), and a large positive trend (slope = 4.0;  $R^2 = 0.3$ ).

For analysis of Pencil Grip see Appendix H.

### **Social Validity**

Results of the social validity were evaluated by calculating the mean and standard deviation of answers provided by the three participant parents to determine whether the parents felt that the intervention was effective and acceptable. First, the parents felt that their handwriting instruction improved handwriting. Second, parents felt that their handwriting instruction improved their child's handwriting at school. Third, parents felt that their handwriting instruction was worth the time and effort. Fourth, parents felt that

the handwriting instruction was worth recommending to others Finally, parents felt that the handwriting instruction protocol was easy to implement. Scores on the questionnaire were recorded on a Likert-type scale from 1 to 5, with higher scores indicating a more favorable impression (see Appendix K Social Validity).

Table 4

*Social Validity Datasheet*

The handwriting intervention:	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
Improved my child's handwriting at home	1	2	3	4	5
Improved my child's handwriting at school	1	2	3	4	5
Was worth the time and effort.	1	2	3	4	5
Was worth recommending to others.	1	2	3	4	5
Was easy to implement	1	2	3	4	5

***Closing statements.*** The purpose of the results section was to describe the outcomes of intervention. Figures and tables were intended to supplement the deeper analysis contained within each participant's results. The next chapter provides a discussion of these results.



## **Chapter Five**

This study examined the effects of handwriting instruction using HWT materials on the acquisition and maintenance of handwriting legibility and generalization of legibility across three people, locations, and types of lined paper for three students with autism.

### **Description of the data**

This chapter will focus discussion on data results from Chapter 4 covering the three research questions across the three participants: legibility, legibility rate, and posture, paper position & pencil grip. Within-phase, between-phase, and between-participant patterns were analyzed for each research question and participant. Each research question contains analysis for the mean, standard deviation, trend line, and PND for acquisition across four letter sets, maintenance compared to legibility domain score, and generalization across single, double, and triple lined paper.

### **Interpretation of the data**

The following interpretation guideline for using PND scores is followed in this study.

90%+ very effective

70-90% effective

50-70% questionable effectiveness

below 50% ineffective.

## **Research Questions**

**Research question 1 data interpretation: Legibility.** Research question one, legibility, is the out of context readability of written numbers, letters, and words, and sentences and calculated by examining the subdomain scores of handwriting performance. This question covers legibility across all phases and participants Keane, Tony, and Owen. See reference Figure 7 in Chapter Four for discussions within this section on legibility mean during all phases of treatment.

**Keane.** Keane's legibility was assessed with different letter sets to show performance across materials. He had not never received any letter instruction and did not attempt to write any letters, therefore, his baseline mean legibility score was 0%. His legibility acquisition score was 16% showing a significant increase in acquisition of handwriting skills. Keane's legibility acquisition within-phase results showed a gradual increase in legibility acquisition and the between-phase data results showed high effectiveness based on the PND of 99%. See figures 30-32 Appendix F for Keane's acquisition writing samples. Within-phase legibility acquisition for letter set one showed a positive trend and the between phase was also very effective based on a PND of 98%. Legibility acquisition of letter set two for within-phase trended slightly downward and between-phase patterns showed no effectiveness based on a PND of 0%. Within-phase legibility acquisition for letter set three trended upward and had questionable between-

phase pattern effectiveness based on a PND of 50%. Letter set four showed a small downward trend for within-phase legibility acquisition and ineffectiveness based on a PND of 0% for between-phase patterns. Overall across all the letter sets, the mean legibility scores during acquisition overall trended upwards from 16%, 11%, 20% to 19%; suggesting a cumulative effective of learning and practicing the letter sets in their current groupings and order. The learning materials were presented in a systematic way in order to scaffold skills sets to meet skill criteria. Results show that instruction needs to be systematic and importantly, the order of the presentation of learning materials improves in acquisition rates of learning (McClannahan et al., 2002, Sundberg & Partington, 1998).

The maintenance in phase results showed a positive trend while the between-phase patterns was ineffective based on a PND of 38%. A surprising finding was an 8% increase in the mean legibility score during maintenance (from 16% to 24%) demonstrating a further increase in legibility from continued practice with the study protocol and materials. Each student's reinforcers were pre-assessed prior to the study and delivered contingent upon the correct response. This shows that instruction combined with reinforcement will produce changes from acquisition to maintenance stages of learning when the schedule of reinforcement is faded to increase the length of time or response effort before the next instance of reinforcement is delivered (Charlop, Kurtz, & Milstein, 1992).

Keane's within-phase generalization results on double-lined paper showed a consistent small upward trend which tracks well with the within-phase legibility

acquisition. His legibility mean during generalization on double-lined paper was 32%, 12% above his maintenance legibility mean. Even though the study trained and tested from baseline through generalization across double-lined paper, this was an unexpected result given that only maintenance was performed, see figure 34 Appendix F for Keane's maintenance handwriting samples. Keane's results for triple-lined paper within-phase patterns also showed a large upward trend of 8% in legibility from a maintenance score of 24% on double-lined paper to generalization score of 32% on triple-lined paper. This was a surprising result given that all other phases were on double-lined paper. This suggests that acquisition and maintenance were constructed well enough to provide generalization across enough of the tested letter constructs (size, sequence, spacing, etc.) to attain generalization to triple-lined paper, see figure 35 Appendix F. It could also be seen that the third upper line provided an upper boundary that fit well with the letter size and control features that were used during acquisition. Single-lined scores were not as high as double and triple-lined paper and showed a negative trend. This suggests the second (middle) line was central to maintaining letter constructs like size, start, sequence and control leading to higher legibility during acquisition. Results for single-lined paper showed a mean of only 4%. This was an expected result given instruction of all letter sets was conducted on double-lines, see figure 36 Appendix F.

Keane's overall results from a 0% baseline to a 32% generalization score, shows the study was very effective in increasing legibility on double-lined paper for a child with no prior hand writing skills. This can also be seen through visual inspection, outside of the analytic analysis results, which were used to attain the legibility scores, in Appendix

E for participant 1. Remarkable improvement can be seen visibly in his handwriting from 29 December 2012 to 12 July 2013 during acquisition. Keane was an ideal baseline candidate within the study given his little to no handwriting instruction (baseline score of mean 0%) prior to the study and during the phases of the study, his performance in legibility show increases in the desired rate and percent of correct responses. This shows the functional relationship between the handwriting intervention and correct legibility responses for Keane, as the between participant analysis showed no impact on legibility from one participant to the other two for any within-phase or between phase analysis.

**Tony.** Tony's baseline legibility showed an initial mean score of 16%, see figure 37 Appendix F for Tony's baseline hand writing samples. Legibility acquisition within-phase results showed a moderate increase in legibility acquisition. Mean legibility scores in acquisition improved from 16% in baseline to a mean of 42%. This was an overall improvement of 26% suggesting an effective strategy for improving legibility of handwriting for a child with initial low legibility.

Tony's legibility acquisition for between-phase data results showed no effectiveness based on the PND of 48%. See figures 38-39 Appendix F for acquisition hand writing samples. Within-phase legibility acquisition for letter set one showed a moderate positive trend and the between-phase patterns were ineffective based on the PND of 22%. Legibility acquisition for letter set two for within-phase trended moderately upward and between-phase patterns showed questionable effectiveness based on the PND of 53%. Within-phase legibility acquisition for letter set three had a large positive upward trend and had no between-phase pattern effectiveness based on the PND of 0%. The

overall trend of mean legibility scores across letter sets during acquisition was 23%, 50%, to 76% from letter set 1 to 3 respectively. This supports a cumulative effective of learning and practicing the letter sets in their current groupings and order and demonstrates that systematic instruction and systematic presentation of materials will show improvements in the desired skill (Cooper, Heron, & Heward, 1987).

The maintenance in phase results showed a positive trend while the between-phase patterns was ineffective based on a PND of 0%. See figure 40 Appendix F for maintenance handwriting samples. The overall legibility mean during maintenance was 72% showing a slight decline from the highest score on the last practiced letter set but still a higher positive trend in the desired direction. Results also show that the mean increase in maintenance legibility was an increase of 30% over the legibility acquisition mean of 42, which is a significant increase from initial learning performance. With some prior learning in the development of legibility skills, Tony's results show that maintenance of these skills once taught, will continue to be demonstrated. This further demonstrates that skill practice and the presentation of learning concepts and materials in a systematic way will improve the relationship between the acquisition and maintenance of the skill and similar to the results shown by Jones and Christensen (1999), the automaticity of these skills will only improve the skill sets learned.

Tony's within-phase generalization results on double-lined paper showed a consistent small upward trend which tracks well with the within-phase legibility acquisition. See figure 41 Appendix F for generalization handwriting samples on double-lined paper. His legibility mean during generalization on double-lined paper was 68%,

4% below his maintenance legibility mean. This tracks with the slight decrease that was evident when going from acquisition to maintenance.

Tony's results for triple-lined paper within-phase patterns showed a large upward trend in legibility generalization with a mean of 50% from baseline. See figure 42 Appendix F for generalization handwriting samples on triple-lined paper. This was an expected result given that all other phases were on double-lined paper. Single-lined scores were not as high as double and triple-lined paper with a mean of 36% and showed a negative trend. See figure 43 Appendix F for generalization handwriting samples on single-lined paper. This suggests the second (middle) line was central to maintaining letter constructs like size, start, sequence and control leading to higher legibility during acquisition. This can be seen in Appendix E for participant 1 on 18 Jan 2014 for triple-lined paper. This shows that when programming for maintenance of the skill, stimulus prompts need to be carefully selected to look for the salient stimulus features of the learning materials that will promote stimulus fading (Cooper, Herod, & Heward, 1987). In the case for Tony, the middle line was a critical stimulus to promote proper legibility performance.

Tony's overall results in legibility performance went from 16% in baseline to 68% for generalization to show that the study was effective in increasing legibility on double-lined paper for a child with pre-existing but low legibility scores. A performance increase of 52% is an effect increase in legibility in the desired goal to improve handwriting skills. This can also be seen through visual inspection, outside of the analytic analysis results, which were used to attain the legibility scores, in Appendix E for

participant 2. Remarkable improvement can be seen visibly in his handwriting 16% to 42% during acquisition and importantly, legibility performance continued to increase during maintenance and generalization phases of the study. This shows that once legibility skills are taught in a systematic way, the actual letter or word produced may be a form of visual reinforcement that matches to the natural contingencies of writing. Results show similar patterns from the study conducted by Jones and Christensen (1999), in that as legibility becomes easier, the automaticity of this skill will only improve the skill sets learned.

**Owen.** Owen's baseline legibility showed an initial mean score of 23% with a small negative trend, see figure 44 Appendix F for Owen's baseline hand writing samples. Starting with a baseline of 23%, Owen's mean legibility scores in acquisition increased to a mean of 56%, which shows an overall improvement of 33%. This demonstrates the need for handwriting skills to be systematically taught and when specific skills are taught with the right learning materials, improvements can be seen (McClannahan et al., 2002). Owen's results show that handwriting intervention is an effective strategy for improving legibility of handwriting for a child with no, low or moderate initial legibility. Owen's legibility acquisition for between-phase data results showed effective patterns based on the PND of 72%. See figures 45-46 Appendix F for Owen's acquisition hand writing samples.

When looking at the effects of legibility across letter sets, there were positive increase in the trend in correct responses. For example, within-phase legibility acquisition for letter set one showed a moderate positive trend and the between-phase



patterns were ineffective based on the PND of 41%. Legibility acquisition for letter set two for within-phase trended moderately upward and between-phase patterns were ineffective based on the PND of 20%. Within-phase legibility acquisition for letter set three had a large positive upward trend and had no between-phase pattern effectiveness based on the PND of 0%. Legibility acquisition for letter set four for within-phase trended moderately upward and between-phase patterns were ineffective based on the PND of 0%. The overall trend of mean legibility scores across letter sets during acquisition was 43%, 61%, 70%, to 61% from letter set 1 to 4 respectively. This shows that when handwriting is taught, that the skill continues to be demonstrated even when the letters in the letter sets change. Effective instruction needs to be systematic in how you teach and what you use to teach. As can be seen in Owen's results, there are improvements of legibility in phases of learning (i.e., acquisition, maintenance, generalization) when instruction and practice of letter sets is taught in systematic groupings (McClannahan et al., 2002).

Comparing performance of legibility mean during baseline (56%) to maintenance (70%) show an improvements in the skill in writing legibly. This shows that instruction in this skill set is important. Another area to consider is changing the stimulus presentation of the writing paper in order to see if generalization across stimulus features is demonstrated. Owen's results for single-lined paper show a mean legibility score of 62%. When provided with double-lined paper, this increased to 70% and when provided with triple-lined paper, the mean legibility score was 68%. Single-lined scores were not as high as double and triple-lined paper with a mean of 62%, actually showing a negative

trend in the desired results. This suggests the second (middle) line was central to maintaining letter constructs like size, start, sequence and control leading to higher legibility during acquisition, but less important for children with higher initial baseline, acquisition, and maintenance scores. When fading the stimulus prompts of the writing material, careful consideration needs to be made in the critical stimulus features required for letter formation (Cooper, Heron, & Heward, 1987).

Owen's overall results going from a baseline mean of 23% to 70% for generalization shows that the study was very effective in increasing legibility on double-lined paper for a child with existing but low baseline legibility scores. This can also be seen through visual inspection, outside of the analytic analysis results, which were used to attain the legibility scores, in Appendix E for participant 2. Remarkable improvement can be seen visibly in his handwriting from 23% to 56% during acquisition and up to 70% during generalization. Results show that handwriting skills need to be taught and when taught in a systematic order, improvements in legibility can be seen.

**Research question 2 data interpretation: Legibility Rate.** Research question two covers legibility rate across all phases and participants, Keane, Tony, and Owen. Reference Figure X Legibility Rate in Chapter 4 for discussions within this section on legibility mean during all phases of treatment.

**Keane.** Keane had no baseline scores for legibility rate since he never received any letter instruction and did not attempt to write any letters. Therefore, his baseline mean legibility rate score was 0%. His legibility rate acquisition score was 1.6 letters correct per minute showing a slow increase in acquisition of legibility rate. Keane's legibility rate acquisition within-phase results showed a gradual increase in legibility acquisition and the between-phase data results showed high effectiveness based on a PND of 99%.

The mean legibility rate score from acquisition to maintenance nearly doubled from 1.6 to 3.0 letters per minute demonstrating a further increase in legibility rate most potentially due to continued practice with the study protocol and materials. Thus, the maintenance in phase results showed a positive trend while the between-phase patterns were ineffective based on a PND of 13%. This is in line with the legibility increase of 8% correct between-phase in legibility mean scores of 16% to 24% from acquisition to maintenance. These results show an increase in legibility while still increasing legibility rate.

Keane's within-phase legibility rate generalization results on double-lined paper showed a consistent small upward trend, which shows a consistent increase in line with the within-phase legibility rate acquisition. His legibility rate mean during generalization

on double-lined paper was 4.1 letters per minute, 1.1 letters per minute above his maintenance legibility rate mean. This was an expected result given that only maintenance was performed. Keane's results for triple-lined paper within-phase patterns for legibility rate during generalization was 3.7 letters correct per minute, 0.7 letters correct per minute higher than double-lined paper legibility rate during maintenance but 0.4 letters correct per minute lower than double-lined paper during generalization. This was an expected result given that all other phases were on double-lined paper. His single-lined paper legibility results of 0.6 letters correct per minute were expected given the same aforementioned reason. This was his lowest legibility rate score, aside from baseline, across all phases.

Keane's results from a 0 letters correct per minute in baseline to 4.1 letters correct per minute generalization score, shows that the study was effective in increasing legibility rate on double-lined paper for a child with no prior hand writing skills. Keane's results in mean legibility scores show an increase across all phase and the rate in which the letters produced show an increase in the fluency in which Keane was forming and producing letters on paper.

**Tony.** Tony's baseline legibility rate showed an initial mean score of 2 letters correct per minute. Mean legibility rate scores in acquisition improved from baseline by 4.1 letters correct per minute to 6.1 letters correct per minute. Tony's legibility rate acquisition for between-phase data results showed slight effectiveness based on the PND of 56%. The maintenance in phase results showed a positive trend while the between-phase patterns was ineffective based on a PND of 0%. The overall legibility rate mean

during maintenance was 5.6 letters correct per minute, a decrease of 0.5 letters correct per minute from acquisition. Results show an inverse relationship between legibility and legibility rate mean scores for the maintenance phase, which means that as Tony was writing faster, the formation of his letters were not as accurate.

For Tony the legibility and legibility rate tended to correlate, with both increasing in earlier phases (for both within and between-phase) of the study (baseline and acquisition to maintenance). His legibility rate increase did not always track with his corresponding increase in legibility. For Tony, legibility and legibility rate tended to have an inverse relation in the later phases (maintenance and generalization). An example is Tony's 4 letters correct per minute between-phase increase in legibility rate (from maintenance to generalization) to his decrease of 4% in legibility mean for the same period. The legibility rate tended to decrease as Tony's handwriting becoming more legible in later phases.

The legibility rate was affected by the type of paper provided. For example, Tony's result on single-lined paper was 5.5 letters correct per minute and 5.9 letters correct per minute for triple-lined paper, with a higher legibility rate when all writing lines were present. Overall, Tony shows improvements in his legibility rate. Starting from a baseline of 2 letters per minute to up to 6.1 letters per minute, factors such as phase of learning and type of paper had some affect in legibility rate.

**Owen.** Owen's baseline legibility rate showed an initial mean score of 0.6 letters correct per minute. During the acquisition phase, improvements can be seen to a mean of 1.7 letters correct per minute, which is an overall improvement of 1.1 letters correct per

minute. This suggest that when effective handwriting instruction and strategies are provided, there are improvements in the legibility and rate of handwriting for a child with no prior skills. Over time, improvements in handwriting rate can still be seen. For example, the maintenance phase results show a positive trend in the overall legibility rate during maintenance to 2.6 letters correct per minute.

Looking at performance given different writing materials, Owen's within-phase generalization legibility rate results on single-lined was 2.7 letters correct per minute, 2.9 for double-lined paper, and 2.9 for triple-lined paper. The stimulus features of the writing paper did not make an impact in the legibility rate for Owen. Owen's overall results from a baseline mean of 2 letters per minute to 8 letters per minute for generalization, show that handwriting instruction was effective, even when the materials that were presented were different in the stimulus features (i.e., single, double, triple-line), positive trends are demonstrated in legibility rate.

**Research question 3 data interpretation: Posture, paper position, and pencil grip.** Research question three investigates posture, paper position, and pencil grip for the participants in the study. Reference Figure X Posture and Figure Y Paper Position, in Chapter 4 for discussions within this section on legibility mean during all phases of treatment.

**Keane.** The posture score for Keane was at zero for baseline. Keane showed an increase in mean posture scores from baseline to acquisition. Keane showed an increase of 41% which is an effective change from baseline in the correct posture of writing. Maintenance showed an increase of 47% in percent of correct posture for Keane,

however when changes to the writing materials were phased in, changes can be seen in the percent of correct posture. For example, decreases in the posture score can be seen the most decrease for double-lined paper, then to single-lined paper, and lastly double-lined paper. When looking at performance with legibility and rate, Keane showed a small drop in legibility and legibility rate for triple lined paper but a significant drop in single-lined paper, in contrast to a slight drop in posture for single-lined paper. The type of writing material that was presented showed some variability in the results of handwriting but in general, Keane showed an increase in mean posture scores from baseline to acquisition (32%) and increase in paper position. For example, Kean showed an increase of 24% to 56% in paper position, however, no consistent trend or correlations can be seen in posture and paper position scores. Results show that when programming and teaching handwriting instruction, the materials used to teach and generalize results were more important than the poster and paper position.

Actually, over time, results in the generalization phase show that posture may even decrease over time. Keane showed a decrease of 56% in posture. This may be that even with the decrease in scores for poster, there were still gains in legibility and rate. There were still increased improvements in the production of letters and the rate in which they were produced, even when poster and paper position decreased. For example, Keane's posture scores dropped from 14% for double-lined paper to 6% for triple-lined paper and to 11% for single-lined paper but there was only a small drop in legibility and legibility rate for triple lined paper but a significant drop in single-lined paper. This

shows that posture and paper position are secondary to the type of writing material that is presented to the student.

**Owen.** Owen's posture during baseline was 0% and when taught correct posture and paper position, his scores went from 0% to 67% during acquisition. During maintenance, Owen went from 44% to an increase to 85% in correct posture and paper position, however, there was a decrease in correct responses in the generalization phase. During this phase, Owen's score went from 85% correct to as low as 71% given different types of writing material, with the lowest correct in single-lined paper, and the highest percent correct in double-lined paper. This shows that posture and paper position need to be taught, however, more importantly, than the posture and paper position is the teaching materials used for maintenance and generalization. With the decrease in posture and correct paper position, there was a slight 2%-8% decrease in the legibility.

### **Implications**

This study showed results across three students with Autism that systematic instruction in handwriting produced effective changes in legibility, legibility rate, posture, and paper position. The intervention showed changes from baseline to intervention in the skills the students obtained to produce letters in a legible way and to write at a rate that was consistent to legibility. First, instruction was critical in the systematic structure in which instruction was provided across phases of learning and second, the fading procedures in the learning materials showed variability in the results of legibility. These are important consideration when programing for handwriting instruction.



Another implication is the inclusion of handwriting instruction in the home setting using HWT materials, allowing parents to instruct their children, who are on the autism spectrum, in a skill that is being taken out of the school environment. Specifically the results of the study imply that handwriting legibility can be acquired, maintained, and generalized in the home environment through parental instruction using the HWT material and methodologies applied in this study for children of autism (within the restricted group included in this study). It could also be implied that since the strategies and materials were effective for children with autism in acquiring, maintaining and generalizing handwriting legibility in the home that these same strategies and materials may be effective in the community. The instructional practices and systematic tasks analysis of skill need to be further explored to generalize the home to school environment. Although results show preliminary results of handwriting instruction and productions in legibility, the effectiveness of these strategies and materials used in the community to help children with autism acquire and maintain handwriting legibility still requires future research to generalize results to other students.

The results of this study imply that a subset of the autism population can acquire, maintain, and generalize handwriting legibility within the home environment. An implication of this study is that the basic instructional components of this study could be applied to other written forms using the same alphabet, applying the same methodology to task analyze letters into letter sets and word groupings for training, practice and testing sheets.

## **Limitations**

One of the main inherent limitations of this study was that it only included three English-speaking children with autism who reached 10 years old by the onset of the study. The study used the following criteria to exclude children with autism: 1) score of 37 or greater on the Childhood Autism Rating Scale (CARS), which would subsequently place them in the severe autism category; 2) received a score on the Vineland Adaptive Behavior Scales maladaptive behavior that would identify them as having significant maladaptive behaviors; 3) younger than 10 years old.

Another inherent limitation of the study was that all training and testing for each of the phases was conducted in the home environment and not in the community. As this study focused on parents as teachers this limitation was not significant to this study but to a broader application of the strategies employed in this study. The study was conducted in the natural environment and each of the home environments was different in the materials, space, and distractions presents. The natural environment may have influenced the acquisition and maintenance of the child's handwriting legibility in different ways as each had its own distractions and varied daily living environment, versus a consistently controlled setting. Thus, each family environment presented different challenges and had both positive and negative effects on the child's acquisition. The generalization process tried to normalization the testing of this variability between home environments as much as possible by testing across different locations and people within each home environment. Although the study tested legibility across three different individuals and locations in the home environment future research would need to be conducted to

ascertain the effectiveness of these strategies in the community.

The exclusive use of the HWT materials and their specific application in this study is another potential limitation when looking to a broader applicability as the procedural accuracy in the implementation of this material need to be determined. Community school environments use a wide variety of materials that are determined through a strict and lengthy process. The home school environment affords greater freedom in determining what materials and protocols to use. The procedures used to introduce letters would need to be implemented in the same fashion, where the English alphabet was divided into four letter sets with a specific introduction order: miscellaneous letters, magic c letters, diver letters, and diagonal letters.

The overall multiple baseline design could also be a limitation from the standpoint that each participant needs to establish stability of trend and variability in baseline prior to the introduction of the intervention, then establishing stability of trend and variability in treatment prior to the introduction of the intervention for the next person. This would likely be too limiting for large community classroom settings where the interdependencies of intervention per person could keep many participants from completing all letter sets, if one person is struggling to establish stability of trend and variability in baseline for one intervention.

Future research would be required to ascertain the efficacy of these materials and change in methodologies in the community for the acquisition and maintenance of handwriting legibility. Looking further into the data and construct of the study itself there are several limitations that came to light when performing the data analysis. The variation

or extended periods in maintenance for each participant was a limitation of this study in that it did not provide opportunity for some participants to finish all letter sets. For example, the multiple baseline design construct of this study delayed Tony's ability to start letter set four because of its dependency on precedent participants reaching mastery. At this point it became overwhelming for the family to continue on maintenance at the end of letter set 3, which may have led to Tony's decrease in legibility mean between acquisition and maintenance. The construction of the study in this way was also a limitation in that letter set 4 was not covered. Given Tony's acquisition legibility and legibility rate, and the expected increase in overall legibility mean, once letter set four was completed, this would have been useful and supportive data for this study, further showing the efficacy of the design and protocol for increasing handwriting legibility.

Both internal and external validity presented several limitations: participant's past handwriting history, training effects, test-retest errors, selection bias, potential diffusion of treatment as a result of a lack of videotaped parent training sessions and all participant parents maintaining potentially distracting items, sounds, and/or activities near the instructional area. See Chapter Three for a discussion of the potential mitigation to these limitations.

Another limitation within the study is the type and amount of past hand writing instruction of each child. Although the results showed improvement for children with no, little, or moderate handwriting legibility there is still an unknown effect due to past experience. Past instruction may have presented letters in different orders and groupings, different writing styles or construction, quantity and severity of bad habits or behaviors,

or incorrect writing habits. Any of these could have been in contention with the methodology used in this study affecting legibility acquisition and maintenance depending on severity.

Limitations also exist in the varying quality of each parent's instruction. Although each parent received the same quality and quantity of instruction from the researcher, each parent had different levels of expectation and prior teaching experience. Therefore variability in the outcome of both legibility and legibility rate could have come from the level, consistency, and quality of instruction given to each participant.

Limitations also existed in the understanding that each parent of each aspect of instruction. Even more important is having them understand and being motivated by the importance of each component of instruction. However, when you are working with the parents that who have limited exposure to instructional variables, the requirements to educate the parents on importance of each is too great to fit into the limitations of a study like this, it would need to be a study in and of itself. The parents weren't trained on the variables involved in legibility because it was not in scope and too complicated to begin with, let alone teaching all those individual aspects that needed to be tweaked in relation to each of the variables and their interrelations. It was incorporated into the script anyways, so to keep matters simpler the script was used along with the model, the chalk board wet, dry, try, and giving enough practice, or what was perceived to be enough practice, to have a reasonable acquisition rate that the parent would maintain motivation. However, I didn't anticipate the frustration that would come from the child beginning to acquire legibility then losing the acquisition, or not acquiring on a continuum. There are

several way the study would need to be modified in the future. First of all, there is too much data, components, and variables to be analyzed all together in one study, to stay within scope. It's too much to be able to determine parental instruction and legibility acquisition together without a control. There's no way to look at those two things independently, in the way the study was designed.

A future study would need to take more data on the parents' fidelity of implementation, look at the motivation level on any given day, or how they could tell me what error less teaching is on any given day, like once a week, or every other day. This study only had a procedural reliability checklist (see Appendix J Figure 52) that they checked off. The control on the sheet was lacking in that they sometimes did or did not actively check off each of the components. Therefore, sometimes never really checking it. Some assumed they met each of the criteria because they checked it yesterday, not really applying what was on the list, checking without even looking at what was really being checked. For example, one participant withdrew from the study due to the checks on parent fidelity

In addition to parent motivation, another limitation is the accuracy in which rewards were delivered and if these rewards matched the response effort required within the task.

Along with the match between response effort and reinforcement, the primary area that was not accurately portrayed was how reinforcing was the interaction between the parent and child in the home setting. For example, one student liked having one on

one time with parents but if the parent was frustrated due to other events, it may influence the interaction with the child.

### **Future Research**

Many of the future research ideas outlined below are a look forward as to how the strategies used in this study can be applied larger groups, community groups, populations other than autism, and potentially other languages. Many of the implications and limitations are taken into account when describing many of the areas of future research below.

Further research could be conducted to determine if a different ordering or grouping of letter sets increases or decreases legibility and/or reduces acquisition time. This would help support or refute the researcher's hypothesis that acquisition is easier across letters that are grouped according to features. To test this hypothesis more generally and to expand upon the potential global applicability of this study the letter groupings, word / sentence constructs and teaching constructs could be applied to future research using other languages. This would help further ascertain the validity of a broader application of the researches hypothesis regarding grouping letters according to features as well as the overall effectiveness of the teaching strategy. For example, research could be conducted in combination with or without the lower case letters.

The package of instructional practices and materials may need to be task analyzed to determine the most critical features of instruction. How effective the strategies implemented in this study apply to environments outside the house and to other populations in the community requires future research.

Some of the other limitations related to children's prior hand writing experience and parents prior teaching experience could be reduced or eliminated with the use of larger groups or an expanded study with a larger participant size and groups participants by prior experience in legibility. Referencing several limitations mentioned earlier on parents as teachers and their understanding of instructional variables and their motivation from this understanding leads to several areas for future research, that can be addressed by answering the following questions: How quickly do parents learn the instructional variables, and how much do they understand the importance of the instructional variables? After they begin teaching with the instructional variables at what point does it break down the precision of the instruction and what affect does that have on the learner and on the acquisition rate? The learner's acquisition is also affected by the learner's motivation, attention, etc. What affect does the teacher have on the learner? Not a lot of research has been done on parent instruction, particularly precision teaching.

## **Conclusion**

Results show consistent increases in legibility across acquisition and maintenance for all participants and consistent increases in legibility rate across acquisition and maintenance. This study contains an effective strategy for handwriting instruction using HWT materials on the acquisition and maintenance of handwriting legibility.



## Appendix A



Office of Research Integrity and Assurance  
Research Hall  
4400 University Drive, MS 6D5, Fairfax, Virginia 22030  
Phone: 703-993-4121; Fax: 703-993-9590

TO: Michael Behrmann, College of Education and Human Development

FROM: Aurali Dade  
Assistant Vice President, Research Compliance *[Signature]*

PROTOCOL: 7890      Research Level: Doctoral Dissertation

PROPOSAL NO.: N/A

TITLE: Parents as Teachers: Toward Improving the Print Handwriting of Adolescents with Autism

DATE: December 7, 2012

Cc: Tamara Genarro

On December 7, 2012, the George Mason University Institutional Review Board (GMU IRB) reviewed and approved the continuation of the above-cited protocol as submitted following expedited review procedures.

Please note the following:

1. Copies of the final approved consent documents are attached. You must use these copies with the IRB stamp of approval for your research. Please keep copies of the signed consent forms used for this research for 3 years after the completion of the research.
2. **Any modification to your research (including the protocol, consent, advertisements, instruments, funding, etc.) must be submitted to the Office of Research Integrity & Assurance (ORIA) for review and approval prior to implementation.**
3. Any adverse events or unanticipated problems involving risks to subjects including problems involving confidentiality of the data identifying the participants must be reported to the ORIA and reviewed by the IRB.

The anniversary date of this study is 12/6/2013. **You may not collect data beyond that date without GMU IRB approval.** A continuing review form must be completed and submitted to the ORIA 30 days prior to the anniversary date or upon completion of the project. In addition, prior to that date, the ORIA will send you a reminder regarding continuing review procedures.

## INFORMED CONSENT

### **PARENTS AS TEACHERS: TOWARD IMPROVING THE PRINT HANDWRITING OF ADOLESCENTS WITH AUTISM**

#### **RESEARCH PROCEDURES**

If you agree to participate in this research study, the following will occur:

1. You will be asked to participate in individual instruction to learn how to teach your child printed handwriting of lowercase letters and numbers. This instruction will take 60-90 minutes.
2. You will be asked to teach your child print handwriting for 15-30 minutes once each day of the week within your home for 14-16 weeks between 9/14/12 and 3/31/13.
3. You will also be asked your age, gender, race, socio-economic status, and educational background; and background information about your child, including age, gender, race, diagnosis, age of diagnosis, types of treatment given, medical/health issues, educational level, recent assessments, and types/amount of current instruction.
4. If you agree to participate in this research study, a videotape of many sessions will be made for research purposes.

#### **RISKS**

There are no foreseeable risks to you or your child for participating in this research.

#### **BENEFITS**

There are no benefits to you or your child as a participant other than to further research in

parents as teachers and handwriting instruction for adolescents with autism. We hope the results of the research will help students with autism acquire higher academic achievement and a better quality of life for both the student and the family.

## **CONFIDENTIALITY**

The data in this study will be confidential. Names and/or identifiers will not be placed on written products, interview notes, or other research data. All data will be stored in a locked file cabinet.

## **PARTICIPATION**

Your child's participation is voluntary. You or your child may withdraw from the study at any time and for any reason. If you decide you do not want your child to participate or if you withdraw from the study, there is no penalty or negative consequence for you or your child. There are no costs to you or any other party associated with this research.

## **CONTACT**

This research is being done by Tamara Genarro and supervised by Dr. Mike Behrmann at George Mason University. If you have any questions, you can call Ms. Genarro at 703-XXX-XXXX. You can also call Dr. Behrmann at 703-993-3670. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

## **VIDEOTAPING**

Videotaping will occur throughout the research. Videotaping will be used to show how the student responds to the instruction and to ensure that the research procedures are followed as intended. All video will be stored in a locked file cabinet accessible only to the researcher. Videotapes will be maintained in this manner indefinitely.

\_\_\_\_\_ I agree to videotaping.

\_\_\_\_\_ I do not agree to videotaping.

## CONSENT

I have read this form and agree to participate in this study.

_____	_____
Parent	Date of Signature

_____	_____
Witness	Date of Signature

Version date: October 3, 2011

## INFORMED ASSENT

### **PARENTS AS TEACHERS: TOWARD IMPROVING THE PRINT**

### **HANDWRITING OF ADOLESCENTS WITH AUTISM**

#### **RESEARCH PROCEDURES**

I am doing a study to learn how kids with autism learn to print. I am asking you to help because I don't know very much about how kids your age learn to print letters, words, sentences, and numbers. ☺

If you agree to be in my study, we are going to write for 15-30 minutes once each day for 14-16 weeks between 9/14/12 and 3/31/13.

#### **RISKS AND BENEFITS**

There are no costs or risks to you for joining this study. There is no benefit to you to write these letters, words, sentences, and numbers, except that you will help us to learn how your mom or dad can teach you and how kids your age learn to write.

#### **CONFIDENTIALITY**

Your personal information and writing will stay private and will be kept safe in a locked file cabinet.

#### **PARTICIPATION**

Being in the study is up to you, and no one will be mad if you don't want to help me or if you change your mind later. If you decide at any time not to finish, you can ask me to stop.

## **CONTACT**

This research is being done by Tamara Genarro and supervised by Dr. Mike Behrmann at George Mason University. If you have any questions, you can call Ms. Genarro at 703-XXX-XXXX. You can also call Dr. Behrmann at 703-993-3670. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

## **CONSENT**

If you sign this paper, it means that you have listened to me read this and that you want to be in the study. If you don't want to be in the study, don't sign this paper.

## **PLEASE CHECK ONE**

\_\_\_\_\_ I agree to videotaping      \_\_\_\_\_ I do not agree to videotaping

\_\_\_\_\_  
Student

\_\_\_\_\_  
Date of Signature

\_\_\_\_\_  
Parent

\_\_\_\_\_  
Date of Signature

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date of Signature

Version date: October 3, 2011

## Appendix B

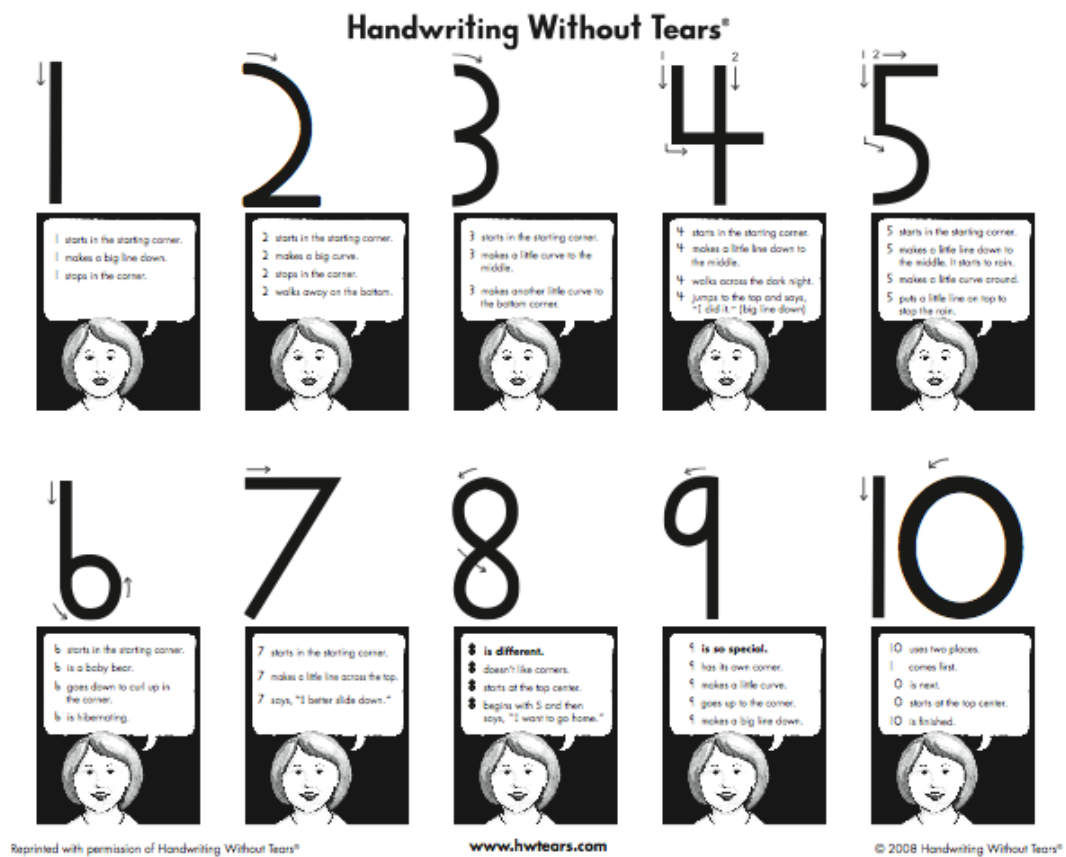


Figure 11. HWT® number formations chart.

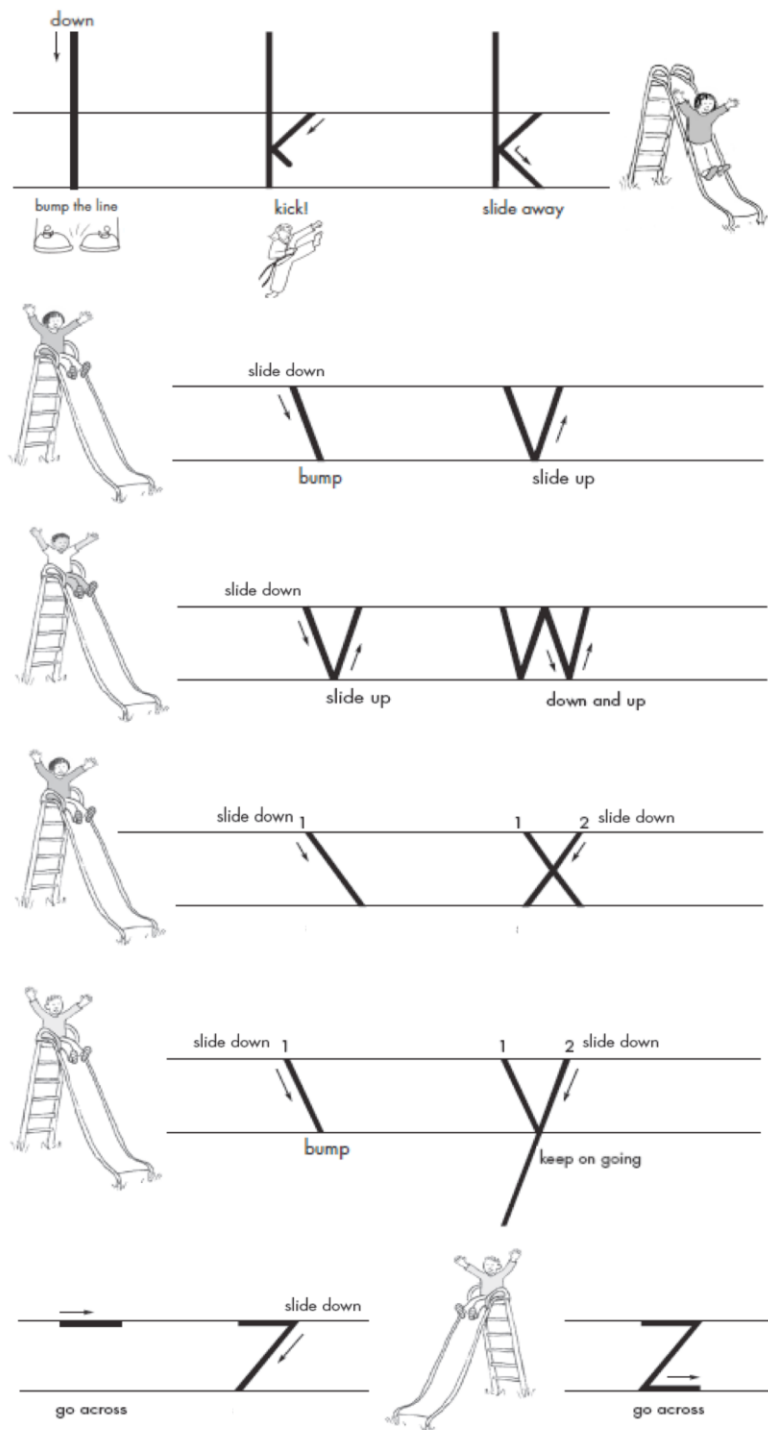


Figure 12. HWT® Miscellaneous letter formations chart.



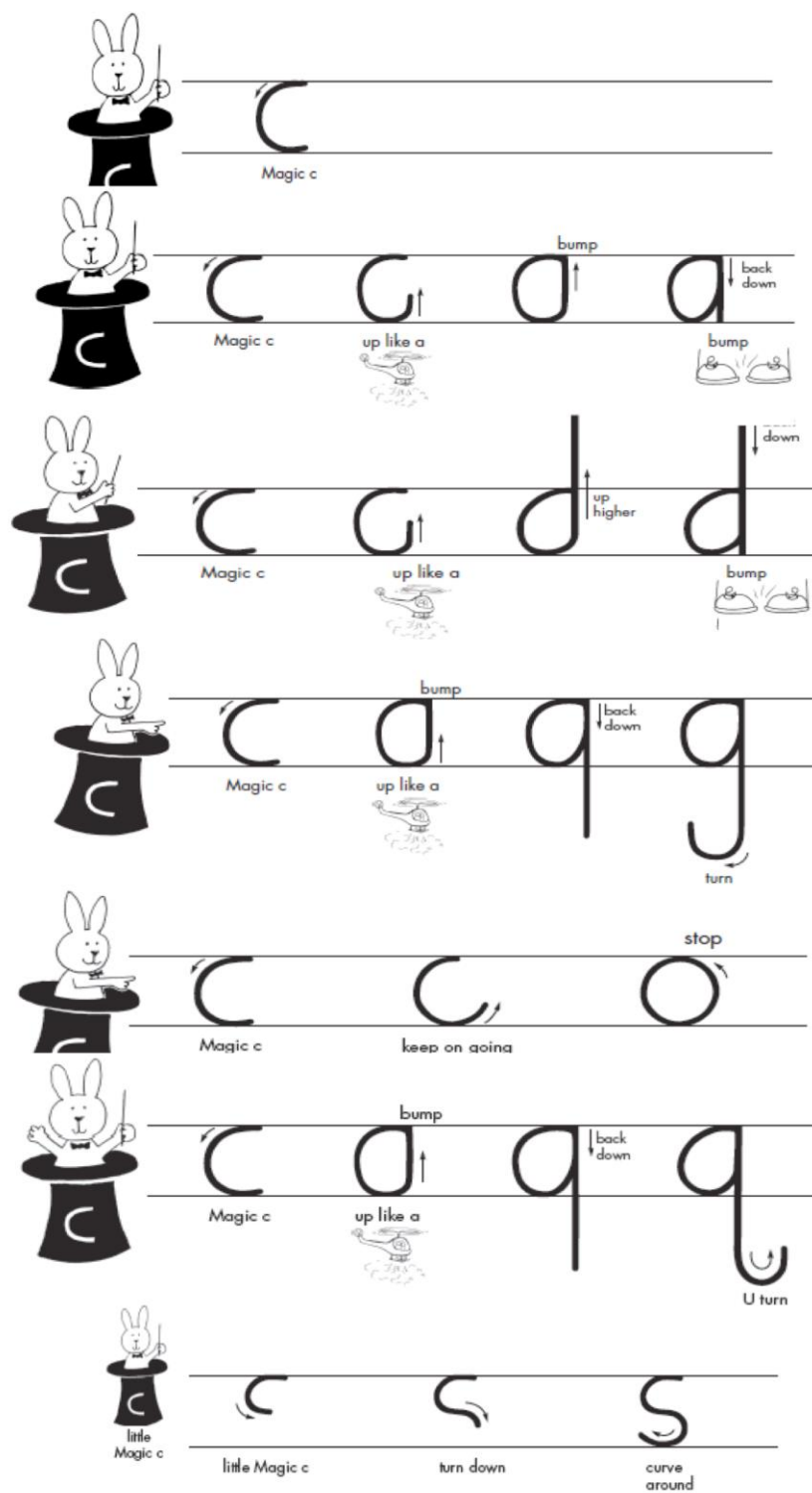


Figure 13. HWT® Magic c letter formations chart.

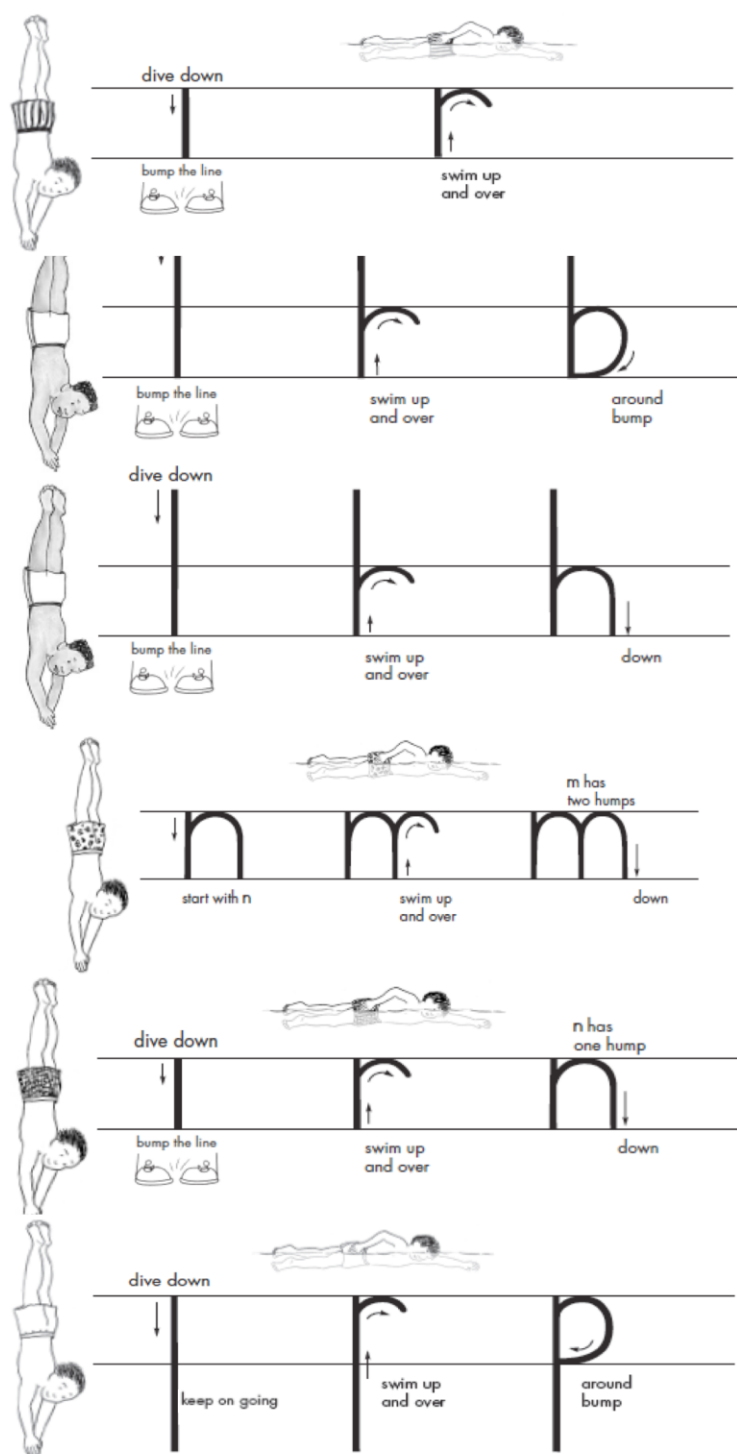


Figure 14. HWT® Diver letter formations chart

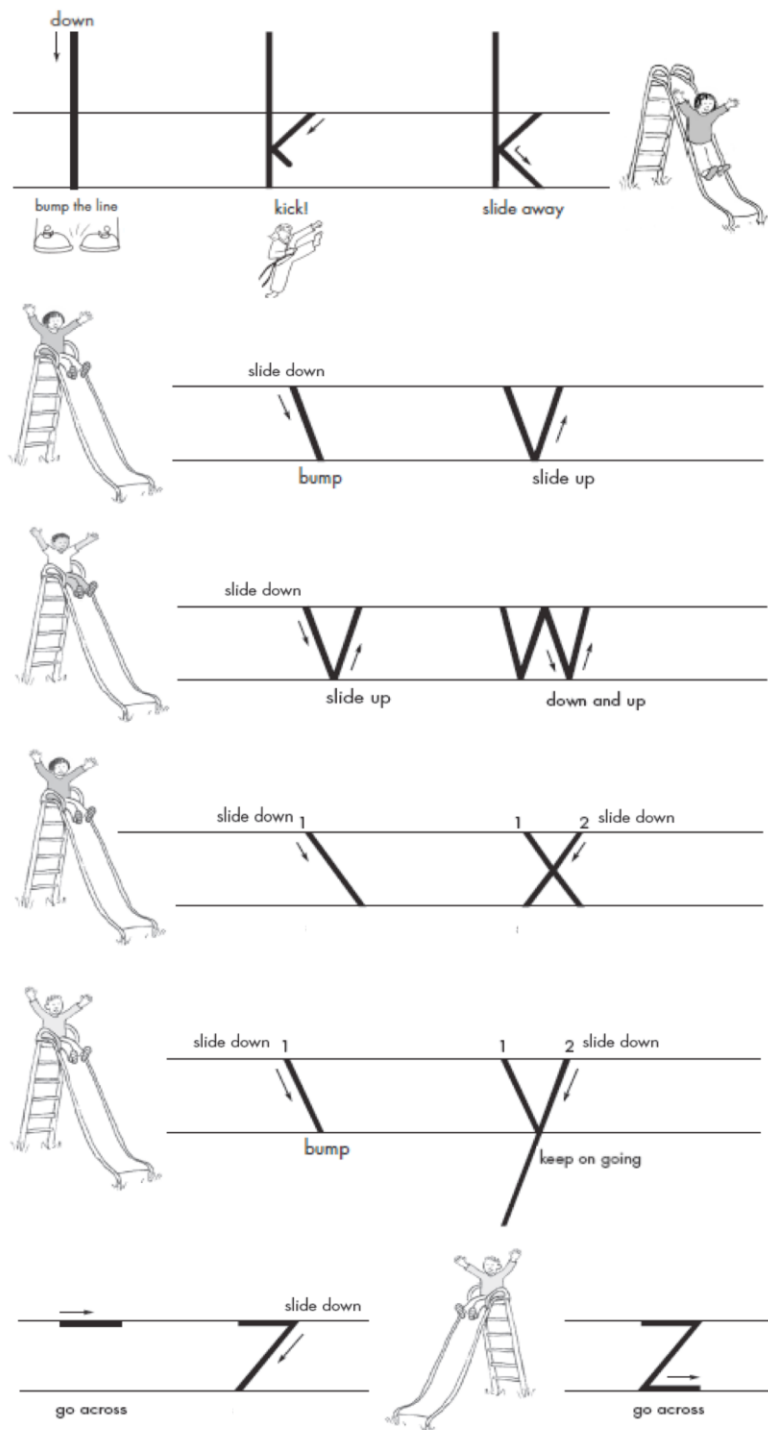


Figure 15. HWT® Diagonal letter formations chart.

## Print Tool™

### Level 1 Frequently Missed: Placement

Refer to The Print Tool™ Guide for Placement Rules

**Remember:**

- Use the Measuring Tool — Placement Portion
- If the letter that needs to be on the baseline is in the gray then it is okay.
- Look at the letter. If any part of the letter that should be on the baseline is out of the gray, then it is a Placement error.

1)



Is this letter n a Placement error?

- This is written in D'Nealian.
- The end of the tail is not supposed to be on the baseline.
- It is not a Placement error.

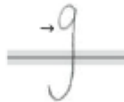
2)



Is this letter a a Placement error?

- This lowercase a is written in D'Nealian.
- The part of the a where the arrow is pointing should be on the baseline.
- Since it is not in the gray, it is a Placement error.

3)



Is this letter g a Placement error?

- The arrow is pointing to the part of the letter g that should be in the gray area.
- Since it is not in the gray, it is a Placement error.

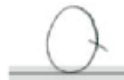
4)



Is this letter K a Placement error?

- Yes. This is a Placement error.
- The right side of the letter k is touching the gray area.
- It needs to break the plane of the gray to be correct.

5)



Is this letter Q a Placement error?

- Yes. This is a placement error.
- The little line of the letter Q should be in the gray area.

\* The 1st-4th grade placement line was used for examples above.

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Figure 16. HWT® The Print Tool™ placement examples.

## Level 1 Frequently Missed: Size

Refer to The Print Tool™ Guide for Size Rules

**Remember:**

- Full size lowercase letters use the entire box. Small lowercase letters use half of the box.

1)



1st

Does this letter j fit in the 1st grade box?

- Yes. When measuring the lowercase letter j for size, you do not measure the dot.
- Measure the letter from the bottom of the letter and not the line.
- You will use the full size box.

2)



1st

Does this letter i fit in the 1st grade box?

- Yes. When measuring the lowercase letter i for size, you do not measure the dot.
- Line up the bottom of the box with the bottom of the letter.

3)



1st

Does this letter p fit in the 1st grade box?

- Yes. When measuring lowercase letter p you will use the full box because this is a full size lowercase letter.
- It is a descending lowercase letter.

4)



1st

K

What letter size is the n?

- The first example of the lowercase letter n shows that the little line is extending into the upper portion of the box.
- The lowercase letter n is a small lowercase letter. Therefore, only use half of the box. The 1st grade box is too small. Move to a bigger box. The lowercase letter n fits into the K box.

Figure 17. HWT® The Print Tool® size examples.

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## Print Tool™

### Level 1 Frequently Missed: Start

Refer to The Print Tool™ Guide for Start Rules

**Remember:**

- Refer to the Letter Appearance Guide that is located in the Print Tool Guide.

1)



Is this letter g a Start error?

- No. It started in the correct place but it went the wrong direction.
- This is an Orientation error.

2)



Is this letter z a Start error?

- Yes. When looking at the letter z in relation to the letter y you can see the letter z touches both the top left and top right. Therefore, the letter z started at the top right making this letter a Start error.

3)



Is this number 5 a Start error?

- No. In the D'Nealian curriculum 5 begins at the top right.
- We accept the Big 3 Curricula of HWT, Zaner-Bloser, and D'Nealian. Please refer to the Number Appearance Guide in your Print Tool Guide.

4)



Is this letter S a Start error?

- No. It started in the correct place but the direction of the stroke is incorrect.
- It is an Orientation error.

5)



Is this number 2 a Start error?

- No. It began at the starting point of the first stroke.
- It is an Orientation error.

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Figure 18. HWT® The Print Tool™ start examples.

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## Print Tool™

### Level 1 Frequently Missed: Sequence

Refer to The Print Tool™ Guide for Sequence Rules

**Remember:**

- Prior Orientation and Start errors are Sequence errors.
- Letters that are formed differently than the Big 3 Curricula are Sequence errors.
- Please refer to the Letter Appearance Guide in your Print Tool Guide.

1)



Is this letter J a Sequence error?

- No. The D'Nealian curriculum does not have a line across the top.

2)



Is this letter B a Sequence error?

- No. The D'Nealian curriculum makes the letter B this way.

3)



Is this a Sequence error?

- Yes. It is a prior Start error. It started at the bottom, which is incorrect.

4)



Is this a Sequence error?

- Yes. The letter O went in the wrong direction. It should have gone to the left and completed the circle.

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Figure 19. HWT® The Print Tool™ sequence examples.

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# Print Tool™

## Level 1 Frequently Missed: Control




Refer to The Print Tool™ Guide for Control Rules

This section is subjective. The grading of this component for Level 1 Certification is given more leniency than those of the other components.

### Incorrect Point:

- 1)  Does this letter P have a point?
  - Yes, the arrow is pointing to the point.
  - This is a Control error.
- 2)  Does this number 3 have a point?
  - Yes, the arrow is pointing to the point.
  - This is a Control error.
- 3)  Does this letter B have a point?
  - Yes, the arrow is pointing to the point.
  - This is a Control error.

### Incorrect Rounding:

- 1)  Does this letter have an incorrect rounding?
  - Yes, the arrow is pointing to the part of the letter that is rounded that should not be rounded.
- 2)  Does this number 6 have an incorrect rounding?
  - No, the number looks fine and is not a Control error.
- 3)  Does this number 8 have an incorrect rounding?
  - No, the number looks fine and is not a Control error.

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Figure 20. HWT® The Print Tool™ control examples.

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## Print Tool™

### Gaps:

- 1)  Does this number 2 have a gap?
  - Yes, the arrow is pointing to the gap.
  - The gap is bigger than the 1/16" box on the Measuring Tool.
- 2)  Does this letter K have a gap?
  - Yes, the arrow is pointing to the gap.
  - The gap is bigger than the 1/16" box on the Measuring Tool.
- 3)  Does this letter R have a gap?
  - No. Think of this letter in isolation. You need to think of a gap as a non-closure.
  - This is a Placement error for a first grader because the left side of the letter does not touch the baseline.

### Overstrokes:

- 1)  Does this letter o have an overstroke?
  - Yes, it does. The part of the letter the arrow is pointing to is more than 1/16" (on the Measuring Tool).
- 2)  Does this letter m have an overstroke?
  - Yes, it does. The line is slightly out of the 1/16" box.
- 3)  Does this letter H have an overstroke?
  - No. The little line across is within the 1/16" box.

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Figure 21. HWT® The Print Tool™ control examples, continued.

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## Print Tool™

### Overtrace:

1)



Is this letter P an overtrace?

- No. The Big 3 Curricula make the P by going down and coming back up and over.

2)



Is this letter T an overtrace?

- Yes. The line at the top is written several times going from right to left. None of the Big 3 Curricula do this.

3)



Is this letter r an overtrace?

- No. It is written correctly. The line going below the baseline shows that this letter is a Placement error but NOT an overtrace.

### Midpoint:

1)



Is this letter y a Midpoint error?

- Yes. When you measure the y with your Measuring Tool you will see that the middle of this letter is not in the gray. Therefore, it is a Midpoint error.

2)



Is this letter K a Midpoint error?

- Yes. When you measure the K with your Measuring Tool you will see that the middle of this letter is not in the gray. Therefore, it is a Midpoint error.

3)



Is this letter p a Midpoint error?

- No. When you measure the p with your Measuring Tool you will see that the lowest point of the curve is in the gray area.

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Figure 22. HWT® The Print Tool™ control examples, continued.

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## Print Tool™

### Identical Parts Porportion

1)



Is this letter w an Identical Parts Proportion error?

- Yes. When you measure the first line of the w with your Measuring Tool, you get a 2. When you measure the line on the right side of the w you get a 4.5. Therefore, these two identical parts are not within 50% of one another.

2)



Is this letter x an Identical Parts Proportion error?

- No. When you measure both of the diagonal lines of the x you will see that they are within 50% of one another.

3)



Is this letter z an Identical Parts Proportion error?

- No. When you measure the top and the bottom line of the z, they are within 50% of one another.

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Figure 23. HWT® The Print Tool™ control examples, continued.

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# Print Tool™

## Level 1 Frequently Missed: Spacing

Refer to The Print Tool™ Guide for Spacing Rules

- 1) Look at the example below for spacing between letters. The child is in first grade. Is the first letter spacing attempt an error?



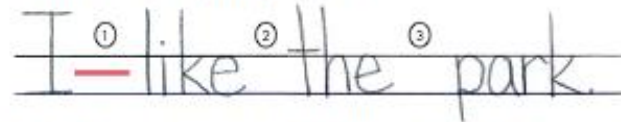
- No, the letters are within the bar for this child.

- 2) Look at the example below for spacing between letters. The child is in first grade. Is the fourth letter spacing attempt an error?



- Yes, this is a Spacing error because the letters are touching.

- 3) Look at the example below for spacing between words. The child is in first grade. Is this 1st word spacing attempt an error?



- No, this is not a Spacing error. The letters are farther than the bar when measuring from the farthest part of the 1st word to the closest part of the next word.

- 4) Look at the example below for spacing between words. The child is in first grade. Is the second word spacing attempt an error?



- Yes, this is a Spacing error for spacing between words. The words are too close together when measuring the bar from the farthest part of the 1st word to the closest part of the next word.

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Figure 24. HWT® The Print Tool™ spacing examples.

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# Handwriting Without Tears®

## The Eight Key Components of Handwriting

When a child writes well, they're doing so many things! Can you name some of the components of handwriting skill? (Discussion)

Here are 8 components:

**Memory** – Remembering and writing dictated letters and numbers

Quick and automatic recall of letters and numbers is very important. Memory is essential for all independent handwriting. Poor memory hurts production, speed, and accuracy.

**Orientation** – Facing letters and numbers in the correct direction

Beginners may reverse a "few" letters and numbers. But with good instruction, children can learn how to orient letters and numbers correctly. Orientation errors are distracting; children stop to think about which way the letters or numbers go. Orientation errors cause spelling and legibility mistakes.

**Placement** – Putting letters and numbers on the baseline

Placing letters and numbers on a line makes writing easier to read. It is important for the flow of writing. Haphazard placement makes printing appear immature, messy, or even illegible.

**Size** – How big or small a child chooses to write

Children need to be able to control their movements so their writing isn't too big for the current grade. Writing too large causes problems with school papers, speed, and spacing.

**Start** – Where each letter or number begins

Good starting habits allow children to maintain neatness even when they print quickly. Children who become messy when they print quickly are typically children with incorrect starting habits. They often start letters at the bottom.

**Sequence** – Order and stroke direction of the letter or number parts

The ability to form letter or number parts correctly is acquired through direct teaching and consistent practice. If children do not form parts in the right sequence, speed and neatness are affected.

**Control** – Neatness and proportion of letters and numbers

Control does not usually require direct remediation. Problems with control are almost always caused by poor habits. If the child has an awkward pencil grip, control will be affected. If the child has a problem with start or sequence, control will be affected. As habits improve, so will the child's control.

**Spacing** – Amount of space between letters in words, and between words in sentences

Spacing is important to the legibility and uniformity of writing. Problems with spacing may be made worse by poorly designed worksheets that do not give enough room for writing.

[www.hwtears.com](http://www.hwtears.com) | 301.263.2700 | [info@hwtears.com](mailto:info@hwtears.com)

Figure 25. HWT® The eight key components of handwriting.

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## Appendix C: Randomization of Letter Sets

Randomized Test Word Sequence Sets																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Pangram 1	2	1	8	1	7	5	1	1	8	4	6	1	5	1	6	8	4	8	8	8
	5	8	7	4	5	1	5	2	2	8	7	8	2	8	5	4	1	7	5	1
	3	5	4	5	2	7	6	6	6	1	3	3	6	7	2	5	2	1	3	4
	1	6	2	2	4	8	4	8	3	3	8	2	3	6	3	1	5	5	4	6
	8	2	3	3	6	6	2	3	7	2	2	6	8	2	4	2	3	6	6	2
	6	4	6	8	1	3	7	7	4	5	4	5	4	3	7	3	8	2	1	5
	4	7	1	7	3	2	3	5	5	6	1	7	7	4	8	6	7	3	2	3
	7	3	5	6	8	4	8	4	1	7	5	4	1	5	1	7	6	4	7	7
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Pangram 2	6	7	2	3	3	6	5	7	3	5	7	5	3	3	3	1	5	7	1	4
	3	2	3	2	4	1	4	5	6	4	1	6	4	4	7	3	1	2	4	7
	5	3	8	8	8	8	6	6	8	1	8	2	8	5	2	4	4	6	7	2
	4	5	7	4	1	7	1	4	2	2	3	1	6	6	6	6	6	4	6	5
	2	4	6	5	7	3	2	8	4	6	5	8	5	7	5	5	8	8	5	6
	7	1	5	1	6	5	3	2	1	8	6	4	2	1	1	7	3	5	3	3
	8	8	4	6	5	4	8	1	5	3	2	7	7	2	4	2	7	3	2	8
	1	6	1	7	2	2	7	3	7	7	4	3	1	8	8	8	2	1	8	1
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Pangram 3	1	4	3	1	1	4	3	2	3	2	1	2	2	3	1	6	6	6	1	3
	5	3	4	2	4	1	1	4	5	4	6	5	1	6	3	4	5	5	5	2
	3	1	6	3	5	5	5	1	4	5	5	6	6	4	5	1	2	1	6	5
	2	6	2	4	6	3	4	3	2	3	4	4	4	2	6	2	4	4	2	4
	4	2	1	6	2	6	6	6	1	1	2	1	5	5	2	3	1	2	3	6
	6	5	5	5	3	2	2	5	6	6	3	3	3	1	4	5	3	3	4	1
	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Pangram 4	4	4	4	5	3	2	5	2	4	3	5	2	6	3	1	4	4	5	3	3
	5	3	3	3	2	5	4	6	3	2	1	4	4	2	5	1	2	2	5	2
	6	6	6	6	5	1	6	3	2	4	6	3	1	4	2	6	6	4	1	4
	1	1	5	1	6	4	3	4	1	6	3	6	5	1	4	5	3	6	6	6
	2	5	1	2	4	3	1	5	6	5	2	5	3	5	3	3	5	1	4	1
	3	2	2	4	1	6	2	1	5	1	4	1	2	6	6	2	1	3	2	5
	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Pangram 5	7	3	3	3	4	4	7	5	1	7	5	5	3	5	7	4	2	4	2	3
	3	6	1	4	2	7	3	3	3	3	3	4	5	6	3	2	4	1	6	5
	4	5	5	6	6	2	5	4	7	5	4	1	6	3	4	7	5	5	3	4
	5	4	7	7	7	6	6	6	2	1	7	6	7	7	2	6	7	6	4	2
	2	1	6	1	1	3	1	2	5	6	1	7	1	1	1	1	1	2	7	6
	1	2	2	5	5	1	4	7	4	2	2	2	2	4	6	3	3	7	5	1
	6	7	4	2	3	5	2	1	6	4	6	3	4	2	5	5	6	3	1	7

Figure 26. Randomized test word sets for five pangrams.

The English alphabet was divided into four sets of six to seven letters based upon HWT® Letter Formations script feature similarity, rather than their prescribed teaching order. The order in which letter sets were introduced into training was randomly assigned. The resultant letter set introduction order was miscellaneous letters, magic c letters, diver letters, and diagonal letters. The researcher diverged from HWT® protocol since their rationale for grouping letters was based upon children's prior knowledge of writing uppercase letters. In their protocol, lowercase letters that are identical to their uppercase counterparts (i.e., except for their size) are introduced first. However, macrographia has been demonstrated to be problematic for children with autism. Therefore, decreasing the size of a letter may have increased task difficulty. Conversely, research suggests that reduced task difficulty facilitates skill acquisition. Additionally, grouping the letters according to features may lessen the burden of weak central coherence in children with autism. Specifically, controlling the degree of between-letter script similarity may increase executive control. Furthermore, since uppercase writing was not a target in the current study, the researcher hypothesized that acquisition would be easier across letters that were grouped according to features.

### **Letter Set 1 Training**

HWT® materials included one slate blackboard, a quantity of 10 - 1" chalk bits, a quantity of 10 - ½" sponges (see Figure 2), a quantity of 100 - 2" x 2" paper towel squares, a quantity of 5 - 4" pencils, and three letter set 1 training sheets for each training session. To contain the number of active instructional targets, the English alphabet was divided into four letter sets. Each set was grouped according to its similarities or lack

thereof. Training sheets were provided to parents as their children qualified for the next condition. The first sheet contained individual letters from letter set 1. Each letter in set 1 was assigned a number in alphabetical order. The range of letters in set 1 (i.e., the smallest-value sequence boundary of one and a largest-value sequence boundary of seven) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 24 times to generate a randomization of 25 sequences of numbers within that range. Training occurred at least once daily, as time allowed, with an anticipated range of 15-25 training sessions across this phase for acquisition of the target letters across each of the dependent variables. Random assignment of the daily training letters was conducted to intersperse training targets.

In order to intersperse word-training targets, two sheets containing 17 child-friendly words using letters that were only found in letter set 1 were collected from [www.a2zWordFinder.com](http://www.a2zWordFinder.com). Nonsense words were excluded. Each word was assigned a number. The range of words in set 1 (i.e., the smallest-value sequence boundary of one and a largest-value sequence boundary of 17) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 24 times to generate a randomization of 25 sequences of numbers within that range. Those words accounted for a potential of 25 daily instructional sessions to acquisition of dependent variables for those targets. The randomized sequence (see figure 26) was entered into two 1<sup>st</sup> grade sentence templates in HWT® Worksheet Maker Lite, generating a total of 50 unique word training sheets.

### **Letter Set 2 Training**



HWT® materials included one slate blackboard, a quantity of 10 - 1” chalk bits, a quantity of 10 - ½” sponges (see Figure 2), a quantity of 100 - 2” x 2” paper towel squares, a quantity of 5 - 4” pencils, and three letter set 2 training sheets for each training session. The first sheet contained individual letters from letter set 2. Each letter in set 2 was assigned a number in alphabetical order. The range of letters in set 2 (i.e., the smallest-value sequence boundary of 8 and a largest-value sequence boundary of 14) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 24 times to generate a randomization of 25 sequences of numbers within that range. Training occurred at least once daily, as time allowed, with an anticipated range of 15-25 training sessions across this phase for acquisition of the target letters across each of the dependent variables. Random assignment of the daily training letters was conducted to intersperse training targets.

In order to intersperse word-training targets, two sheets containing 85 child-friendly words using letters only found in letter sets 1-2 were collected from [www.a2zWordFinder.com](http://www.a2zWordFinder.com). Nonsense words were excluded. Each word was assigned a number. The range of words in set 2 (i.e., the smallest-value sequence boundary of one and a largest-value sequence boundary of 85) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 4 times to generate a randomization of 5 sequences of numbers within that range. Those words accounted for up to 25 daily instructional sessions to acquisition of dependent variables for those targets. The randomized sequence was entered into two 1<sup>st</sup> grade sentence templates in HWT® Worksheet Maker Lite, generating a total of 50 unique word training sheets.

### **Letter Set 3 Training**

HWT® materials included one slate blackboard, a quantity of 10 - 1” chalk bits, a quantity of 10 - ½” sponges (see Figure 2), a quantity of 100 - 2” x 2” paper towel squares, a quantity of 5 - 4” pencils, and three letter set 3 training sheets for each training session. The first sheet contained individual letters from letter set 3. Each letter in set 3 was assigned a number in alphabetical order. The range of letters in set 3 (i.e., the smallest-value sequence boundary of 15 and a largest-value sequence boundary of 20) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 24 times to generate a randomization of 25 sequences of numbers within that range. Training occurred at least once daily, as time allowed, with an anticipated range of 15-25 training sessions across this phase for acquisition of the target letters across each of the dependent variables. Random assignment of the daily training letters was conducted to intersperse training targets.

In order to intersperse word-training targets, two sheets containing 85 child-friendly words using letters only found in letter sets 1-3 were collected from [www.a2zWordFinder.com](http://www.a2zWordFinder.com). Nonsense words were excluded. Each word was assigned a number. The range of words in set 3 (i.e., the smallest-value sequence boundary of one and a largest-value sequence boundary of 85) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 4 times to generate a randomization of 5 sequences of numbers within that range. Those words accounted for a potential of 25 daily instructional sessions to acquisition of dependent variables for those

targets. The randomized sequence was entered into two 1<sup>st</sup> grade sentence templates in HWT® Worksheet Maker Lite, generating a total of 50 unique word training sheets.

### **Letter Set 4 Training**

HWT® materials included one slate blackboard, a quantity of 10 - 1” chalk bits, a quantity of 10 - ½” sponges (see Figure 2), a quantity of 100 - 2” x 2” paper towel squares, a quantity of 5 - 4” pencils, and three letter set 4 training sheets for each training session. The first sheet contained individual letters from letter set 4. Each letter in set 4 was assigned a number in alphabetical order. The range of letters in set 4 (i.e., the smallest-value sequence boundary of 21 and a largest-value sequence boundary of 26) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 24 times to generate a randomization of 25 sequences of numbers within that range. Training occurred at least once daily, as time allowed, with an anticipated range of 15-25 training sessions across this phase for acquisition of the target letters across each of the dependent variables. Random assignment of the daily training letters was conducted to intersperse training targets.

In order to intersperse word-training targets, two sheets containing 85 child-friendly words using letters only found in letter sets 1-4 were collected from [www.a2zWordFinder.com](http://www.a2zWordFinder.com). Nonsense words were excluded. Each word was assigned a number. The range of words in set 4 (i.e., the smallest-value sequence boundary of one and a largest-value sequence boundary of 85) was then entered in the random sequence generator at [www.random.org](http://www.random.org) and “Again!” was pressed 4 times to generate a randomization of 5 sequences of numbers within that range. Those words accounted for a

potential of 25 daily instructional sessions to acquisition of dependent variables for those targets. The randomized sequence was entered into two 1<sup>st</sup> grade sentence templates in HWT® Worksheet Maker Lite, generating a total of 50 unique word training sheets.

In order to increase test-retest reliability, five pangrams (i.e., sentences that contain all letters of the alphabet), containing child-friendly words, were collected from [www.englishforums.com](http://www.englishforums.com). The chosen pangrams contained all alphabet letters with the least number of duplications of each letter (see *Figure 27.* ). Sentences that contained nonsense words were excluded. One sentence (i.e., pack my box with five dozen liquor jugs) was modified to make it more child-friendly (i.e., pack my box five dozen liquid jugs worth). Each word in each pangram sentence was assigned a number. A maximum of twenty unique pangram 1 test sheets were needed to avoid test-retest error. The range of numbers for each sentence was then entered at [www.random.org](http://www.random.org) (e.g., 8 words for pangram sentence 2) to generate 20 unique sequences of numbers within that range (e.g., The first randomly generated sequence for sentence two is 63542781, which generates a testing word sequence of “over brown jumps fox quick lazy dog the”).

	1	2	3	4	5	6	7	8
Pangram 1	pack	my	box	five	dozen	liquid	jugs	worth
	1	2	3	4	5	6	7	8
Pangram 2	the	quick	brown	fox	jumps	over	a	lazy dog
	1	2	3	4	5	6		
Pangram 3	how	quickly	daft	jumping	zebras	vex		
	1	2	3	4	5	6		
Pangram 4	the	five	boxing	wizards	jump	quickly		
	1	2	3	4	5	6	7	
Pangram 5	heavy	boxes	perform	quick	waltzes	and	jigs	

*Figure 27.* Pangram sentences and the number assignment of pangram words.

Given the five pangrams and 20 unique sequences for each, a total of 100 random sequences were generated in this fashion. Finally, a range of 1 to 100 was entered at [www.random.org](http://www.random.org) four times to generate four sets of 100 random sequences for daily testing administration (i.e., each of the participants was assigned a different test sequence of the same 100 sheets). Testing occurred once per day on every day following a training day, with a maximum of 86 acquisition testing sessions, 5 maintenance sessions, and a maximum of 27 maintenance and generalization testing sessions across three different people. The 27 generalization tests were on nine double-, nine triple-, and nine single-lined sheets; but they were otherwise identical to acquisition test sheets. The same nine sentences were used for each paper type. As such, a total of 100 randomly generated test sequences were assigned to each potential participant.

Random assignment of the daily test words (i.e., five different pangrams) and order of presentation (i.e., randomization of pangram words) was conducted to account for test-retest errors. At the start of the treatment, parents were given an Avery® binder to hold their activity and test sheets. To decrease the demands on the parent, the researcher placed all test sheets into the binder in the order in which they were to be administered and gave them a list of their assigned order in the event that the sheets were inadvertently mixed up. Sentence-level instruction was not introduced since capital letters and punctuation were not targets of instruction.

## Appendix D: Checklists and data collection form

Parents-as-Teachers: Toward Improving the Print Handwriting of Children with Autism:

Lowercase Letter Data Participant #\_\_\_ Sentence #\_\_\_ Pangram #\_\_\_ Sheet

Letter Set: ( - )		Date:		Evaluator:																									
Size:	Orientation	Placement	Size	Start	Sequence	Control	Control Error	Legibility																					
PreK:	e	e	e	e	e	e		e																					
	f	f	f	f	f	f		f																					
	i	i	i	i	i	i		i																					
	j	j	j	j	j	j		j																					
	l	l	l	l	l	l		l																					
K:	t	t	t	t	t	t		t																					
	u	u	u	u	u	u		u																					
	c	c	c	c	c	c		c																					
	a	a	a	a	a	a		a																					
	d	d	d	d	d	d		d																					
1st:	g	g	g	g	g	g		g																					
	b	o	o	o	o	o		o																					
	q	q	q	q	q	q		q																					
	s	s	s	s	s	s		s																					
	b	b	b	b	b	b		b																					
2nd-3rd:	h	h	h	h	h	h		h																					
	m	m	m	m	m	m		m																					
	n	n	n	n	n	n		n																					
	p	p	p	p	p	p		p																					
	r	r	r	r	r	r		r																					
4th:	k	k	k	k	k	k		k																					
	v	v	v	v	v	v		v																					
	w	w	w	w	w	w		w																					
	x	x	x	x	x	x		x																					
	y	y	y	y	y	y		y																					
Total correct Total attempted % correct	z	z	z	z	z	z		z																					
Spacing letter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Spacing word	1	2	3	4	5	6																							
Spacing correct		Letter		Word																									
Spacing attempts																													
% correct																													
Duration:			seconds		Legibility Rate:			letters per minute																					
Notes:	Inversions: ; Missing letters: ; Other (specify)																												
<b>Spacing:</b> N=narrow, W=wide, U=unwritten; <b>Sequence:</b> O=order, D=direction, A=angle, C=continuous; <b>Control:</b> P=point, R=rounding, G=gap, OT=overtrace, OS=overstroke, MP=midpoint parts proportion, IP=Identical parts proportion.																													
Date:														Evaluator:															

Modified from Handwriting Without Tears: The Print Tool, 3rd Edition

Figure 28. Data collection form on child.

Time Sampling Data Collection: 15-second interval  
Parents-as-teachers: Toward improving the print handwriting of adolescents with autism.

Participant: _____		Date: _____		Observer: _____								
Minute	5	10	15	20	25	30	35	40	45	50	55	60
0												
1												
2												
3												
4												
Posture: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %		Paper position: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %										
Pencil grip: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %												

Participant: _____		Date: _____		Observer: _____								
Minute	5	10	15	20	25	30	35	40	45	50	55	60
0												
1												
2												
3												
4												
Posture: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %		Paper position: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %										
Pencil grip: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %												

Participant: _____		Date: _____		Observer: _____								
Minute	5	10	15	20	25	30	35	40	45	50	55	60
0												
1												
2												
3												
4												
Posture: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %		Paper position: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %										
Pencil grip: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %												

Participant: _____		Date: _____		Observer: _____								
Minute	5	10	15	20	25	30	35	40	45	50	55	60
0												
1												
2												
3												
4												
Posture: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %		Paper position: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %										
Pencil grip: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %												

Participant: _____		Date: _____		Observer: _____								
Minute	5	10	15	20	25	30	35	40	45	50	55	60
0												
1												
2												
3												
4												
Posture: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %		Paper position: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %										
Pencil grip: $\frac{\# \text{ Correct}}{\# \text{ Total}} \times 100 =$ _____ %												

Did the correct behavior happen at the end of the interval? Y=Yes, N=No;

Yellow=Posture, Green=Paper position, Orange=Pencil grip

Figure 29. Three Ps scoring sheet.

## **Appendix E: Alec's Case Study**

**Case number four.** This parent-student dyad was excluded from the study because the student did not meet the study inclusion criteria due to his high VABS maladaptive behavior scores.

**Parent four.** Alec's mom was an English-speaking 43-year-old married Caucasian female. She had earned a bachelor's degree in historic preservation and had recently become a certified Christian counselor; however, since the birth of her son, she was a stay-at-home mom. Alec's dad earned a bachelor's degree in forestry and worked as a park ranger. Their household gross income was \$55,000. They had one child. Alec's mom didn't have prior training in education, but had hired therapists and caregivers for Alec for several years. She didn't plan to acquire certification to teach children with autism and hadn't previously received training in providing handwriting instruction.

**Child four.** Alec was a 15-year-3-month old right-handed Caucasian male 8<sup>th</sup> grade public school student who had received a diagnosis of autism at age 5 years old in 2002 and cognitive impairment at age 8 in 2005. At the start of the study, Alec received a score of 36.5 on the Childhood Autism Rating Scale (CARS), which fell at the mild-moderate autism range. Alec's mother responded to the Vineland Adaptive Behavior Scales, Interview Edition Expanded Form (VABS) to provide information regarding



Alec's adaptive behavior. The Vineland is a norm-referenced test that evaluates three domains of adaptive behavior in the areas of communication, daily living skills, and socialization.

Alec received a VABS adaptive behavior composite of 21, which fell below the 0.1 percentile, in the low range, and at a 3 year and 11 months age equivalent. There was a 95 percent probability that his true adaptive behavior composite fell between 14 and 28. Alec received a communication domain composite standard score of below 20 and estimated at 19, which fell below the 0.1 percentile, in the low range, and at a 3 year and 2 months age equivalent. His ratings on all communication subdomains fell in the low range. There was a 95 percent probability that his true communication domain composite standard score fell between 7 and 31. Alec received a daily living skills domain composite standard score of below 20 and estimated at 15, which fell below the 0.1 percentile, in the low range, and at a 4 year and 6 months age equivalent. Among daily living skills subdomains, his ratings fell in the low range. There was a 95 percent probability that his true daily living skills domain composite standard score fell between 7 and 23. Alec's socialization domain composite standard score of 40 fell below the 0.1 percentile, in the low range, and at a 4 year and 1 month age equivalent. Among socialization subdomains, his ratings fell in the low range. There was a 95 percent probability that his true socialization domain composite standard score fell between 31 and 49. Alec received a maladaptive behavior, part 1, domain score of 29, which fell in the significant range for his age.

Table 5

*Vineland Adaptive Behavior Scales Summary Results for Alec*

	Standard/Raw Score	Percentile Rank	Adaptive Level	Age Equivalent
Communication	19 *	Below 0.1	Low	3 - 2
Receptive	44		Low	4 - 8
Expressive	94		Low	2 - 6
Written	16		Low	5 - 3
Daily Living Skills	15 *	Below 0.1	Low	4 - 6
Personal	135		Low	4 - 6
Domestic	25		Low	3 - 10
Community	35		Low	4 - 6
Socialization	40	Below 0.1	Low	4 - 1
Interpersonal Relationships	75		Low	6 - 2
Play and Leisure Time	64		Low	4 - 10
Coping Skills	13		Low	2 - 6
Adaptive Behavior Composite	21 *	Below 0.1	Low	3 - 11

*Note.* Standard Scores of Domains of the VABS are at the 95% confidence interval. Raw scores are listed for Subdomains. Age equivalents are listed as years followed by months.

\*Estimated Standard Scores.

**Setting four.** Alec lived full-time with his mother and father in their single-family home since his birth in 1997. Handwriting instruction was conducted at their rectangular 42" x 90" wood kitchen table while sitting on standard-height high-back wooden chairs. The approximately 10' x 12' dining room had 8' ceilings and a wood floor. Alec's mother sat 12" perpendicular to his right while training and testing. The room was lit with incandescent and natural lighting and was maintained at an average temperature of 70 degrees. The kitchen had light-colored walls and double-glass doors in the room with potential points of distraction including noises in the adjacent family room, adjacent

kitchen activity, and the occasional appearance of the family dog. Usually, small items that could pose an immediate distraction were removed prior to beginning training or testing. Videotaping occurred at a distance of 4' from the table to include the parent and child.

**Appendix F: Handwriting samples across intervention phases for participants one,  
two, and three:**

Participant one:

12/29/12 3:30

Name: \_\_\_\_\_

jump wizards

quickly boxing

the five

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Figure 30. Keane's handwriting acquisition sample double-lined paper 12-29-2012.

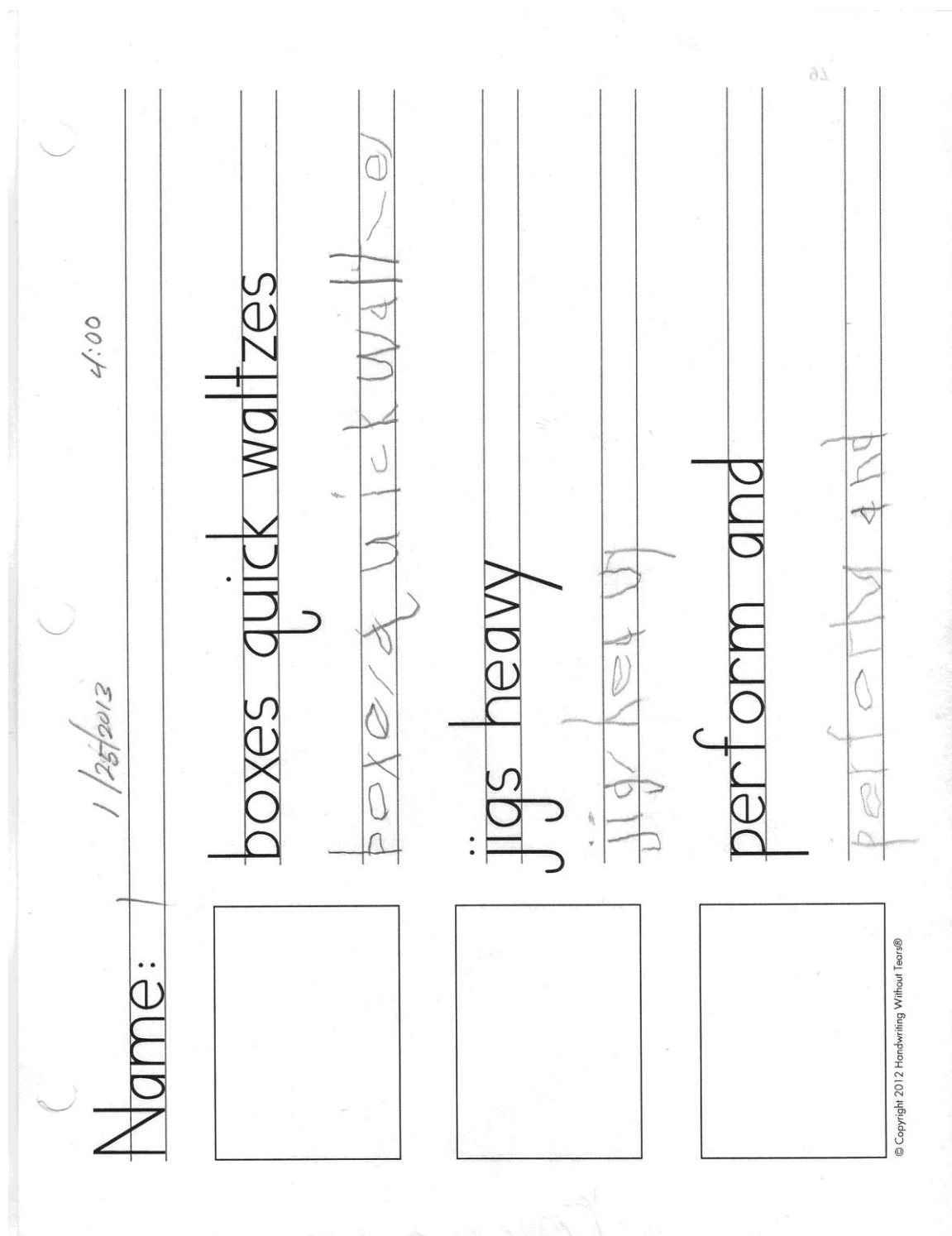


Figure 31. Keane's handwriting acquisition sample double-lined paper 1-25-2013.

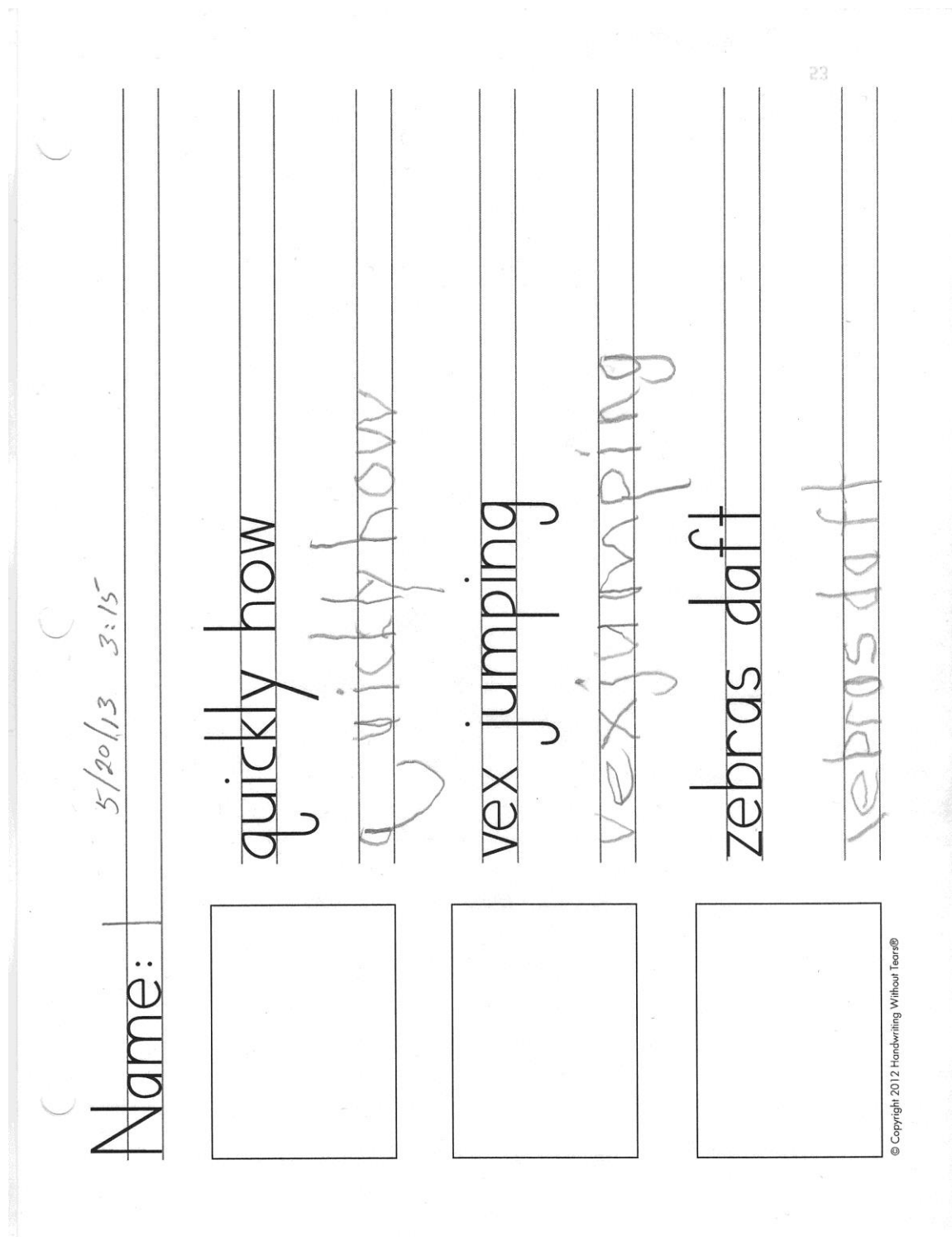


Figure 32. Keane's handwriting acquisition sample double-lined paper 5-20-2013.

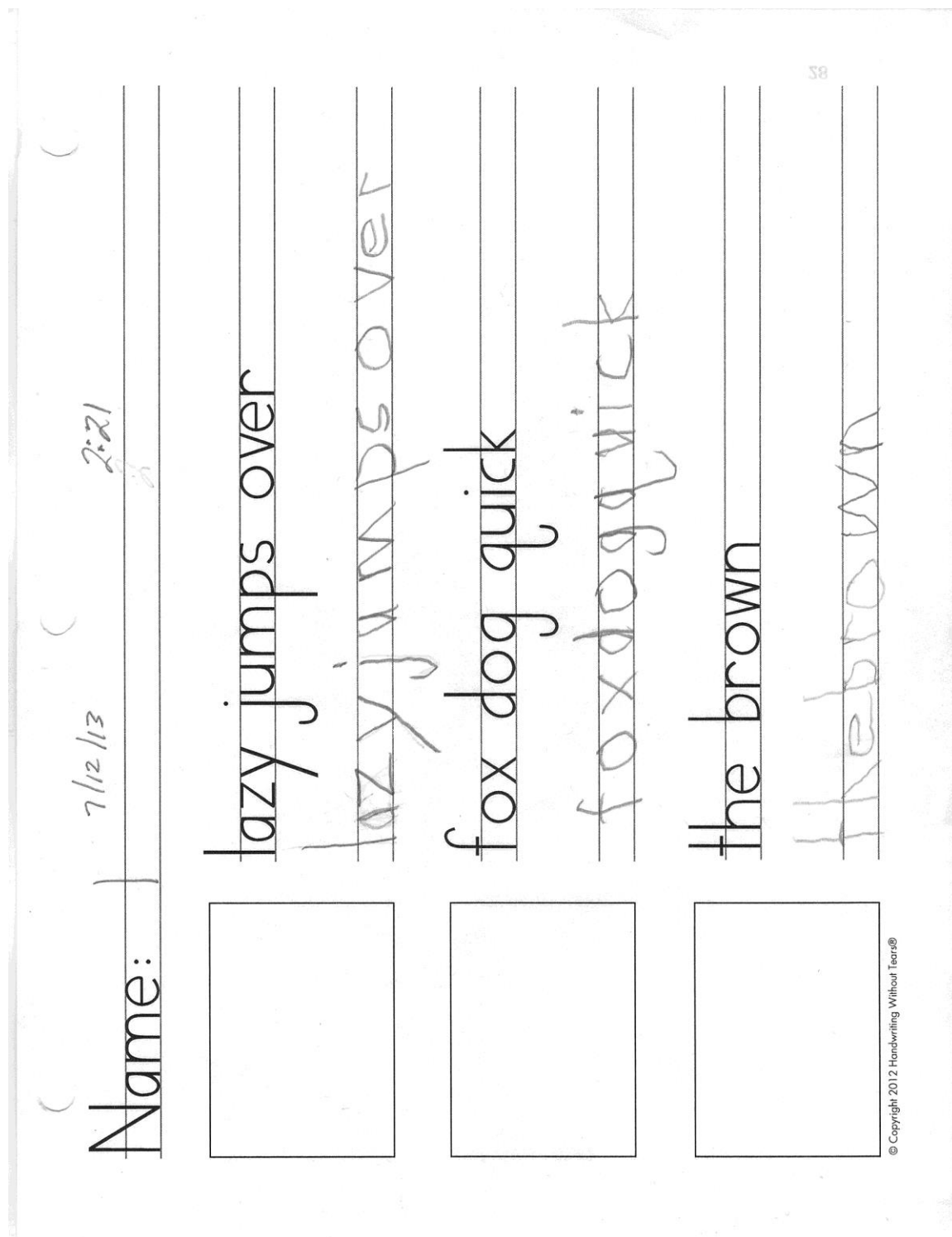


Figure 33. Keane's handwriting maintenance sample double-lined paper 7-12-2013.



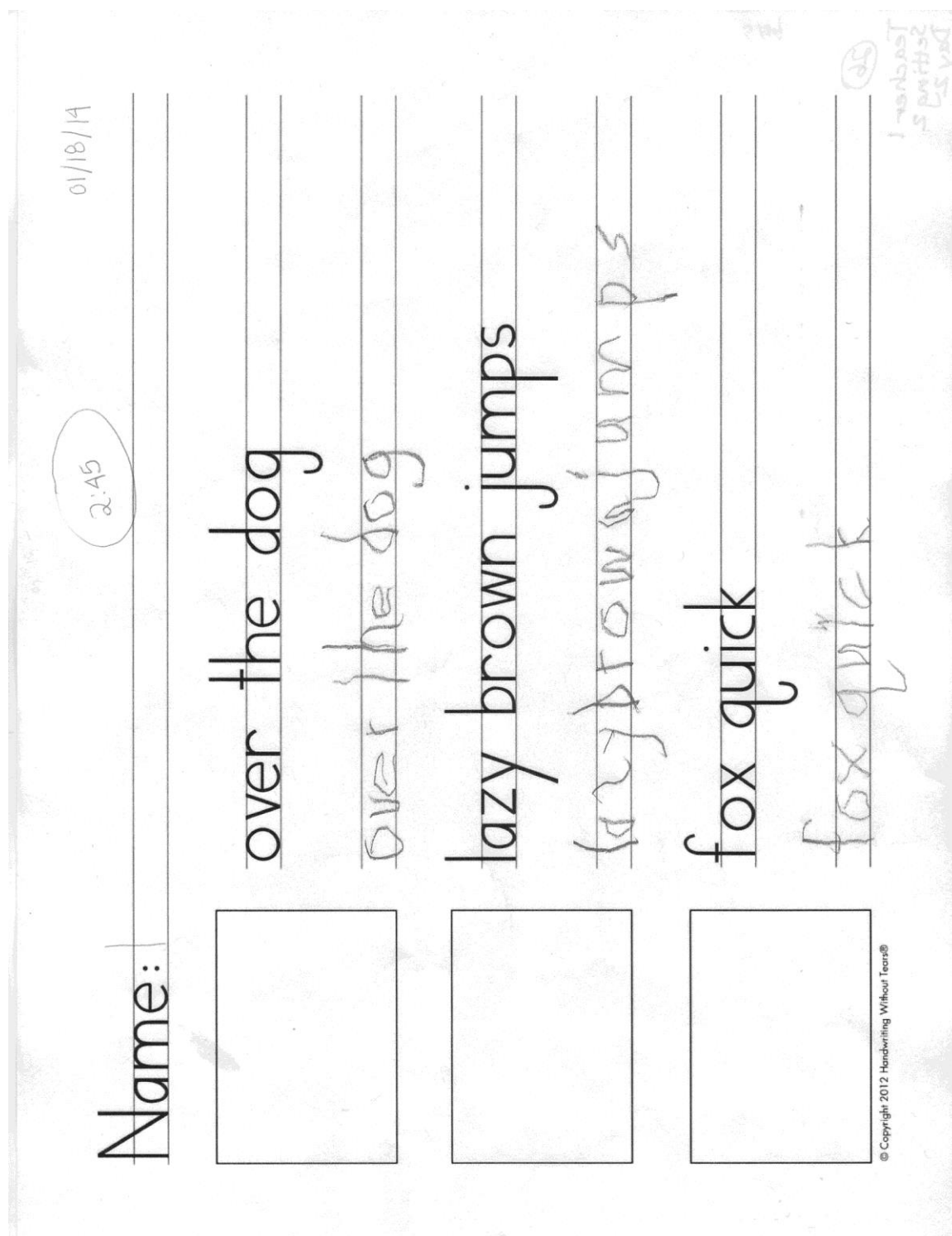


Figure 34. Keane's handwriting generalization sample double-lined paper 01-18-2014.

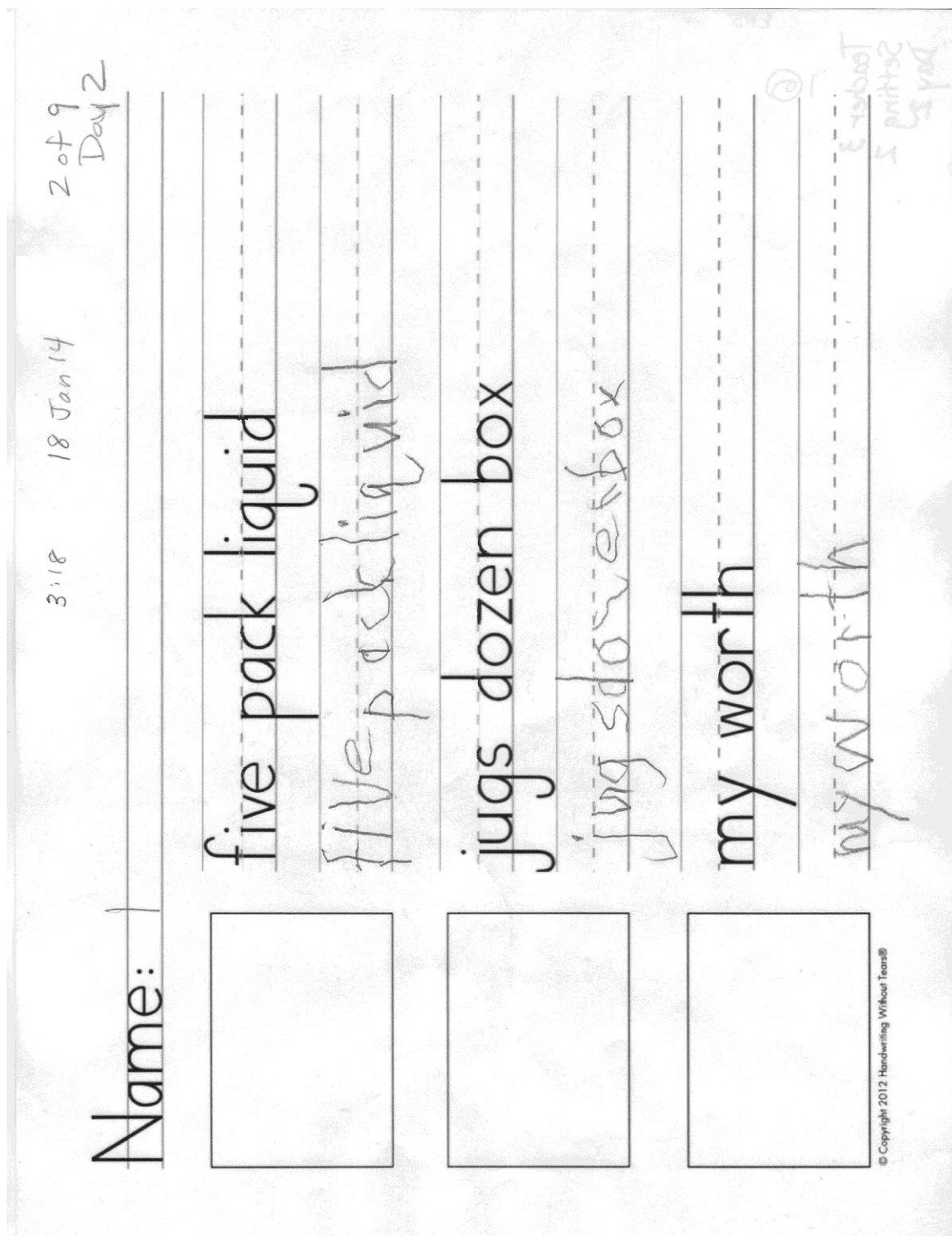


Figure 35. Keane's handwriting generalization sample triple-lined paper 01-18-2014.

18 Jan 14

3:18

1 of 9  
Day 2

Name: \_\_\_\_\_

pack jugs five

packjugsfive

dozen my worth

dozenmyworth

liquid box

liquidbox

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5

5

5

5

5

Figure 36. Keane's handwriting generalization sample single-lined paper 1-18-2014.

Participant two:

Name: 3 12/09/12 0:52 on.made

daft jumping

daft jumping

vex quickly

vex quickly

how zebras

how zebras

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Figure 37. Tony's handwriting baseline sample double-lined paper 12-09-2012.

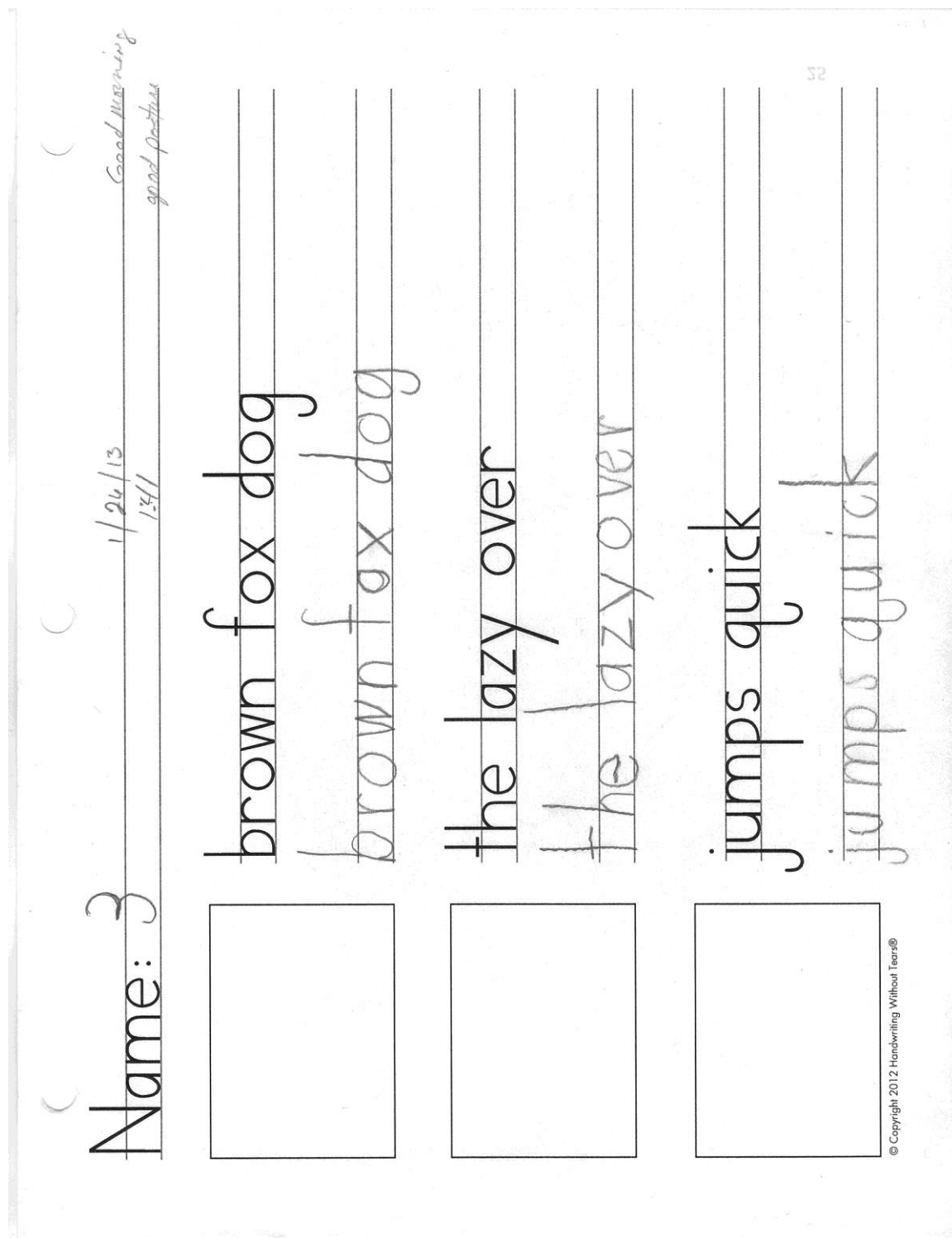


Figure 38. Tony's handwriting acquisition sample double-lined paper 1-26-2013.

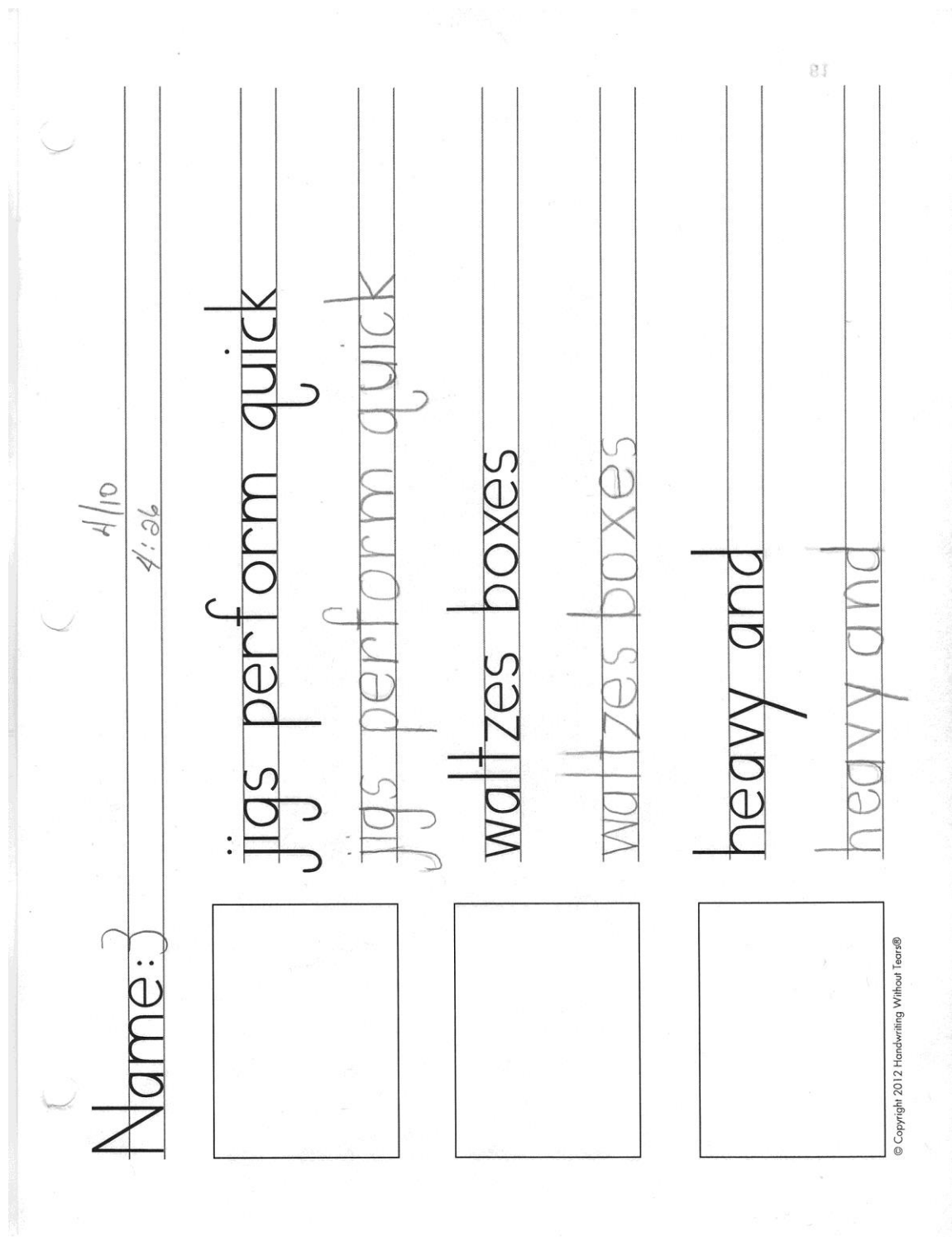


Figure 39. Tony's handwriting acquisition sample double-lined paper 4-10-2013.

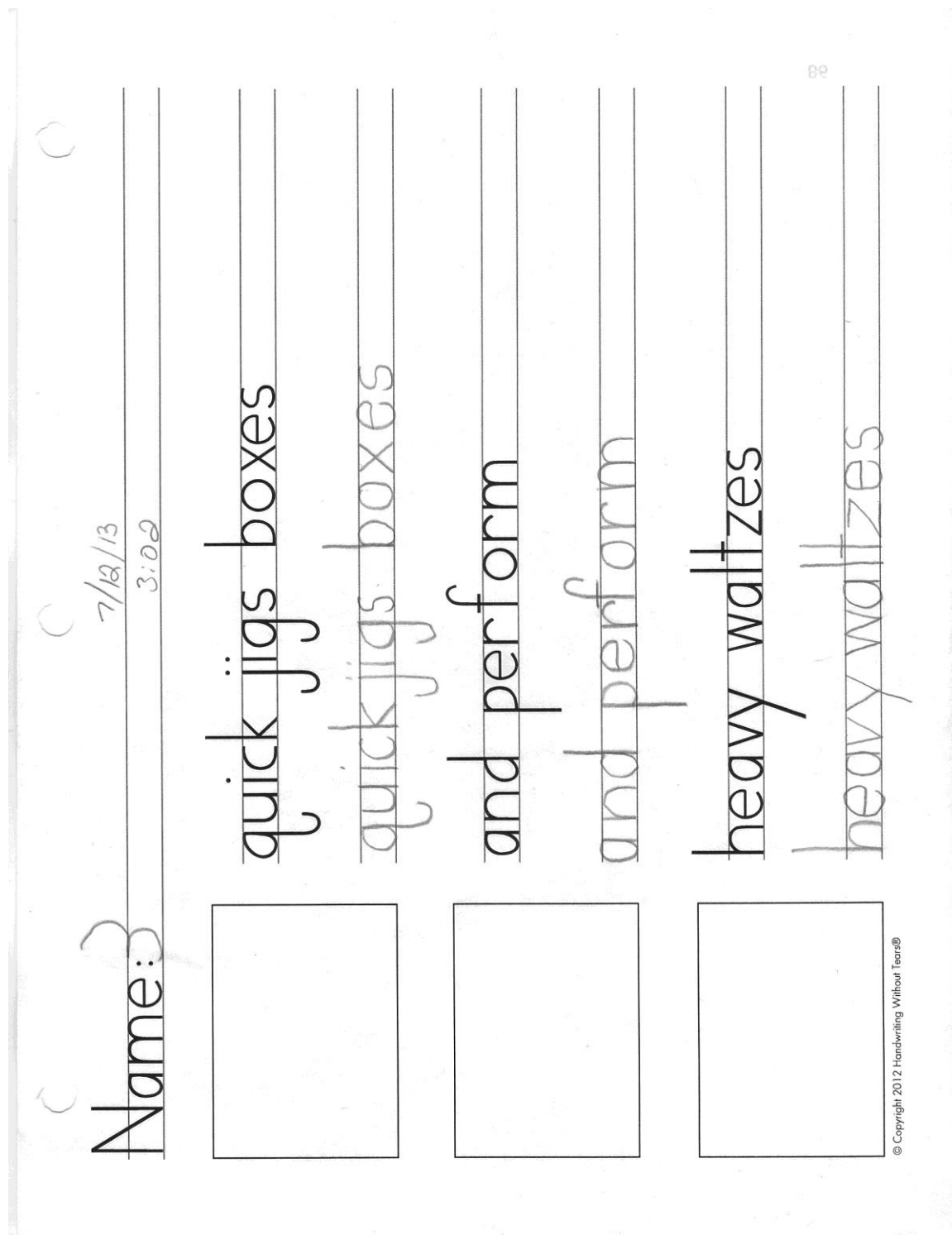


Figure 40. Tony's handwriting maintenance sample double-lined paper 7-12-2013.

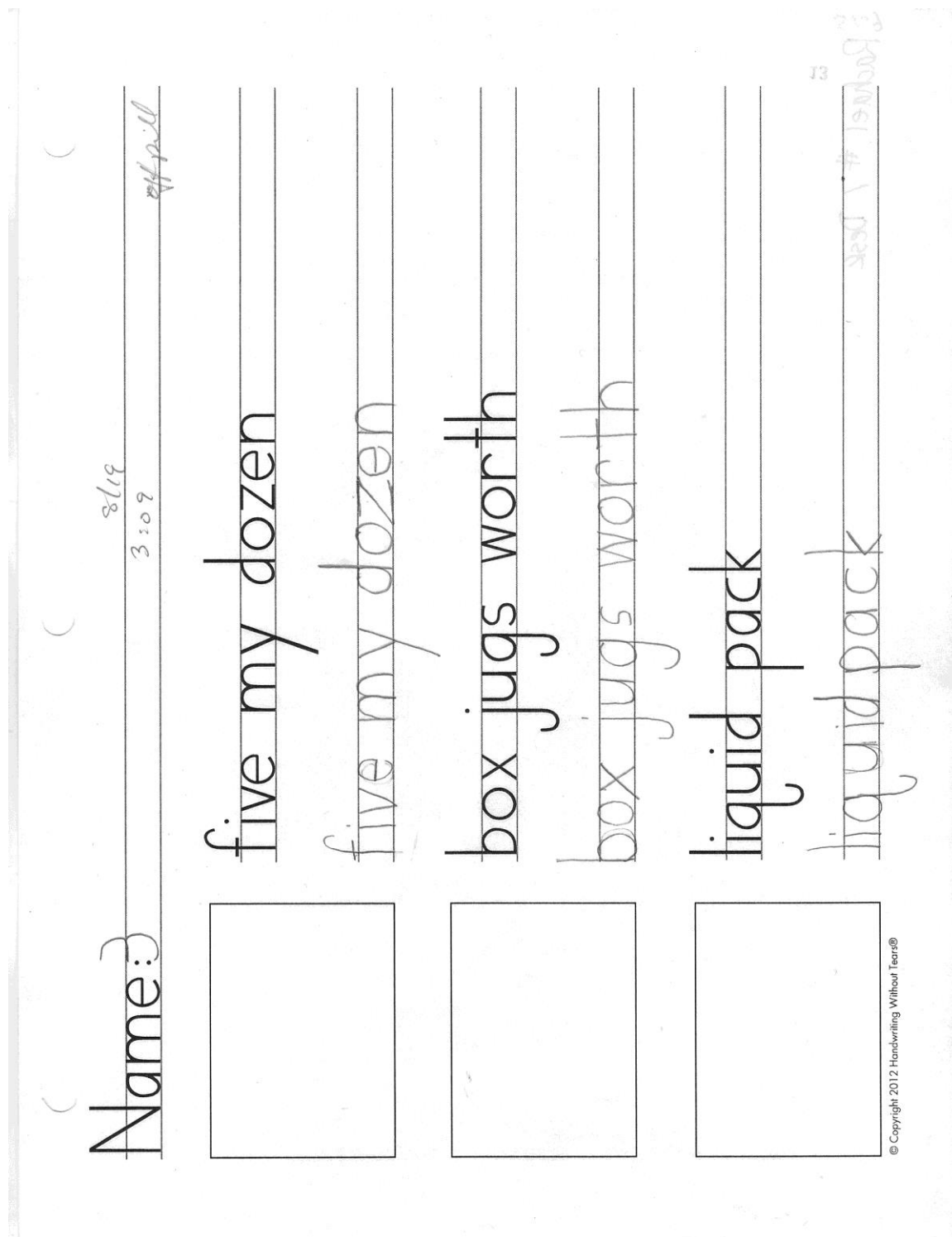


Figure 41. Tony's handwriting generalization sample double-lined paper 8-19-2013.



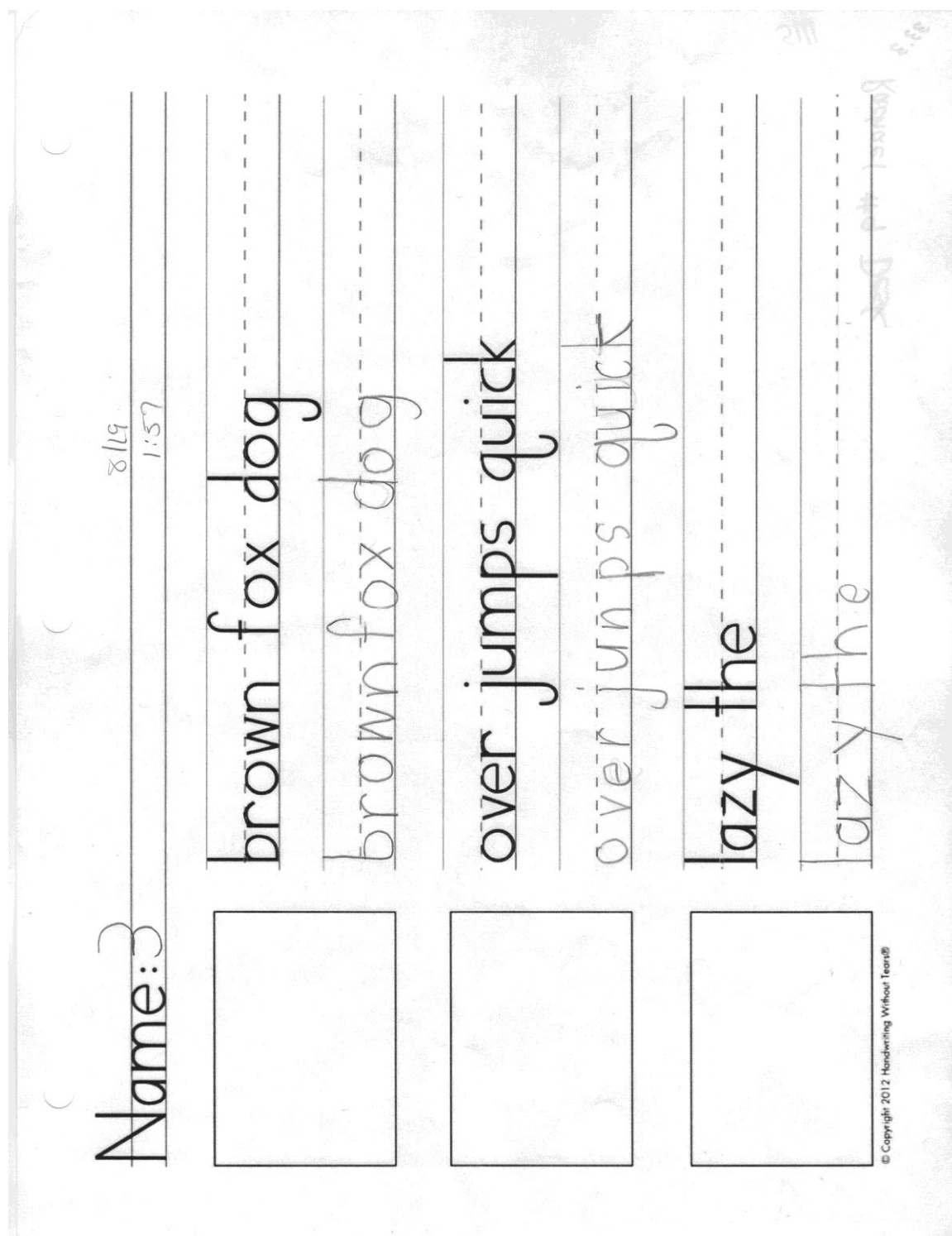


Figure 42. Tony/s handwriting generalization sample triple-lined paper 8-19-2013.

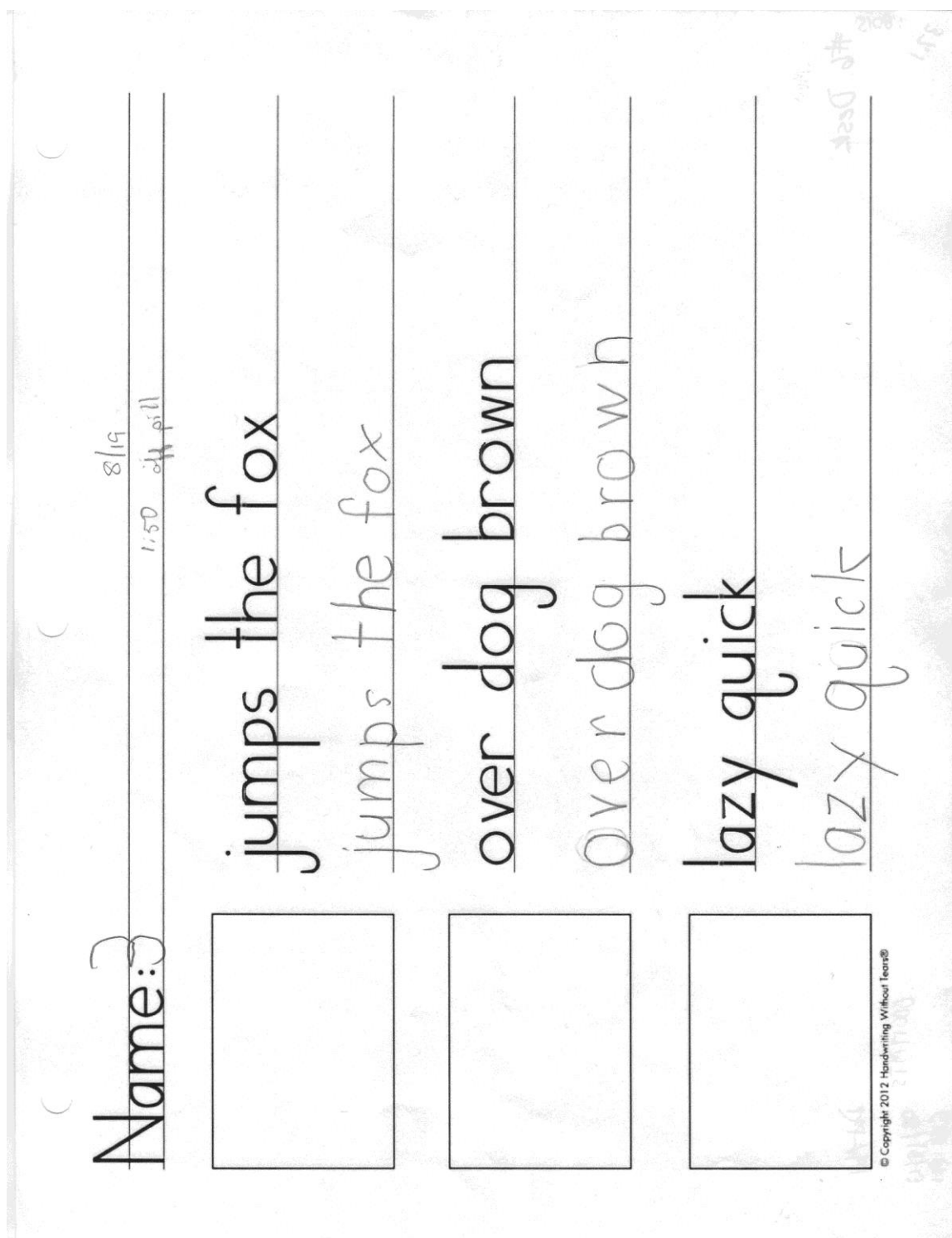


Figure 43. Tony/s handwriting generalization sample single-lined paper 8-19-2013.

Participant three:

12/28/12 2:29

Name: 4

quick jigs boxes

quick jigs boxes

and perform

and perform

heavy waltzes

heavy waltzes

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Figure 44. Owen's handwriting baseline sample double-lined paper 12-28-2012.

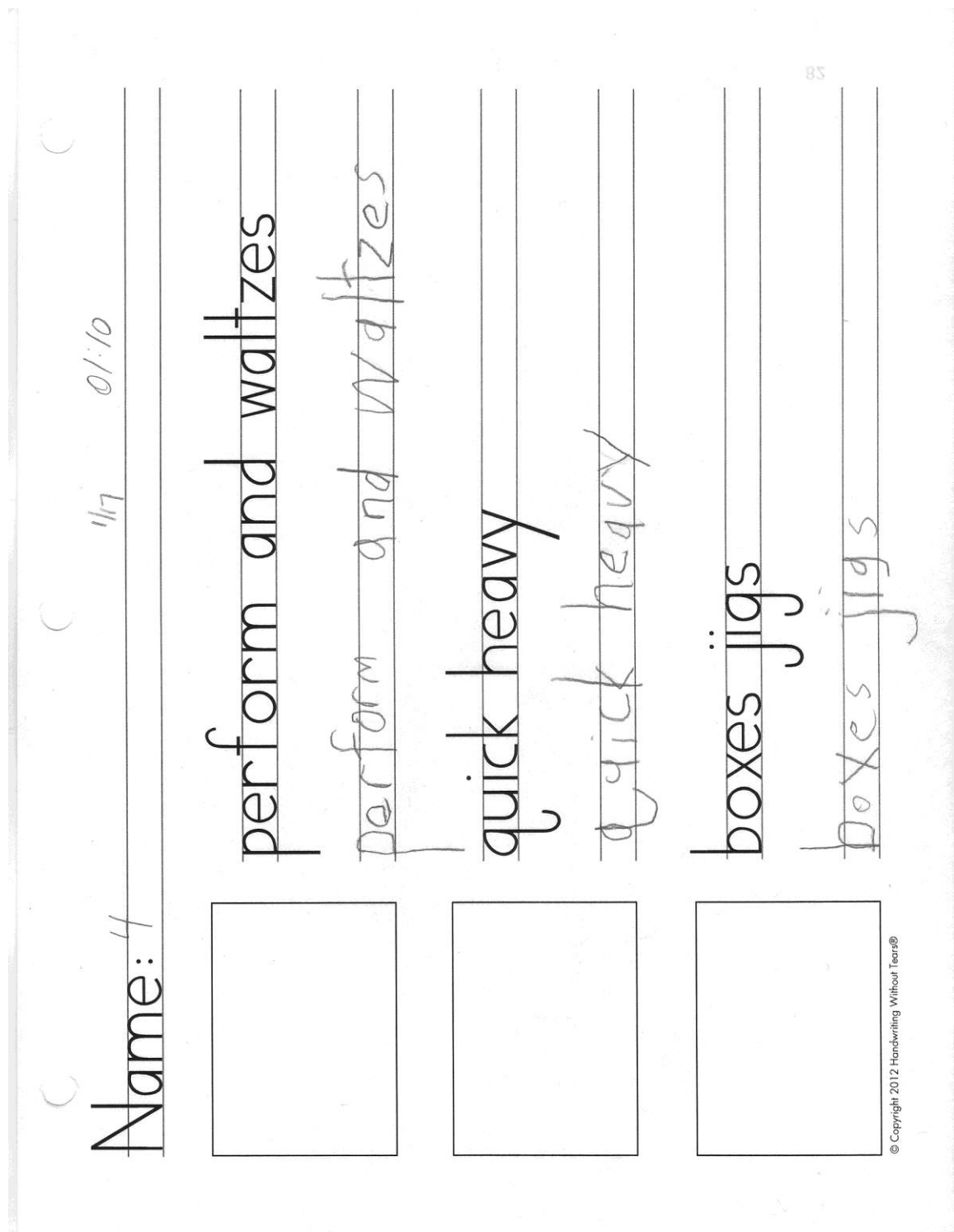


Figure 45. Owen's handwriting acquisition sample double-lined paper 01-17-2013.



Figure 46. Owen's handwriting acquisition sample double-lined paper 03-31-2013.

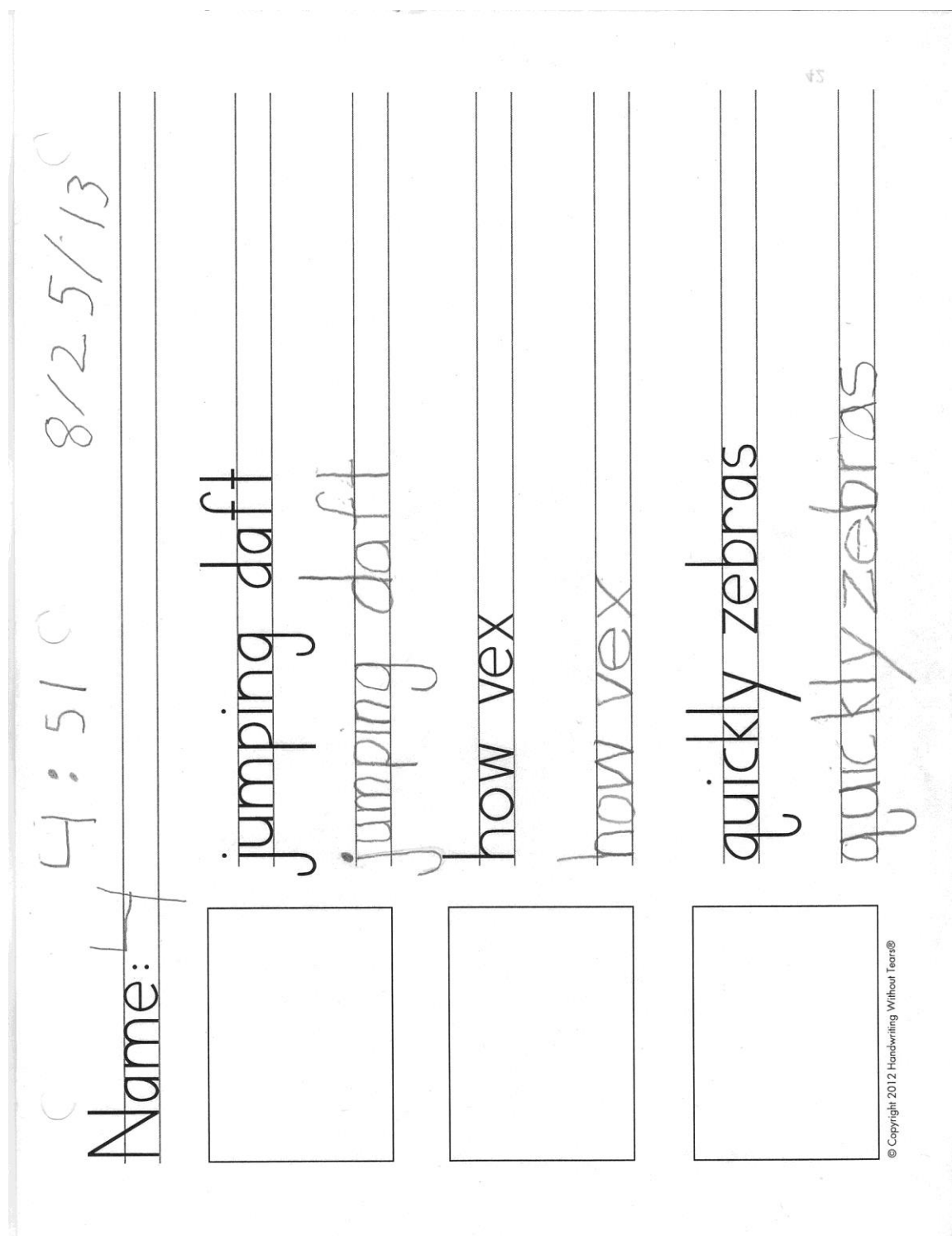


Figure 47. Owen's handwriting maintenance sample double-lined paper 08-25-2013.

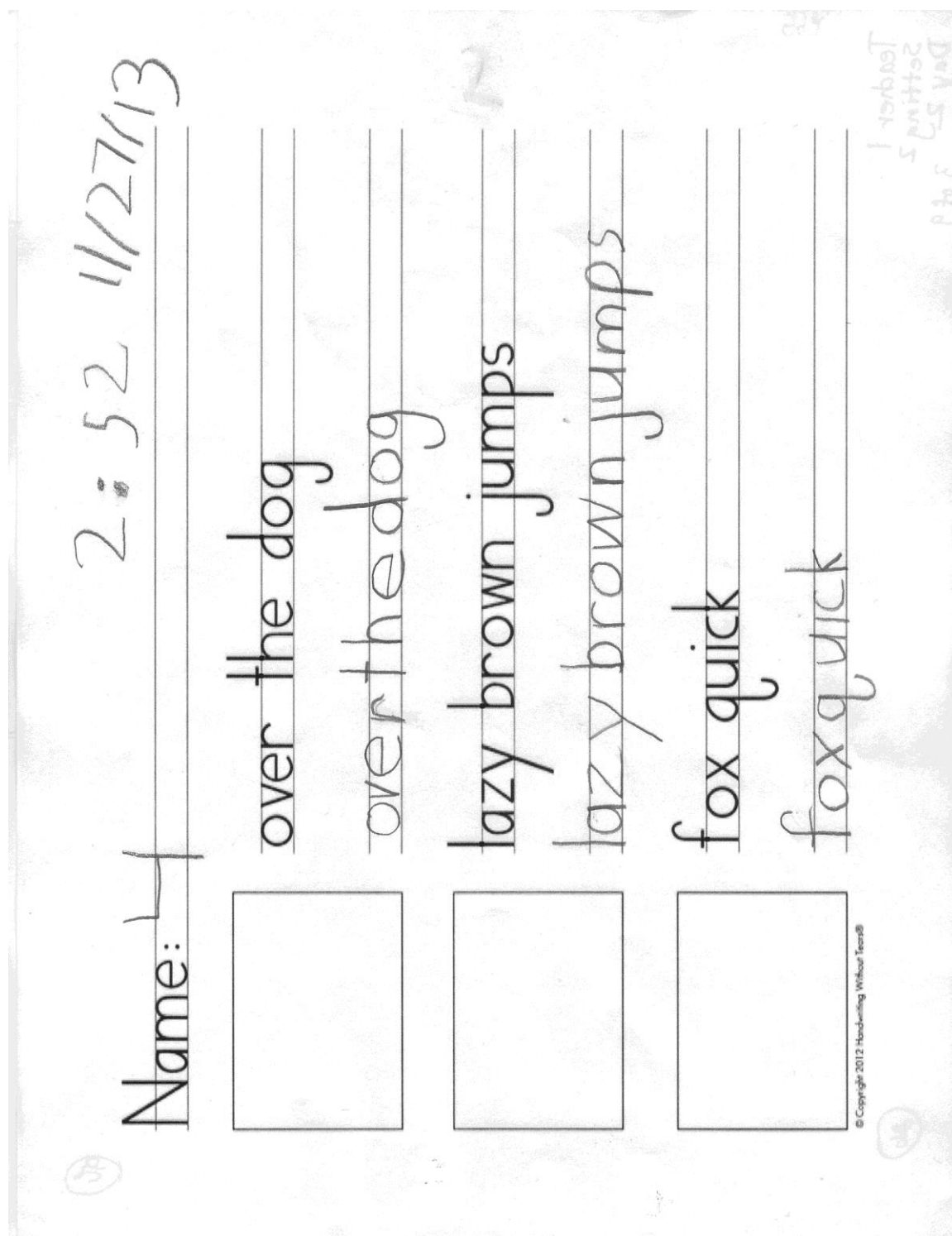


Figure 48. Owen's handwriting generalization sample double-lined paper 11-27-2013.

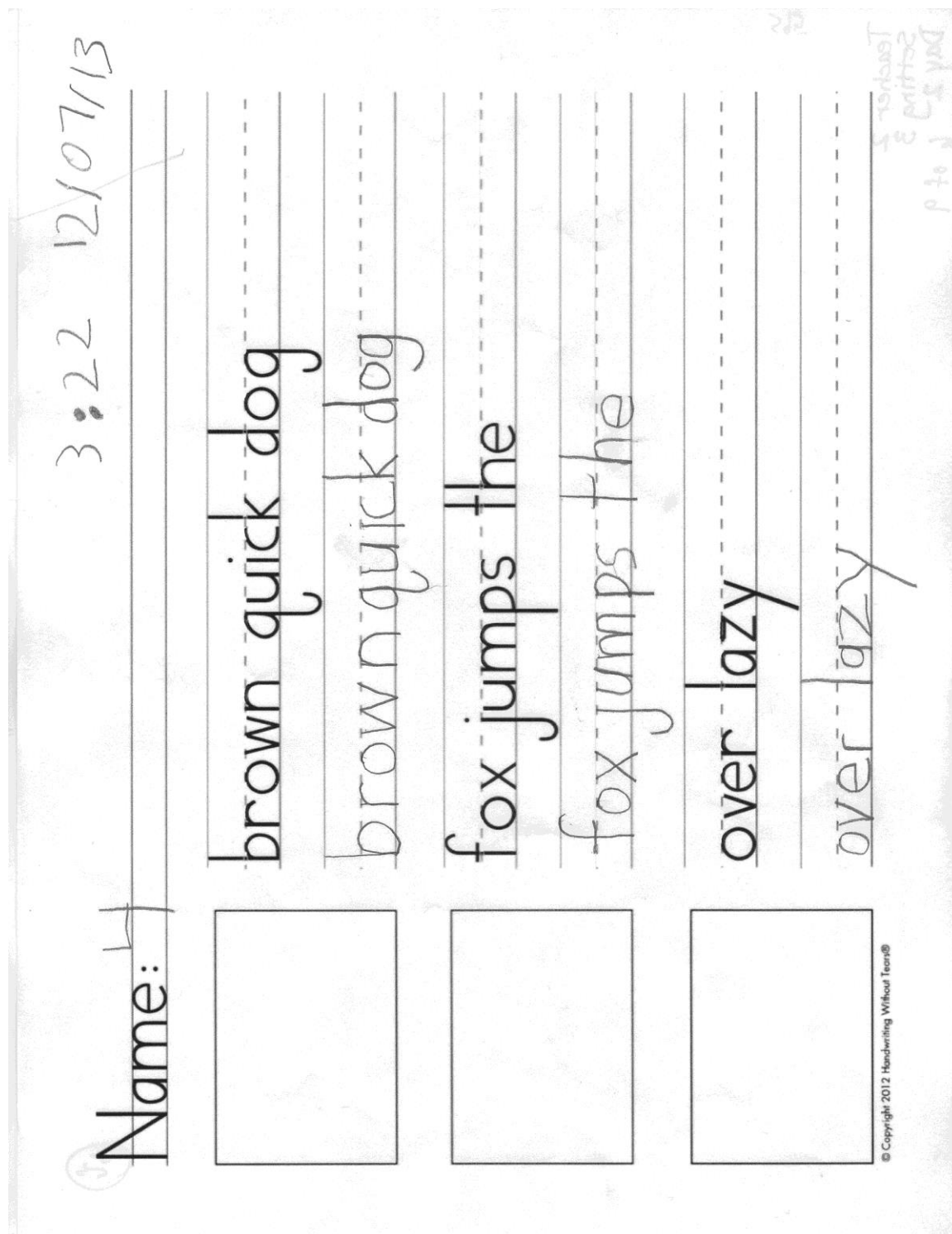


Figure 49. Owen's handwriting s generalization sample triple-lined paper 12-07-2013.



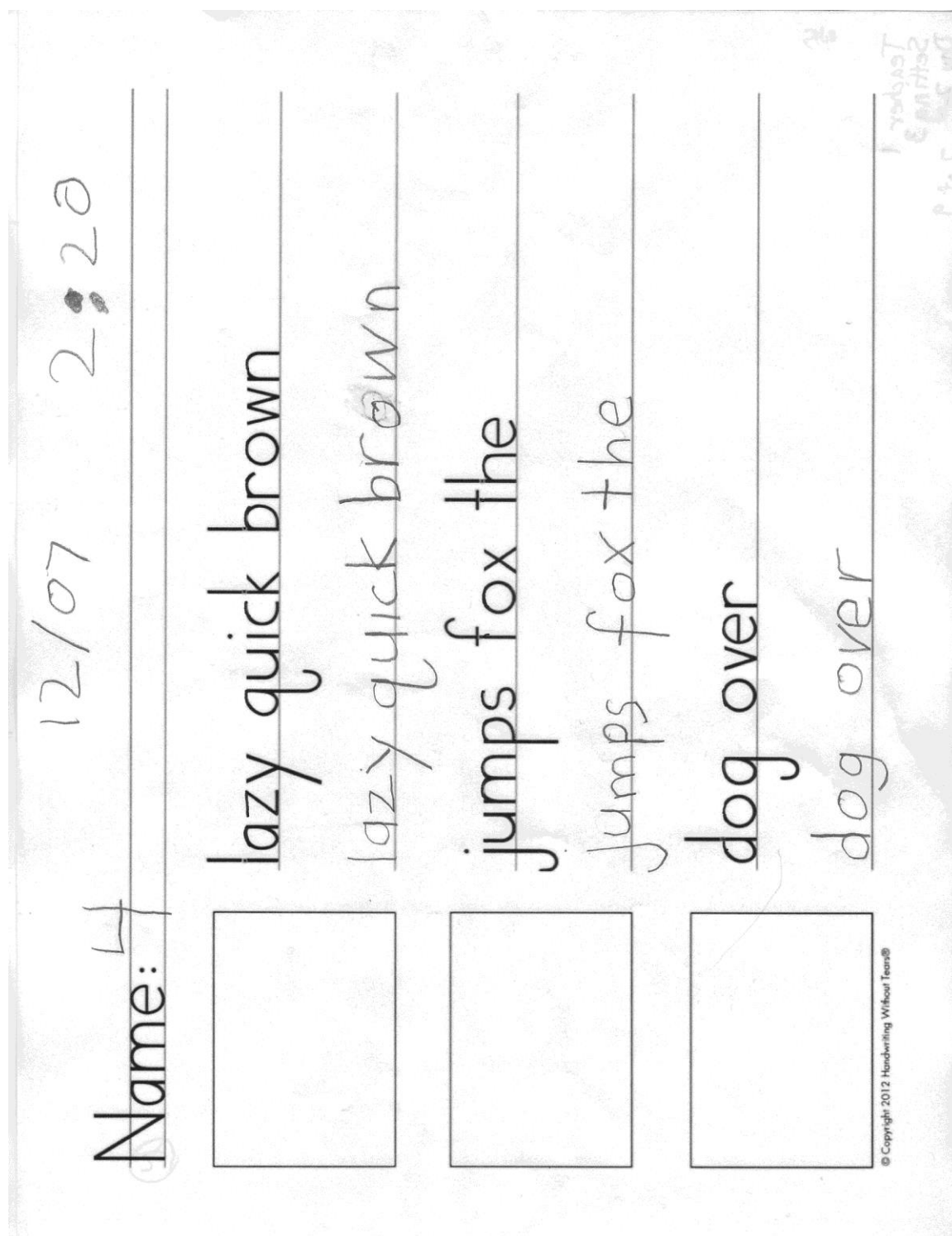


Figure 50. Owen's handwriting generalization sample single-lined paper 12-07-2013.

## Appendix G: Pencil Grip

The researcher had intended to teach and acquire data on pencil grip data within a multiple baseline design. However, the second participant scheduled to receive treatment immediately scored at the ceiling. Per parent request, instruction remained in place for Keane and Owen. Results are listed below for Keane for interested readers and briefly described for Tony and Owen.

***Pencil grip: Keane.*** During pencil grip baseline, the within-phase patterns included a mean of 0%, no variability ( $SD = 0$ ), and a flat trend. The between-participant vertical analysis demonstrated a consistent baseline for Tony and Owen (see Figure 49).

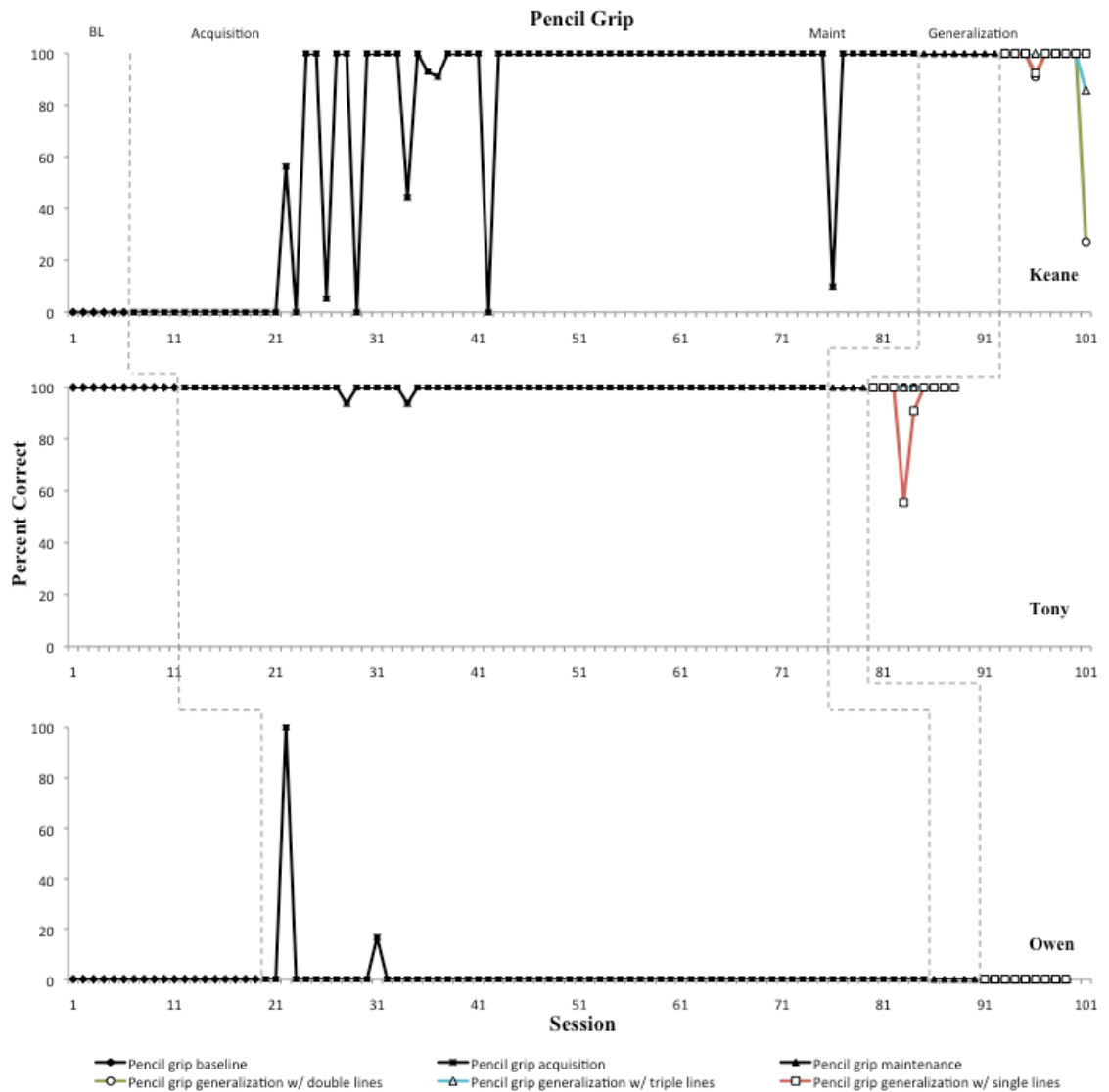


Figure 51 Pencil Grip Scores

During pencil grip acquisition, the within-phase patterns included a mean of 73%, a medium degree of variability ( $SD = 46$ ), and a moderate positive trend (slope = 1.3;  $R^2 = 0.48$ ). The between-phase patterns included no immediacy of effect between the last three data points in baseline and the first three data points in acquisition, a medium mean magnitude of change of +73% correct, a somewhat similar pattern consistency, and a moderate degree of overlap with the previous phase (PND = 77%). The between-

participant vertical analysis demonstrated that the independent variable introduction for Keane did not result in a change in pencil grip for Owen, who had not entered treatment.

During pencil grip maintenance, the within-phase patterns included a mean of 100%, no variability ( $SD = 0$ ), and a flat trend. The between-phase patterns included a flat immediacy of effect between the last three data points in pencil grip acquisition and the first three data points in pencil grip maintenance, a low magnitude of change of +27% correct, a similar pattern consistency, and a very high degree of overlap with pencil grip acquisition ( $PND = 0\%$ ) due to ceiling effects.

During pencil grip generalization on double-lined paper, the within-phase patterns included a mean of 91%, a low degree of variability ( $SD = 24$ ), and a large negative trend (slope = -4.7;  $R^2 = 0.29$ ). The between-phase patterns included a flat immediacy of effect between the last three data points in maintenance and the first three data points in double-line generalization, a low decelerating magnitude of change of -9% correct, a similar pattern consistency, and a very high degree of overlap with previous phase ( $PND = 0\%$ ) due to ceiling effects.

During pencil grip generalization on triple-lined paper, the within-phase patterns included a mean of 98%, a low degree of variability ( $SD = 5$ ), and a small negative trend (slope = -0.95;  $R^2 = 0.3$ ). During pencil grip generalization on single-lined paper, the within-phase patterns included a mean of 99%, a low degree of variability ( $SD = 3$ ), and a small positive trend (slope = 0.13;  $R^2 = 0.019$ ).

***Pencil grip: Tony.*** Tony's scores in baseline were at the ceiling and continued on throughout treatment. As such, the parent and child had no need to continue a multiple baseline across participants for this variable for Tony.

***Pencil grip: Owen.*** Owen's scores on pencil grip were at floor throughout treatment. Data collection for a multiple baseline design was not possible since the second participant scheduled to enter treatment remained at a stable ceiling throughout the timeframe of the study. Instruction for Owen was modified to include HWT® "Hold On...You Have to Teach Grip." Even with modifications, Owen's pencil grip remained at the floor, though his mother said that he had more interest in producing a correct pencil grip since using the rubberband adaption.

## Appendix H: Procedural reliability data

### Parents-as-Teachers: Toward Improving the Print Handwriting of Children with Autism

#### Procedural Reliability Checklist

Student Number: \_\_\_\_\_

Source of observation: \_\_\_\_\_

Person Completing Checklist: \_\_\_\_\_

Within session: ☐

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

Videotape: ☐

Notes of special consideration: \_\_\_\_\_

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#### **Antecedent Strategies**

- |    |   |                          |
|----|---|--------------------------|
| 1  | Videorecorder is set up and has adequate memory availability              | <input type="checkbox"/> |
| 2  | All materials for instruction are available and easily accessible         | <input type="checkbox"/> |
| 3  | Student had any special needs taken care of                               | <input type="checkbox"/> |
| 4  | Ensure student is adequately fed  | <input type="checkbox"/> |
| 5  | Check Student's general state of health                                   | <input type="checkbox"/> |
| 6  | Check Student's state of arousal  | <input type="checkbox"/> |
| 7  | Check amount of environmental stimulation                                 | <input type="checkbox"/> |
| 8  | Student has recently used the restroom                                    | <input type="checkbox"/> |
| 9  | Availability of secondary reinforcers                                     | <input type="checkbox"/> |
| 10 | Vocal prompts to have the child join the parent at the table, as required | <input type="checkbox"/> |
| 11 | Words used to direct the child follow parent instruction wording          | <input type="checkbox"/> |

#### **Probe Data Collection/Instructional Strategies**

- |    |   |                          |
|----|---|--------------------------|
| 12 | Correct testing sheet each day                            | <input type="checkbox"/> |
| 13 | Baseline and treatment conditions introduced as planned   | <input type="checkbox"/> |
| 14 | Errorless teaching  | <input type="checkbox"/> |
| 15 | Prompt fade procedures                                    | <input type="checkbox"/> |
| 16 | Mix and vary activities appropriate to phase of treatment | <input type="checkbox"/> |

#### **Consequence Management**

- |    |   |                          |
|----|---|--------------------------|
| 17 | Token counter every 30-seconds                | <input type="checkbox"/> |
| 18 | Error-correction procedures                   | <input type="checkbox"/> |
| 19 | Reinforcers are reserved only for handwriting | <input type="checkbox"/> |

# Features Completed: \_\_\_\_\_

# Features Planned: \_\_\_\_\_

Strength Areas: \_\_\_\_\_

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Areas to improve before next observation: \_\_\_\_\_

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Figure 52 Procedural Reliability Checklist

## Appendix I: Social validity data

All of the parents identified handwriting as a problem for their children and felt that enrolling in this study was important for their family.

### Parents as Teachers: Toward Improving the Print Handwriting of Adolescents with Autism.

Questions	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
The handwriting intervention:	(Circle one answer for each question)				
improved my child's handwriting at home.	1	2	3	4	5
improved my child's handwriting at school.	1	2	3	4	5
was worth the time and effort.	1	2	3	4	5
was worth recommending to others.	1	2	3	4	5
was easy to implement.	1	2	3	4	5

Based on BP-PBS Acceptability Questionnaire, modified for handwriting.

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## **Biography**

Tamara J. Genarro grew up in Southern California. She attended Santa Clara University in Northern California, where she received her Bachelor of Science in Biology in 1994. She went on to receive her Master of Education in Early Childhood Special Education and certification in Applied Behavior Analysis from George Mason University in 2005. She then received her Doctorate in Education with a specialization in Educational Psychology from George Mason University in 2015. She will begin professional writing and private consulting in Northern Virginia.