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The Impact of Neuro-Education Intervention Methods Upon the Learning and Development of an Individual with Developmental Disabilities

Christopher Merideth

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Chairperson — Date

DocuSigned by:

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Committee Member — Date

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Additional Committee Member — Date

Approved:

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DocuSigned by:

REDACTED — 3/29/2021

Dean of the Unit — Date

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Abstract

The purpose of this qualitative retrospective case study was to measure the impact that intervention methods derived from Arwood's Neuro-Education Model had upon the learning and development of one young adult with moderate to severe developmental disabilities. One participant received the intervention methods over the course of 2 years from a single practitioner operating in a private clinic setting. Drawings, writings, and oral language samples were coded and analyzed to track how the participant evolved over time in the developmental domains of cognition, language, and social-emotional functioning. Additionally, these same artifacts were coded and analyzed to identify changes to the participant's capacity for learning, as measured by language function. At the onset of the study the participant was 16 years of age, yet functioned at levels associated with 3- to 4-year-old developmental milestones. Results demonstrated that the participant exhibited approximately 3 years of growth in language development, 2 years of growth in cognitive development, and 3 years of growth in social-emotional development during the time period studied. Similarly, results showed that the participant advanced in all measured language functions including semanticity function, referential function, productivity function, flexibility function, and displacement of ideas. These advancements were observed in multiple literacy processes including thinking, speaking, listening, reading, writing, drawing, observing, and calculating. The participant was also reported to have experienced demonstrable changes to their quality of life including greater social-

emotional engagement with family members and peers at school. Though this study was not experimental by design, and thus causation could not be confirmed, the changes observed in the participant throughout this study were hypothesized to have occurred primarily due to their exposure to the Neuro-Education based methods, as these particular interventions had not been experienced by the participant prior to them initiating services at the clinic setting.

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The study of Neuro-Education would not be possible without Dr. Ellyn Arwood, who long ago envisioned a way that the education of young people could follow a more humanistic trajectory if we better understood how children learn best. Here's hoping that your work will continue to inspire many more generations of teachers to come.

Lastly, the completion of this work would not have been possible without the ongoing help and support from my wife Tiffany. Your feedback helped shape my dissertation from beginning to end and continued to instill confidence at the most essential times.

Dedication

This work is dedicated to each and every person who has struggled to learn at some point in their life. May you know that there is always a way for your brain to begin firing again when provided the right combination of input.

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Chapter 1: Introduction

John Dewey (1916) famously stated that democratic societies such as the United States require a mechanism like public schooling to ensure that principles of ethics, egalitarianism, and civic duty are passed along from generation to generation. Today, receiving a free and appropriate public-school education (FAPE) is a right that is afforded to all U.S. citizens by law (IDEA, 2004). However, this was not always the case. The history of public schooling in America is fraught with countless examples of attempts at both the national and local levels to exclude many groups of the populace from receiving an education such as immigrants, people of color, and individuals with disabilities (Spring, 2016). In the time since formal schooling began in the United States, being afforded the opportunity to learn has been described as a social justice issue that holds the potential to allow all citizens to participate equitably in society (Duncan, 2010).

With the passage of Public Law 94-142 in 1975, now entitled the Individuals with Disabilities Education Act (IDEA, 2004), students with disabilities in the United States were for the first time afforded the opportunity to become evaluated by their local public school district, create an individualized education program (IEP) with academic goals, and attend a comprehensive public school to the maximum extent possible in which they would be successful. A large body of research conducted since this time, however, has demonstrated that many populations of students with disabilities have struggled to become integrated into inclusive classrooms in a manner that equitably meets their academic, social, and educational needs (Alquraini & Gut, 2012; Klaver et al., 2016; Stalker, 2012).

In particular, many students who have developmental disabilities have historically found it challenging to navigate the expectations and norms of inclusive classrooms and consequently have endeavored to find ways to fit into these settings successfully (Katz & Mirenda, 2002). There are a multitude of different ways to define the term developmental disability. One commonly used description states that developmental disabilities are a series of neurobiological conditions that may impact a child's functioning in the areas of learning, thinking, language, communication, behavior, socialization, and mobility (Zablotsky et al., 2019). Examples of developmental disabilities as classified by the Centers for Disease Control and Prevention (CDC, 2019a) include autism, attention deficit hyperactivity disorder (ADHD), cerebral palsy, and fetal alcohol syndrome. Although scholars have noted that it can be challenging to determine the precise prevalence of individuals classified as having a developmental disability, best estimates from the American Academy of Pediatrics purport that approximately 17% of children in the United States between the ages of 3 and 17 years old have one or more diagnosed condition (Zablotsky et al., 2019).

In part due to these historical and systemic challenges, many students with developmental disabilities continue to spend the majority of their school career in excluded classrooms or special education placements where they remain socially isolated from their typically developed peers (Morningstar et al., 2017; National Council on Disability, 2018). Statistics regarding precisely how many of these students remain removed from integrated classrooms are challenging to verify (Yell, 2015). Though findings from the National Center for Education Statistics (NCES,

2019) demonstrate that roughly 95% of students with disabilities are enrolled in mainstream schools, students with developmental disabilities have historically struggled to get in through the door of mainstream classrooms (Katz & Mirenda, 2002). Moreover, federal placement data examined between the years of 2000 and 2015 revealed that students who were significantly impacted by a developmental disability were far more likely to be placed in a separate classroom or separate school than their typically developed peers (Morningstar et al., 2017).

Evidence shows that students in these socially excluded environments make less progress on long-term academic and social goals and graduate at lower rates than their socially included peers (U.S. Department of Education, 2018). This finding has led some scholars to question why students with developmental disabilities still struggle to learn in schools when a free and appropriate public education is a right afforded to all students in the United States (Ayres et al., 2011; National Council on Disability, 2018). As with many complex topics within the field of education, the answer to this question varies depending upon whom is asked and what philosophical background they hold to frame these issues.

Articulating the multifaceted needs of a heterogenous population such as individuals with developmental disabilities has long been a contentious process that has been taken up by a wide range of academic disciplines. For example, scholars from multiple fields of study including disability studies, special education studies, and developmental psychology posit that students with developmental disabilities languish in their school careers in part because society does not adequately understand the unique needs of this population; and, because educators fail to see their full potential for learning (Ayres et al., 2011; Buntinx, 2013; Harry & Klingner, 2007; Siegel & Allinder, 2005). As a result of this lack of understanding, some scholars argue that educators fail to celebrate the rich and diverse fabric of neurodiversity inherent in each student (Kapp et al., 2013; Robertson, 2010). Moreover, according to Watson and colleagues (2012), society has long seen individuals with disabilities as *others*, characterized as having medical, intellectual, and social deficits. In response to this entrenched societal attitude, educators have historically attempted to normalize students with developmental disabilities by trying to fix the deficits these students are perceived to have (Moore & Slee, 2012). Some argue that these practices still continue to this day and systemically prevent students with disabilities from self-actualizing through their own process of self-determination (Culham & Nind, 2003; Yates, Dyson, & Hiles, 2008).

By pursuing divergent lines of thinking, scholars from the field of disability studies advocate that educators – and society at large – must reconceptualize what it means to have a developmental disability by focusing on the strengths inherent in each student, not on what the student cannot do (Buntinx, 2013; Klein & Kraus de Camargo, 2018). In order to best accomplish this reconceptualization, disability theorists argue that educators must learn how to ascertain accurately what their students can accomplish by assessing their functioning in multiple developmental domains, such as cognition, language, and social-emotional understanding (Buntinx, 2013; Klein & Kraus de Camargo, 2018). Moreover, educators stand to benefit from learning more about their students than what traditional disability labels might convey (Florian et al., 2006; McDowell & O' Keefe, 2012). In particular, Battro (2010) calls upon educators to discover more knowledge about their students' brains and neurobiology, such as through the completion of additional teacher preparation coursework. Understanding the unique learning qualities inherent in each pupil may unlock valuable insights into who they are and what they need to learn in their best way.

Influential thinkers from the field of disability studies such as Kapp and colleagues (2013) have called for educators to utilize theoretical and pedagogical approaches that are designed to harness student strengths in multiple developmental domains in order to maximize these students' potential to learn. Semrud-Clikeman (2010) adds that, because learning is neurobiological in nature, it would stand to reason that educators would benefit from learning more about how their students' brains function and utilize strength-based intervention methods based upon this knowledge. However, researchers studying these issues have found few educational intervention methods currently being used that meet these specific aims (Battro, 2010; Klaver et al., 2016; Wood et al., 2005). Because scant literature exists identifying and evaluating such strength-based educational interventions, scholars have recommended that further research is needed on this topic and that educators may be well served by examining lesser explored theories that take a multidisciplinary approach towards helping those students succeed who have exhibited long-term challenges with learning (Dee et al., 2006; Hornby, 2015).

Conceptual Framework

Established less than 30 years ago, neuroeducation is an academic discipline that translates research from the fields of neuroscience and cognitive psychology into information intended to help educators better understand the learning needs of all individuals, including those who have neurodiverse minds and brains (Ansari et al., 2012; Feiler & Stabio, 2018). Traditional forms of neuroeducation, also referred to as Mind, Brain, Education or educational neuroscience, investigate research from two fields – neuroscience and psychology – and synthesize academic findings from these disciplines into scientific guidance for educators (Bruer, 1997; Fischer, 2009). While most versions of neuroeducation draw from these two fields alone, one iteration of neuroeducation called *Arwood's Neuro-Education Model* adds language as a third lens of study through which to view human learning and behavior (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016). For the purposes of this study, Arwood's Neuro-Education Model will be referred to as *Neuro-Education*.

Arwood (2011) argues that the analysis of language is of critical importance to the study of learning and development because language names the underlying neurobiological processes inherent in our thinking. By studying the language one uses to function in the world, researchers and educators can measure that person's capacity for complex cognition and social-emotional competence, called *language function* (Arwood, 2011). A thorough search of the literature uncovered many instances of scholars studying language, learning, and development as separate processes (Gauvain & Cole, 2009; Shaffer & Kipp, 2013). However, Arwood's Neuro-Education Model was the only framework discovered that considered language function as the cornerstone of both learning and development. Because this theoretical perspective is lacking in academic literature, scholars may neglect to understand a holistic description of the multifaceted components that undergird human learning (Arwood & Merideth, 2017).

Learning and Development

Picking up where fields such as disability studies or developmental psychology leave off, the discipline of Neuro-Education aims to empower educators by explicating how and why all individuals are neurobiologically unique. For example, Neuro-Education posits that teachers often struggle to help their pupils learn because few educators understand the symbiotic relationship between learning and development that unfolds in their students' brains, minds, and bodies (Arwood, 2011). In fact, the terms learning and development are sometimes used interchangeably in academic literature even though these concepts represent distinct processes that happen within each person (Masadeh, 2012). According to Arwood (2011), learning refers to the never-ending neurobiological process of cellular integration in the brain and the body, while development is exemplified by a set of products that someone learns how to do such as walking, speaking, or writing. The relationship between the forces of learning and development is inextricable, reciprocal, and ever-changing (Hoare, 2006; Latta, 2019).

Learning and development have been described as two sides of the same coin, where one cannot exist without the other (Khosrow-Pour, 2012). However, some assert that development results *from* learning (Salkind, 2004; Vinter & Perruchet, 2000), and therefore individuals with developmental disabilities experience delays in their maturation due to barriers impacting their learning (Reschly, Myers, & Hartel, 2002; Walker et al., 2011). Moreover, Arwood (2011) elaborates that learning occurs in an individual only when their brain increases its capacity to acquire sufficient amounts of language. Since language names our thinking, individuals must use their own language to grow, develop, become an agent, and eventually function in the world (Arwood, 2011; Robb, 2016).

Viconic Language Methods

By applying the theoretical framework of Neuro-Education into educational practice, Arwood (2011) developed a system of educational intervention methods, called *Viconic Language Methods*, that are designed to use knowledge about human neurobiology to help pupils acquire information through often-overlooked access points into their brains. Research conducted by Arwood (2011) has found that approximately 95% of students process information and think with a visual language system, meaning they make pictures, movies, and graphics in their mind's eye. Arwood explains that though students think visually, they are often taught using auditory methods such as oral lectures or activities devoid of contextual meaning. Instead, Viconic Language Methods (VLMs) harness the visual strengths inherent in students' brains by overlapping multiple – and meaningful – visual and motor input streams simultaneously (Arwood, 2011).

Examples of Viconic Language Methods include a teacher cartooning out ideas in real-time, where students watch the movement of the hand as it makes shapes. In addition, a practitioner may take a student's hand in theirs and trace over semantic content while simultaneously providing contextual narration of ideas. In these examples and many others, the movement of the hand coupled with additional visual input streams has been shown by research in neuroscience to connect to the motor cortex and then integrate overlapping visual pathways into input that is meaningful for the student (Gallese & Lakoff, 2005; Pulvermüller, 2013).

By nature of being alive and having a brain, all students hold the inherent potential to learn (Leffman & Combs-Orme, 2013). However, some students, especially those with developmental disabilities, do not learn and develop to their full potentials. According to Arwood (2011), these students may not have received educational input in a way that was conducive for their brains to process. For example, not receiving overlapping visual-motor input, like that provided by VLMs, may have jeopardized their opportunities to learn from a type of input that matched the intuitive workings of their brains (Xiang-Lam, 2016). In sum, the use of Viconic Language Methods with those students who have struggled to learn may be described as truly strength-based in that they are designed to capitalize on what a student can do well (Arwood, 2011; Rappolt-Schlichtmann et al., 2018). The use of these strategies would appear to match the aforementioned recommendations from disability scholars who advocated that educators must seek out alternative ways of helping students with developmental disabilities learn in school to their maximum potentials (Hornby, 2015; Kapp et al., 2013; Simpson, 2004).

Purpose of the Study

Scholars have argued that understanding the unique neurobiological learning profiles of individuals with developmental disabilities may help educators better address their learning needs (Howard-Jones, 2014; Lefmann & Combs-Orme, 2013). However, few interventions and pedagogical strategies were found in the literature that drew from scientific findings about the brain to propose novel ways of finding latent strengths for learning in those who have traditionally struggled in school (Battro, 2010). Arwood's Neuro-Education Model triangulates research from three overlapping disciplines of study to develop brain-based, strength-based educational intervention strategies called Viconic Language Methods. However, due to its status as an emerging academic field, few peer-reviewed studies have been conducted investigating what outcome Viconic Language Methods have upon students receiving these strategies.

While some recent research has measured the effects of Viconic Language Methods on neurotypical populations (Green-Mitchell, 2016; Jaskowiak, 2018; Kelley-Hortsch, 2018; Robb, 2016), a gap in the research currently exists investigating how these methods might help individuals with developmental disabilities learn and therefore become more fully integrated into inclusive classrooms. Therefore, the purpose of this retrospective single case study is to investigate the impact that Neuro-Education intervention methods have upon the learning and development of an individual with developmental disabilities.

Research Question

The following research question guided this inquiry: What impact do intervention methods derived from Arwood's Neuro-Education Model have upon a young individual with developmental disabilities' cognitive, linguistic, and social-emotional functioning over time?

Significance

Duncan (2010) maintains that the ability to learn is a social justice issue that should be afforded to all students, regardless of their race, gender, or disability status.

Learning is of paramount importance because students who cannot learn are effectively denied access to the world, and ultimately do not forge the trajectory for their own lives (Arievitch, 2017). Researchers studying the topic of learning, however, note that many students with developmental disabilities struggle to learn in school and be included with their peers in inclusive classrooms (Alquraini & Gut, 2012; Klaver et al., 2016; Stalker, 2012). There are a multitude of reasons that might explain these findings.

Teachers may, in fact, be ill-informed about how to help their struggling students because they do not sufficiently understand the neurobiological components to how humans learn and develop (Battro, 2010). Moreover, researchers have found sparse examples of educational intervention methods that utilize information about the brain to help teachers find latent strengths for learning among their students (Battro, 2010; Levine & Barringer, 2008). Consensus among many scholars from these academic fields is that new teaching, learning, and intervention methods are needed to help fill this void of knowledge about how to serve this traditionally marginalized population (Ayres et al., 2011; McGrew & Evans, 2004; Ryndak et al., 2001).

By using a grounded theory approach, Viconic Language Methods derived from Arwood's Neuro-Education Model were designed to help educators understand the needs and inherent strengths of the population in this study. Therefore, should these intervention methods positively impact students by helping them learn, they may provide one example of a theory and pedagogy that meets the academic and social-emotional needs of this population. Moreover, a fidelitous application of these intervention methods in a comprehensive school setting could potentially allow socially-excluded students to be integrated into a variety of inclusive classrooms, including settings in public school locations. Should this study find that the methods of assessment and pedagogies informed by Arwood's (2011) brain-based educational applications help this population learn, these findings may hold the potential to help reverse the historic trend of social isolation that students with developmental disabilities have faced for the past many generations (National Council on Disability, 2018).

Overview of Methods

Methods for this study were chosen to investigate the research question. A brief overview of the methods used to address this question is provided below.

Research Design

Literature relevant to the topic of academic attainment explains that observing changes in learning and development in individuals with developmental disabilities often takes considerable amounts of time, as progress to reduce gaps in multiple developmental domains can be exacting and slow (Hornby, 2015). In response to this reality, previously compiled sets of longitudinal data were sought out in which a practitioner had provided intervention methods derived from Arwood's Neuro-Education Model to students over the course of many years in a private clinical setting. Access to a series of student archived case files from this setting was granted, with each file containing drawings and writings compiled over long stretches of time from initial evaluation to stoppage of services. Included in each file were also qualitative case notes taken by the practitioner who provided intervention services that detailed notable observations of each student. Given the slow process of measuring developmental change articulated, a qualitative retrospective single case study research design utilizing the analysis of archived case file data best served the problem set out above, the purpose of this study, and stated research question.

Document Analysis

Drawing from the qualitative research paradigm, this investigation utilized the process of document analysis to review artifacts derived from the participant's case file (Bowen, 2009). In order to provide context to the set of documents gathered for the study, this investigation utilized two cognitive frameworks culled from related literature presented in Chapter 2: (a) learning, as represented by changes over time in the participant's capacity to use increasingly complex language to function (Arwood, 2011), and (b) development, as represented by observable changes in developmental products in the linguistic, cognitive, and social-emotional domains (Bruner, 1975; Edwards, 2016; Kohlberg 1983; Piaget, 1959; Vygotsky, 1962).

These two cognitive frameworks served as conceptual guides for how to interpret the artifacts in each case file and determine whether each document adhered to, or deviated from, this framework (Bowen, 2009). Through the constant comparative approach (Glaser & Strauss, 1967), this filtering process took place in the form of qualitative coding. Specifically, sets of *a priori* codes were taken from relevant literature and artifacts were interrogated such that the a priori codes were either confirmed or absent in the data. In addition, this process of coding revealed unanticipated, emergent codes (Bowen, 2009).

Specifically, a priori codes measuring learning were derived from propositions inherent in Arwood's (2011) *Neuro-Semantic Language Learning Theory* (NsLLT), a grounded theory of human learning designed to draw from all three lenses of Neuro-Education. The NsLLT analyzes aspects of individuals' language as representative of the underlying neurobiological complexity of their thinking. Such aspects include displacement, semanticity, flexibility, productivity, and redundancy (Arwood, 2011). A priori codes measuring development were derived from sets of norm-referenced, chronological, age-based developmental milestones covering the domains of language, cognition, and social-emotion (Bruner, 1975; Edwards, 2016; Kohlberg 1983; Piaget, 1959; Vygotsky, 1962; Travers et al., 2009).

Artifact Mediums

The artifacts that students create, such as drawings and writing, represent aspects of their thinking translated on to the page (Cherney et al., 2006; Papandreou, 2014). In addition, the behavior that students exhibit represents a form of communication that provides insight into their social-emotional functioning (Arwood et al., 2015; Siegel, 2001). Cherney and colleagues (2006) posit that everything that a student does or creates serves as an emblem of whom they are and therefore can be analyzed for meaning.

The case file for the participant selected for this study included multiple drawings and writings that they produced while receiving the Neuro-Education based interventions. In addition, these files contained brief qualitative notes written from the Neuro-Education practitioner. According to Rocco and Plakhotnik, (2009), it is important for the researcher to utilize specific methods of analysis that are tailored to match the specific medium they are examining. Taking this into consideration, this study utilized multiple processes of document analysis depending upon which medium (drawings, writing, or notes) was being explored.

Practitioner Interviews

Bowen (2009) advises that utilizing retrospective document analysis alone may expose the researcher to certain limitations, such as difficulty deciphering precisely which interventions were given at what time, or how the temporal relationship between artifacts unfolded in continuity. To guard against these disadvantages, this investigation incorporated additional data sources to provide multiple vantage points upon the data and reduce potential biases (Patton, 1990). One brief, semi-structured interview was conducted with the practitioner that was involved in working with the participant and collecting the data compiled in their case file. Sample interview questions included: (1) *What interventions did you generally do with the participant in this study?*, (2) *What is your assessment of the changes that the participant exhibited in learning over time during the period measured for this study?*, and (3) *What is your assessment of the changes that the participant exhibited in development over time during the period measured for this study?* Data from this interview were coded using a two-cycle inquiry process where first cycle open coding led to the establishment of second cycle patterns and themes (Saldaña, 2015). These two rounds of coding were then compared for consistency. A full list of questions asked can be found in Appendix A.

Yin (2003) informs that the use of multiple data sources of evidence coalesce through the process of triangulation, where the researcher seeks convergence of findings based upon diverse methods of analyses. In this study, triangulation occurred between the existing literature on the interplay between learning and development, analysis of pre-existing data files for the impact of Neuro-Education intervention methods, and analysis of the semi-structured interview transcript.

Summary

Neuro-Education is a multidisciplinary theoretical framework that triangulates literature from three different scientific fields to help educators assess students' developmental functioning in multiple domains and find students' strengths. While some recent research has measured the impact that intervention methods derived from Neuro-Education theory have had upon typically developed individuals, a gap in the literature exists measuring how these intervention methods may impact students with developmental disabilities in terms of their learning, development, and academic success. Studying intervention methods derived from the theoretical framework of Arwood's Neuro-Education Model may address the gap in current intervention literature regarding supporting and understanding the needs of students with developmental disabilities from multiple learning lenses. Viconic Language Methods may provide a strategy to provide information in a novel way that better matches the processing of students, thus helping them acquire new knowledge. In addition, helping students learn has been shown to increase their sense of agency, ultimately leading to greater self-determination (Morningstar et al., 2017). Lastly, students who are self-determined and who have developing strategies to learn on their own may be more holistically capable of succeed in inclusive school environments (Kapp et al., 2013; Wood et al., 2005). Students who succeed in school have been shown to hold a greater chance of meaningfully participating in society throughout their lives (Buntinx, 2013; Dee et al., 2006; Duncan, 2010).

This study utilized multiple methods of qualitative document analysis, as well as a brief semi-structured interview in an attempt to triangulate multifaceted perspectives of archived data into a rich, composite profile of the participant. By synthesizing these findings, and by being afforded access to a longitudinal data set, this investigation created detailed descriptions of the changes that the participant underwent over a period of years. Such synthesis allowed for a more accurate investigation into the impact that Neuro-Education intervention methods have upon the learning and development of individuals with developmental disabilities.

This concludes Chapter 1. A thorough review of literature pertaining to the topics investigated for this study is presented next in Chapter 2.

Chapter 2: Review of Literature

Literature relevant to the topics of this study was reviewed to understand more about the learning needs of students with developmental disabilities and how these needs might be better addressed in the future. Chapter 2 begins with an overview of who students with developmental disabilities are and how they are described in developmental and medical literature. Next, the history of how these students have struggled to be included in comprehensive classrooms since the advent of PL 94-142 is covered. Possible contributing factors to these challenges are addressed, including current default approaches to testing and teaching in U.S. schools. The academic discipline of disability studies is introduced as an alternative approach to elucidate the needs of this population.

The differences between a deficit-based and strengths-based model of educational assessment are explored next in Chapter 2. These factors are examined within the context of teacher education programs at higher education institutions. Research is explored documenting the lack of exposure to the role of the brain in learning in these preparation programs; this knowledge is shown as a possible route to understanding the learning needs of students with disabilities on a deeper level. Next, the study of neuroeducation is introduced. Arwood's Neuro-Education Model (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016) is explored and established as the conceptual framework guiding this investigation. Theories of language and intervention strategies particular to this model are presented.

Chapter 2 concludes with an examination of research depicting how to measure progress in students by analyzing the artifacts that they create. The lenses of development and language function are advanced as two reciprocal frameworks that can be used to measure changes in student-created artifacts. Lastly, the topics in Chapter 2 are summarized as a foundation that may address the learning needs of students with developmental disabilities and help foster their goals of self-determination.

Students with Developmental Disabilities

The concept of disability in American schools has long been a matter of contention (Buntix, 2013). Historically, disability-based labels have been assigned to students who are viewed as different by those from the dominant majority (Moore & Slee, 2012). In practice, this has meant that determining which students become identified as having a disability has been a divisive issue in both the academic community and society at large. One reason for this contentiousness is that literature relevant to the topics of development and disability defines both terms differently depending which academic discipline is used. For example, the field of medicine characterizes developmental disabilities as a series of neurobiological conditions that may impact a child's functioning in the areas of learning, thinking, language, communication, behavior, socialization, and mobility (Florian et al., 2006). Conversely, the discipline of disability studies counters the limitations imposed by this medical definition by proposing that the concept of disability itself is a social, cultural, and political construct (Society for Disability Studies, 2019). In addition, the academic area of developmental psychology aims to bridge these two viewpoints by exploring how nature (genetics) and nurture (social environment) may be inextricably interconnected in the development of each individual child (Sameroff, 2010). The study of the interplay between these two factors is frequently referred to as epigenetics (Shaffer & Kipp, 2013). For the purposes of this paper, these definitions and perspectives of developmental disability will be explored to provide a multidisciplinary context to this complex topic, and to attempt to view children with disabilities in a holistic and positively affirming manner.

Types of Developmental Disabilities

According to Klein and Kraus de Camargo (2018), to understand the learning needs of students with developmental disabilities, one must first acknowledge who is traditionally included under this diagnostic umbrella. Many educators and psychologists first learn of developmental disabilities through the lenses of epidemiological medicine and psychological classification (Florian et al., 2006). Thus, these two reference points are examined here.

As reported by the Centers for Disease Control and Prevention (CDC, 2019a), the term *developmental disability* is used to describe a wide-ranging group of chronic conditions that may impact one's mind and body. Public Law 106-42, entitled The Developmental Disabilities Assistance and Bill of Rights Act (2000), adds that developmental disabilities are considered life-long, occur in individuals five years of age or older, are onset before 22 years of age, and bring about significant functional impairments in three or more life capacities. The CDC (2019a) identifies 13 different classifications of developmental disabilities including: attention-deficit hyperactivity disorder (ADHD), autism spectrum disorder, cerebral palsy, fetal alcohol spectrum disorders, fragile x syndrome, hearing loss, intellectual disabilities, kernicterus, language and speech disorders, learning disorders, muscular dystrophy, Tourette syndrome, and vision impairments. Research conducted by the American Academy of Pediatrics (Zablotsky et al., 2019) has found that, of these conditions, those with the highest incidence rates in the United States are: ADHD (9.04%), learning disorders (7.74%), and other developmental delay (68%).

Cosier and Pearson (2016) remind educators that behind each of these labels is the story of a child who has their own unique identity and desires to be included in schools and society at large. Although much progress has been made to integrate these students into educational institutions over the past 50 years, scholars agree that more work is needed in this area (National Council on Disability, 2018). The history of inclusion in the United States public schools system is documented next.

Special Education

During the first 60 years of the 20th century, few children with developmental disabilities were afforded the opportunity to attend public schools (Webber, Plotts, & Coleman, 2008). According to Yell (2015), the prevailing approach towards youth with disabilities in the United States during this time period was to encourage parents to either homeschool their children, or to send them to state institutions where most remained hospitalized for their entire lives. Yell estimates that as recently as the early part of the 1970s, 1.75 million children with disabilities were excluded from attending public schools. At this time, the general belief among psychologists, educators, and the general public alike was that most children meeting these descriptions were ill-equipped to learn, and therefore did not stand to benefit from educational inclusion (Gajar, 1979; Talmadge et al., 1963; Webber et al., 2008).

Complicating these issues was the fact that by the start of the 1970s, scholars had been struggling for nearly 100 years regarding how to conceptualize, classify, and diagnose what it means to have a disability (Webber et al., 2008). In fact, these disagreements continue to this day. For example, Degener (2006) notes that not once over the past century has there been a universally accepted educational definition of what it means for a person to have a developmental disability. This lack of consensus has hindered multiple generations of educators seeking guidance about how to work with children of this population; and, has spurred others to advocate for new ways of classifying those children who exhibit learning differences (Delano et al., 2008).

In 1975, Congress passed the Education for All Handicapped Children Act (Public Law 94-142) which, by law, afforded all children in the United States, including those with developmental disabilities, the right to attend a comprehensive public school that met their educational needs (IDEA, 2004). With PL 94-142 granting a new cross-section of students' access to public education, academics quickly began to wrestle with how to best socially include a population that is, by nature, diverse and heterogeneous (Alquraini & Gut, 2012).

Inclusion

By law, IDEA states that all students have the right to be educated in the least restrictive environment (LRE) in which they will most likely experience school success, irrespective of the specific nature of their condition (IDEA, 2004). In the 45 years since the passage of PL 94-142, school districts have been required to adopt an institutional policy of inclusion, where students with disabilities are designed to be incorporated into mainstream, general education classrooms with neurotypical peers to the fullest extent possible (McLeskey, Landers, Williamson, & Hoppey, 2012). This inclusion mindset dovetails with the philosophy of the service delivery model, which is a design embedded into the concept of special education that dictates that appropriate support services are supposed to follow the student into any classroom – not have the student go to specific classrooms to receive appropriate services (Kysilko, 1992).

According to extensive research conducted by the National Council on Disability (2018), receiving an inclusive education has been shown to result in the best learning outcomes for *all* students, regardless of their disability status. The National Council on Disability has found no research that supports the value of students being segregated or excluded from comprehensive classes. In a related study, Delano and colleagues (2008) found similar outcomes, leading the authors to conclude that all educators receiving a license to teach today should know how to educate all students, even those with moderate to severe disabilities, in inclusive general education settings. Reviewing the history of inclusion of students with disabilities in the United States over the past 45 years reveals both a mixture of positive findings and unsatisfactory shortcomings. The history of these narratives is covered in the ensuing sections.

Gains in Rates of Inclusion. Scholars remain in consensus that more students today are included in mainstream classes than ever before (Friend, 2018; Yell, 2015). Nevertheless, calculating exactly how rates of inclusion have changed since IDEA's passage is impracticable due to large fluctuations in the U.S. population over the past 45 years. While precise statistics on this topic remain unavailable, some positive trends have been established in the literature. For example, Yell and Shriner (1997) cited figures from the U.S. Department of Education showing that students who qualified for special education services increased 23% between the years of 1976 and 1990. More recently, the percentage of students receiving these services has plateaued, and in some cases declined. However, according to the National Center for Educational Statistics (NCES, 2019a), as of 2018 approximately 95% of students between the ages of 6 and 21 were enrolled in regular schools. The NCES further reported that in 2018 only 3% of students were served solely in special schools and less than 1% of students were homebound or in hospitals.

Lack of Inclusion. While research is clear that progress has been made at increasing the numbers of students with developmental disabilities into mainstream classroom settings, a multitude of scholars point to other signs and indicators that more work is needed for this population to reach its educational potential in these settings (Ayres et al., 2011; McGrew & Evans, 2004). According to Grieco (2019), part of the breakdown in the larger promise of educational inclusion in the United States may stem from the fact that school districts have primarily focused on making sure they are in compliance with federal law, or looking good ‘on paper,’ without actually doing the hard work of putting these plans into action. For example, much research conducted since the passage of IDEA has consistently demonstrated that, despite having an institutional policy to prioritize inclusion, public schools have struggled to integrate students with developmental disabilities into existing school programs in a manner that adequately meets their academic and social needs (Alquraini & Gut, 2012; Klaver et al., 2016; Stalker, 2012). Moore and Slee (2012) frame this finding more simply by stating that, despite over 40 years of trying, schools still have not learned how to educate this population in an equitable manner.

Though findings from the National Center for Education Statistics (NCES, 2019) demonstrate that roughly 95% of students with disabilities are enrolled in mainstream schools, students with developmental disabilities have historically struggled to get in through the door of mainstream *classrooms* (Katz & Mirenda, 2002). As a result of these struggles, a large number of students from this population still spend at least a portion, if not all, of their school career receiving their instruction in segregated environments (Morningstar et al., 2017; National Council on Disability, 2018). Though the NCES has documented that only 3% of students receiving special education services are served in special schools, students with developmental disabilities are much more likely to be placed in these secluded settings, according to Wilczynski and colleagues (2007). Many types of specialized classrooms still serve large numbers of students with disabilities today. These types of classrooms, and the impact that they have upon students' long-term well-being are explored in the following sections.

Types of Educational Classrooms. Where students with developmental disabilities are physically placed in schools matters because each type of classroom comes with a different set of academic and social expectations (Kysilko, 1992). For example, students with developmental disabilities frequently receive their education in specialized classrooms that often have distinctive designations such as *life skills*, *functional behavior, or adaptive behavior* (Council for Exceptional Children, 2019). What most of these classrooms have in common is that in place of traditional academics they primarily focus on helping students acquire the kinds of fundamental skills necessary for independence later in life, such as toileting, food preparation, housekeeping, home safety, mobility skills, and money management, among others (Council for Exceptional Children, 2019). In fact, research has found that the more impacted a child is by their exceptionalities, the more likely teachers are to overlook that child's academic needs and instead focus exclusively on activities of daily living (Wilczynski et al., 2007). Moreover, some researchers have found that these tasks of daily living can take up the majority of students' day-to-day school schedules (Morningstar et al., 2017). Katz and Mirenda (2002) write that these practices continue to deny students the kind of education that PL 94-142 initially promised. For example, in their study Katz and Mirenda found that educators teaching this population only infrequently implemented rigorous academic routines. Despite writing individualized education programs (IEPs) that prioritized working on academic content, educators in these life skills classrooms instead taught watered down competencies, because students were deemed incapable of striving for more rigorous instruction (Katz & Mirenda, 2002).

Effects of Educational Seclusion. Today, educational scholars note that regular exclusion of students with developmental disabilities into secluded settings, such as life skills classrooms, prevents these students from accessing high quality curriculum and precludes them from developing social interactions with typically developed peers (Berns, 2016; Friend, 2018). In fact, Boutot and Bryant (2005) found that those students with autism who had fewer academic IEP goals were more likely to wind up in more restrictive placements. Such trajectories ultimately detract from the educational and social benefits of both those students with or without disabilities (Katz & Mirenda, 2002).

Over the course of their school careers, students with developmental disabilities who engage in life skills curriculum take longer to graduate high school and more frequently complete academic programs that are less rigorous in nature (U.S. Department of Education, 2018). Despite working on life skill competencies until the age of 21, many students with developmental disabilities never develop the ability to function independently and subsequently require adult living assistance for their entire lives (Ayres et al., 2011). Some researchers (Ayres et al., 2011; Patton, Cronin, Bassett, & Koppel, 1997) have questioned whether such basic skills curriculum sufficiently challenges these students to reach their full potentials. Given these findings, some theorists have argued that society must challenge the merits of these low expectations and that humankind would stand to benefit from viewing students with developmental disabilities in a new, more positively affirming light (Buntinx, 2013; Stalker, 2012). Before this can happen, some argue, society must recognize how default approaches to testing, teaching, and labeling have shaped how these students have been perceived by others (Florian et al., 2006; Moore & Slee, 2012). These considerations are explored in greater detail in the subsequent section.

Default Approaches to Testing and Identification

The history of how students with disabilities have become identified for special education services over the past 45 years reveals a story of a society that has been compelled to rank, order, and classify its citizenry (Park, 2019). Starting with intelligence quotient (I.Q.) measurements in the late 19th century and evolving into multi-subject batteries such as the Wechsler Intelligence Scales in 1955, the field of special education has used testing as its primary mechanism for developing a profile of each students' intellectual and social capacities (Overton, 2016; Reschly et al., 2002). According to Walker (2014), the practice of testing to compare students to one another significantly ramped up under the No Child Left Behind act. The author calls U.S. school systems today 'obsessed' with norm-referenced testing. The fact that testing is ubiquitous in schools has not prevented some scholars from advocating that current approaches to identifying students with disabilities and recommending them for specialized services may warrant further scrutiny (Harry & Klingner, 2007; Siegel & Allinder, 2005). These issues still remain factious to this day, and as a result are explored in further detail in the following sections.

Testing

At its core, the concept of testing incorporates the psychometric principle that data are valuable when findings can be compared to other data in a systematic manner (Michell, 1997). In schools, students take tests to demonstrate that they have developed mastery of a subject. Testing for content knowledge by design requires that some students' answers (data) are considered acceptable, while others are deemed incorrect (Overton, 2016). These same principles of testing are also used by educational psychologists and medical practitioners when they identify a student as having a disability. In practice, this means that a student who struggles to perform in school over an extended period of time is first flagged for further examination (Friend, 2018). If their lack of school success continues, these students then take a wide range of diagnostic tests in multiple subject areas. The work they complete on these tests is then compared against norm-referenced data (Overton, 2016). Here, norms refer to the skills and aptitude that would be expected for students to perform successfully at various chronological ages (Gay et al., 2012).

Testing is seen as holding statistical validity when it compares students against very large norms, sometimes referred to as ‘sample sizes’ (Price et al., 2018). Muijs (2011) explains that the practice of testing or comparing various data sources to draw comparisons forms the cornerstone of quantitative research analysis. Educational psychologists, the personnel most frequently involved in screening and then testing students for disabilities, have grounded their diagnostic methods in this quantitative analysis episteme since the beginning of the 20th century (Price et al., 2018).

Educational Screening

After the passage of PL 94-142, schools were directly tasked with educating a new cross-section of society and looked to implement systemic testing practices to screen students for their relative levels of academic competence (Webber et al., 2008). According to Gibbons and Warne (2019), one of the first challenges that educators faced was deciding upon which measurement devices to use to classify students’ level of intelligence. The impetus of this challenge was practical: educators needed an efficient way to determine which students might be able to be included in mainstream classes, and which students would be better served in specialized placements. At this time, the use of intelligence tests had become widely accepted as an accurate and scientific approach to measuring students’ academic abilities (Overton, 2016). As such, standardized tests of intelligence became the de-facto tool to screen students for having a developmental disability (Reschly et al., 2002). Today, the use of such tests has been questioned by scholars who find their inequitable historical origins to be troubling (Harry & Klingner, 2007; Siegel & Allinder, 2005). However, despite these critiques of their usage, intelligence tests are still used to this day to develop cognitive profiles for a wide range of student populations, including many students with developmental disabilities (Overton, 2016).

Historical Origins of Intelligence Testing

The use of tests to characterize human intelligence is a practice with long historical origins. Beginning in the late 1800s, educational psychologists such as Alfred Binet and Theodore Simon began using norm-referenced standardized intelligence tests to determine an individuals' intelligence quotient (I.Q.), or general cognitive aptitude (Gibbons & Warne, 2019). Scores on these IQ measurements are designed to vary from the 90-109 range, generally considered average, to a score of 69 or below, classified as extremely low (Overton, 2016). The IQ score that a child receives after taking such tests has long been used as an indicator not only of how intelligent that child is, but also of what could be expected of that child over the course of their lifetime (Price et al., 2018). Part of the reasoning behind this logic is that for many years psychologists have demonstrated that, although fluctuations may occur, IQ scores typically do not change substantially after a child has passed adolescence, especially for individuals with moderate to severe cognitive disabilities (McGrew & Evans, 2004). As such, such composite intelligence scores have long been used as cognitive markers that outline a child's likely educational future.

Educational Diagnoses

In 1979, psychologist Anna Gajar outlined a set of educational recommendations for adults to follow when working with individuals who scored below 69 on such tests of intelligence. According to the author, a student with an IQ score range between 60 and 69 was considered an *educable mentally handicapped person*, meaning they should be expected to attend at least a few remedial classes offered in comprehensive schools alongside some typical peers. Students with an I.Q. score between 40 and 59 were labeled *trainable mentally handicapped* and were only expected to learn the most basic reading, writing and math at a kindergarten level or below. The term *trainable* referred to their perceived lack of capacity to attend grade-level courses with their peers. Students with scores below 40 were classified as *severely* or *profoundly* handicapped. Severely handicapped students were not expected to master even the most basic living skills needed to care for oneself. In the mind of many psychologists at the time, this meant that they were destined to require an adult to care for all of their needs throughout their entire life (Gajar, 1979; Hannam, 1975).

Today the terms 'mentally handicapped' and 'educable' are no longer used to describe students with disabilities. Nevertheless, Francis and colleagues (2005) observe that new terms have replaced them such as 'intellectual disability'. A recent report by the American Educational Research Association (2014) explained that though some diagnostic terms used for this population have been updated, many special educators still divide students into ability groups based upon these original I.Q. designations. Moreover, MacMillan and Siperstein (2002) found that the diagnostic label a student with disabilities received determined what their school experience would be. In fact, some scholars have noted that students with moderate to severe developmental disabilities, such as those with overtly noticeable iterations of autism or Down syndrome, might only rarely see the inside of a mainstream classroom during their school careers (Wilczynski et al., 2007).

Critiques of Educational Diagnoses. Over time, some educational researchers have taken issue with the way that students with developmental disabilities have been identified for special education status (Gould, 1981; Siegel & Allinder, 2005). For example, Francis and colleagues (2005) argue that testing young students at a single point in their schooling careers only provides a single snapshot in time of how they are functioning in multiple developmental domains. They contend that using only one isolated viewpoint of the student is not psychometrically sufficient for determining the long-term trajectory of their edification.

In addition, other researchers have questioned whether the use of some common diagnostic tests such as the Kaufman Assessment Battery for Children or the Woodcock Johnson Test of Cognitive Ability is appropriate for students with moderate to severe developmental disabilities (Siegel & Allinder, 2005). Sattler and Dumont (2004) explain that in order for a student to take these tests under standardized protocols, that student must be able to hear, understand directions, have sufficient vision, and demonstrate ample fine motor skills. These authors question whether such tests allow for an accurate depiction of what students with developmental disabilities can or cannot do, let alone provide an accurate comparison of how these students' scores measure to normed data (Sattler & Dumont, 2004; Siegel & Allinder, 2005).

According to Reschly and colleagues (2002), the critiques surrounding the usage of the psychometric testing paradigm as the vehicle for identifying students for special education services can be traced back to the implementation of I.Q. tests at the advent of PL 94-142. These authors claim that the decision to utilize these tests as the gold standard diagnostic tool of disability effectively provided scientific evidence that would confirm previously held beliefs that these students were unable to learn. In turn, this set the stage for society to view this population as unable to measure up to typically developed students (Reschly et al., 2002). MacDonald and Valdivieso (2011) expounded upon the use of the testing paradigm for educational diagnostic purposes by stating, “The data we now collect give us at best inadequate and often misleading information about young people; that, in fact, our dominant approach to data collection—learning what is *wrong* with young people—is fundamentally flawed” (p. 150).

The complex issues surrounding testing and identification of disability may continue to be unresolved for many years to come. Nevertheless, some scholars argue that examining default testing practices is important because how we test our students ultimately informs how we teach them (Klein & Kraus de Camargo, 2018; Suskie, 2009). As such, literature examining default approaches to teaching students with disabilities is documented in the following sections.

Default Models of Teaching

According to Suskie (2009), teaching and testing form a reciprocal relationship for the educator, as one practice defines the implementation of the other. Put another way, many teachers teach to prepare students for the tests they will take. For example, depending upon which subjects they teach, educators must demonstrate that their students have met a long list of learning targets set forth by state and federal mandates on an annual basis (Friend, 2018). Testing entire classrooms provides an educator with a bevy of information about what their students know and do not know in relation to these learning targets. Those students who demonstrate sufficient competence in each subject area remain on a long-term path towards likely continued success and graduation, while those students who perform below benchmarks on their tests are classified as deficient and needing remediation in one or more areas (Katz & Mirenda, 2002). The rationale frequently given for providing remediation to those students who struggle stems from educators' default tendency to help individuals make progress on their deficits (Buntinx, 2013). Over time, and with enough specialized instruction, remedial education is seen to help struggling students catch up academically with their peers (Vaughn et al., 2002). However, other authors have questioned whether this approach merely perpetuates historical approaches of *normalization,* or forcing children to fit a mold (Moore & Slee, 2012). A review of literature encompassing these topics found that remedial practices remains a commonly identified approach utilized by special educators to this day (Cosier & Pearson, 2016; Buntinx, 2013). These default approaches and models of teaching are examined further here.

Current Educational Interventions for Students with Developmental Disabilities

Over the past few decades, scholars have conducted various meta-reviews of literature describing educational intervention practices for students with developmental disabilities and have found that remedial education practices have been common for students with developmental disabilities (Klaver et al., 2016; Vaughn et al., 2002; Wood & Shears, 2018). For example, Vaughn and colleagues (2002) examined research conducted between 1975 and 2000 describing the outcomes of various intervention approaches for students with learning disabilities and emotional/behavioral disorders in general and specialized classrooms. In their searching, the authors found numerous examples of interventions that were derived from the philosophy and approach of remediation. The merits of this approach were questioned. In the 16 studies that met their inclusion criteria, the authors found abundant evidence of low-quality reading instruction, limited time dedicated to direct instruction strategies, and wasted time engaged in academic tasks unrelated to the lessons at hand. In response to these findings, these authors concluded that none of the strategies provided to the students in these studies could be deemed as successful at meeting the stated goal of helping struggling students catch up academically (Vaughn et al., 2002).

In a related review of literature, Klaver and colleagues (2016) studied interventions designed for students identified with social-emotional disabilities, such as students with behavioral disorders or trauma-inflicted adversities. In a summary of their findings, these authors noted that both general and special educators greatly struggled to meet the needs of those students exhibiting behavioral or social-emotional challenges. The authors found that teachers in more than half of the reviewed studies utilized social-emotional intervention strategies that could be classified as informal and unsystematic. Simpson (2004) conducted a similar, yet less extensive meta review. Findings from this study suggested that special educators frequently utilized methods that promised extraordinary results yet had not been validated by empirical research. Lastly, Hastings (2005) summarized similar phenomena by stating that special educators struggled to translate theoretical knowledge about students with disabilities into clinical and educational practices. These findings have been echoed by additional educational research scholars such as Wood and colleagues (2005), and Siegel and Alinder (2005) who have noted an overall lack of pedagogy for students with disabilities that is directly grounded in academic theory designed for this population.

Further Critiques of Remedial Practices. Other scholars surveying the field of special education have found additional reasons to question the default approaches to testing, teaching, and the identification of students with disabilities (Ayers et al., 2011; Delano et al., 2008). Primarily, these criticisms revolve around the finding that providing remedial practices to students in secluded settings pulls them away from being exposed to life in a typical classroom. As schools are frequently viewed as microcosms of larger society (Kirby, 2016), in effect this seclusion means that students are provided fewer opportunities to learn the ropes of socialization and spend less time trying to fit in with their peers.

Other academics such as Rappolt and colleagues (2018) take moral issue with the impact that remedial practices have upon children. In their view, students that are deemed deficient are devalued for what they do not know or cannot do (Rappolt-Schlichtmann et al., 2018; Wood & Shears, 2018). Critics state that the opposite should be occurring: teachers should be tasked with using any means available to find student strengths, or what their pupils can do – sometimes referred to as capacity building (Rappolt-Schlichtmann et al., 2018). According to Wood and colleagues

(2005), interventions provided to students with developmental disabilities in school settings should be designed to increase their level of academic independence so that they can maximize their potential to succeed in increasingly less-restricted environments.

In an attempt to summarize the status of special education today, Hastings (2005) identified that the lack of theory-based educational intervention methods in the field is interrelated to the lack of research exploring new possible pedagogies. According to Gallagher (2004), the reality of this situation leaves students with developmental disabilities in a double bind where: (a) existing pedagogies have been shown to not meeting their needs, and (b) sparse research studies exist that might guide educators into trying new pedagogies. Hastings (2005) argues that both of these conditions constitute gaps in educational research that will require further attention moving forward. Reflecting upon these realities, Simpson (2004) concludes that in order for the field to move forward there will need to be new identification processes and new theory-based intervention strategies designed specifically for individuals with development disabilities and other pronounced learning needs.

Reconceptualizing (Dis)ability

Thus far, this review of literature has provided an account of the approaches that the United States has used to address the learning needs of students with developmental disabilities, as well as how these approaches have sometimes disenfranchised these individuals and left them marginalized in U.S. schools (Culham & Nind, 2003; Moore & Slee, 2012). One relatively new academic discipline, the field of disability studies, approaches these issues from an alternative perspective.

According to Watson and colleagues (2012), disability theorists share what might be considered intransigent views to the topics of learning, neurodiversity, and the labeling of individuals who experience the world differently. This worldview provides alternative entry points into the topics encompassing this study; and, because these views may add a multidisciplinary perspective to this topic, provide rationale for additional investigation.

Disability Studies

Comprised of scholars and thinkers from a wide variety of backgrounds, such as critical theorists, philosophers, and social justice advocates, the realm of disability studies takes a distinct view of how differences in learning and development may affect human beings and their experiences of navigating the world. Though their work and ideas have long been studied in higher education courses as a relatively niche area of concentration, these theories have not yet found their way into the kinds of coursework geared toward preparing preservice teachers for future educational practices (Cosier & Pearson, 2016). Thus, many educators may not be familiar with this field. Despite this, insights from disability theorists have made their way into other areas of society such as law, sociology, art, politics, economics, and more (Watson et al., 2012). One of the main motivations of disability theorists is to push for humanity to expand its view of the concept of disability to conceive of it as a social construct that is continuously in flux and updated as new understandings emerge (Watson et al., 2012). In sum, the field of disability studies is focused on improving the lives of individuals with disabilities and furthering their civil rights and self-empowerment (Society for Disability Studies, 2019).

Rethinking Inclusion

Over the past 40 years, disability theorists have been calling upon society to fundamentally reform how it conceptualizes the process of inclusion (Watson et al., 2012). Echoing the aforementioned arguments shared by the National Council on Disability (2018), these critics have long stated that public neighborhood schools should by definition be required to serve every single student that resides in their catchment area, regardless of that student's developmental profile (Moore & Slee, 2012; Yates et al., 2008). Achieving this goal, however, would require school professionals at all levels to radically alter their placement practices of students with disabilities. To start this transformation, disability critics have outlined a series of steps that educators must complete if they are earnest about upholding their role in this restructuring process.

Abandoning Deficit-Based Thinking. Many disability theorists have challenged the traditional way that society has identified individuals with disabilities; that is, by cataloging their deficits, or what they cannot do (Buntinx, 2013; Stalker, 2012). To surpass the existential weight that these classifications have imposed upon both disabled and non-disabled individuals alike in society, disability theorists propose that entirely new frameworks and theoretical models are needed to understand the true essence of what it means have physical, cognitive, and social differences. By reframing disability solely in terms of differences – and not lack of abilities – these scholars hope to promote the viewpoint that all humans exist on a spectrum of *neurodiversity*, where humans actually have more that unites us than divides us neurobiologically (Kapp et al., 2013).

Being encouraged to find strengths among all students pushes educators to understand the notion that a disability does not define a person’s limitations, but instead provides alternative avenues of helping them learn and develop. Disability scholars argue that if all teachers – both general educators and special educators – understood and believed in this philosophy, society might stop erecting barriers for inclusion of students with developmental disabilities, and instead make efforts to fully involve them in comprehensive classrooms with typically developed peers (Friend, 2018; Moore & Slee, 2012; Singer, 2017).

Finding Inherent Strengths in Students. Many scholars, including disability theorists, advocate that educators can most positively impact their students with disabilities by taking a refreshed look at *who* these children are as individuals (Dee et al., 2006; Singer, 2017; Wood & Shears, 2018). More specifically, educators can reconceptualize what it means to have a disability by focusing not on what students cannot do, but instead on what they can do (Buntinx, 2013; Singer, 2017). This practice of shifting one’s mindset helps educators find the inherent strengths of their students and may uncover learning abilities possessed by their pupils that have never been harnessed before.

To help identify inherent strengths among students with learning differences, some theorists have advocated for society to pay less attention to the labels that are used to define disabilities, and instead focus more attention on determining how each individual with physical or learning differences functions in multiple domains (Klein & Kraus de Camargo, 2018). One of the reasons for doing this is that professionals working directly with these students may mistake getting to know the diagnostic description of the individual with getting to know the lived experiences of the individuals themselves (Klein & Kraus de Camargo, 2018). Instead, determining how a student functions in the world has been described as tantamount to understanding how their mind and brain uniquely processes their surroundings (Howard-Jones et al., 2009; Plomin, 2010). This is because our past experiences of the world neurobiologically modify and shape how we interpret our present reality (Shaffer & Kipp, 2013).

According to Kapp and colleagues (2013), the most effective way to find these strengths is not by testing students on norm-referenced devices, as these will primarily compile a list of skill deficits. Instead, educators can carefully assess students in multiple developmental domains by using a variety of formal and informal observations of their applications of cognition, uses of language, and applications of behavior. Such practices aim to celebrate neurodiversity rather than catalog differences from the norm (Kapp et al., 2013). MacMillan and Siperstein (2002) note that though the terms ‘testing’ and ‘assessment’ are often used interchangeably by educators, these two practices are fundamentally distinct. As such, these concepts are detailed further in the section after next.

The Need for Strength-Based Interventions. Lastly, while finding strengths in their students is considered a positive first step by many disability theorists, educators must also know how to harness these strengths into action if they wish for their students to make new academic progress (Klein & Kraus de Camargo, 2018). However, scholars that have reviewed literature relevant to these topics have found scant examples of such strength-based theoretical, pedagogical, or intervention methods in the current research episteme (Klein & Kraus de Camargo, 2018; McDowell & O'Keeffe, 2012). Moreover, the intervention methods that currently do exist for students with developmental disabilities have been shown by years of research to be ineffective at promoting functional independence in students with moderate to severe learning challenges (Ayres et al., 2011; Vaughn et al., 2002).

Educators working with this population frequently find themselves stuck between a lack of access to quality pedagogies and a dearth of contemporary learning theories that are designed to inspire new teaching practices (Gallagher, 2004). Moreover, as research has demonstrated, many existing learning theories, pedagogies, and interventions for students with developmental disabilities do not incorporate knowledge about the brain and human developmental domains into their design (Battro, 2010). This lack of knowledge deprives educators of some of the most essential information they need in order to truly help their students thrive. The disconcerting nature of these findings has led some authors to suggest that the field of special education would be well served to venture into new – and potentially underexplored – areas of educational research in order to try augmented approaches toward serving a population that has historically struggled to learn in schools (Dee et al., 2006; Simpson, 2004). Summarizing this viewpoint, Hornby (2015) states that the field of special education needs a new long-term vision and outlook if it is to make progress at including students with developmental disabilities in more inclusive settings.

Strength-Based Assessments

Traditionally, many educators have confused the terms 'testing' and 'assessment' despite the fact that their design and administration are fundamentally different. Bowman and colleagues (2001) explain that tests refer to standardized instruments that hold the purpose of systematically comparing an individual to their peers from a norm-referenced population. Testing writ large in education can most easily be visualized as the bell-shaped curve, where student scores are placed alongside each other corresponding to which percentage of the curve most accurately describes their numerical delineation (Gay et al., 2012). Assessments, on the other hand, may consist of a wide variety of formats such as observations, adaptive behavior assessments, performance evaluations, or analysis of student-created artifacts (Bowman et al., 2001). Importantly, many measurement devices that claim to be assessments are actually norm-referenced in design (Bowman et al., 2001).

Deixis Approach

Deviating from the realm of norm-referenced measurements, some researchers have concentrated less on a global response to the limitations of functional assessments, but instead have advocated for educators to probe students using a process that is customized to each pupil. For example, Arwood (2011) developed an alternative qualitative method for assessing the developmental functioning of students that can be described as a process of interpersonal *deixis*. The concept of deixis originates from the field of linguistics, where researchers note that the meaning behind our words changes depending upon where, when, how, and why that language is used (Lyons, 1977). Just like how our use of language can vary, so too does our use of gestures, eye movement, finger pointing, facial expressions, and virtually any other act of body language (Arwood, 2011; Todisco et al., 2020).

In practice, this means that educators must learn to pay precise attention to the body language that their students exhibit. This tenet is especially relevant when working with students who have moderate to severe developmental disabilities. Language and communication capabilities in this population may appear at first to be inaccessible to educators; but, upon closer inspection, one can learn to see the meaning behind subtle expressions. For example, due to expressed difficulties in sound articulation, students with moderate to severe developmental disabilities are often not understood by the adults around them when they attempt to vocalize (Boutot & Bryant, 2005). Deixis, however, informs that everything that a person does with their body could be interpreted as communication (Arwood, 2011; Todisco et al., 2020). Examples of this include how some students with profound disabilities reply to yes or no questions by moving their eyes towards different parts of the room or contorting their mouth to make specific shapes (Ayres et al., 2011).

The concept of deixis is also supported by research in neuroscience. For example, by nature of being alive and having a brain, humans can engage with their surroundings, even if this engagement is only on a rudimentary level (Baars & Gage, 2010). Thus, at its core the deictic process utilizes the principle that everything that a student does must be understood within the semantic context of their particular circumstances. The significance behind these findings means that every individual act that a student performs has inherent meaning. An educator who uses the lens of deixis eventually becomes trained to seek out the semantic meaning behind every piece of behavior that a student exhibits (Arwood et al., 2015). Adopting this frame of mind propels educators to pay close attention to the behavior of their students; and, even more importantly, to attempt to decipher what this behavior may be communicating.

Educators Struggle to Find Strengths

Thus far, this review of literature has demonstrated that the default approaches used in U.S. schools of testing/assessing students to find deficits, diagnosing students with disabilities based upon these deficits, and providing remediation to help students more closely align with the normative culture are all interconnected (Harry & Klingner, 2007; Katz & Mirenda, 2002; Moore & Slee, 2012). However, because these practices are so widely utilized, they are considered by some to be ingrained into conventional wisdom and are thus infrequently challenged (Buntinx, 2013; Rappolt-Schlichtmann et al., 2018). According Semrud-Clikeman, (2010) educators may benefit from reconceptualizing the way that they understand learning as it relates to students with disabilities. Specifically, discovering new strengths in students may require educators to learn more about potentially untapped aspects of students' brains and neurobiological learning systems (Semrud-Clikeman, 2010). As stated by Howard-Jones and colleagues (2009), however, these subjects are rarely covered in teacher education programs.

According to Owens and Tanner (2017), the fact that research about the brain is not regularly infused into teacher preparation programs severely limits educators' understanding about the true meaning of having neurobiological, developmental differences. Moreover, teachers may continue to struggle to find untapped student strengths for learning if they do not acquire such scientific knowledge. Rock and colleagues (2008) argue that because teachers do not study brains and biology in detail, they may not be aware of their capacity to help students with developmental disabilities overcome and transcend their developmental conditions. Despite the overwhelming amount evidence about the brain's role in learning and development, few teachers receive specialized coursework in exploring how differences in the brain might result in differences in development (Semrud-Clikeman, 2010). Even more, the accuracy of the little training that teachers do currently receive about learning and development has been called into question by some educational critics (Battro, 2010; Semrud-Clikeman, 2010). These findings have caused scholars from multiple fields to call for teacher preparation programs to incorporate knowledge about the brain and human development into all of their coursework; and, revamp how the act of learning itself is conceptualized by these institutions (Ansari et al., 2012; Fischer, 2009).

Teachers and Brain Research

Though brain research has not been incorporated into many teacher education programs, some scientific advocates have found success in translating their work into a few select institutions of higher education. Over the past 30 years, scientists from around the world have made coordinated efforts to make knowledge about the brain accessible enough for educators to use in order to better serve the needs of their students that have struggled to learn (Feiler & Stabio, 2018). Various global groups and universities have interpreted this academic quest slightly differently, resulting in multiple names and iterations of brain-based education being used. For example, the largest academic society in this field is called *Mind, Brain, and Education*, or MBE (Fischer, 2009). Based primarily out of Harvard University, MBE seeks to translate findings from research in the fields of neuroscience and cognitive psychology into units of knowledge that might help inform educators about how to provide instruction to their students (Fischer, 2009).

Other iterations of brain-based research-into-practice use the terms *educational neuroscience,* or *neuroeducation* to describe their pursuits. Similar to MBE, many different iterations of neuroeducation exist. Although differences do exist between these models, some authors have recently compiled key components that exist in common between them all. For example, Feiler and Stabio (2018) conducted a meta-review of literature to determine the most common epistemological themes that make up the field of neuroeducation. Out of an original 501 articles reviewed, the authors culled their list to 64 articles meeting inclusion criteria. By analyzing only these included articles, the authors distilled their findings to define the field of neuroeducation using three overarching criteria. These were: (a) application of neuroscience to classroom learning, (b) interdisciplinary collaboration, and (c) translating knowledge between fields as an interpretive practice (Feiler & Stabio, 2018). These three tenets provide the backbone for most iterations of neuroeducation.

Contributions of Brain Research to Education

In many preparation programs that adopt brain research into their curricula, pre-service teachers study about the neurobiological processes that underlie human learning. The rationale for this study stems from the axiom that teaching practices themselves are only functionally useful if they result in demonstrable changes in learning among pupils (Battro, 2010). Moreover, because learning occurs in the brain then this means that understanding how this organ operates is of fundamental importance (Feiler & Stabio, 201). In accordance, pre-professionals who study the brain take coursework involving taxonomies of knowledge that are often outside the purview of traditional teacher preparation courses. For example, Johns Hopkins University (2019) offers a two-year, 15 credit graduate certificate called Mind, Brain, and Teaching, where attendees study neurocognitive development, neurobiological differences in learning, brain functions involved in literacy and numeracy, and case studies involving students with developmental disabilities. A review of higher education found similar coursework offered at Harvard University (2019), and the University of Texas Arlington (2019).

Researchers have studied how impactful the act of incorporating knowledge about neurobiology has been for teachers that work with students who have atypical development (Ansari et al., 2012). Results from these inquiries have generally been positive, though some limitations have been identified. For example, Tokuhama-Espinosa (2011) states that the field of neuroeducation has helped some educators understand commonalities regarding how all of our brains are wired similarly. Plomin (2010) adds an account of educators who received training in analyzing the kind of developmental profiling that occurs during in-depth psychological assessments. Such developmental profiles frequently include a comprehensive history of a student's childhood and may incorporate results from genetic testing or functional magnetic resonance imaging (fMRI) brain scans (Plomin, 2010). Many scholars agree that acquiring more knowledge about the neurobiological processes of learning has been helpful for teachers (Semrud-Clikeman, 2010; Siegel, 2001). Educators informed about both the brain and human development can use this information to understand the developmental trajectories their students have undertaken thus far in their lives.

Predominantly, research about the brain is culled from two scientific disciplines: (a) neuroscience, and (b) cognitive psychology (Feiler & Stabio, 2018). Institutional programs such as MBE then translate this research into information for the educator audience (Feiler & Stabio, 2018). These two fields define human learning slightly differently, though some overlap exists between these definitions. Because neuroscience and cognitive psychology have held the largest amount of influence upon the translation of brain research into education, these definitions of learning necessitate further exploration.

Cognitive Psychology and Learning. The field of cognitive psychology has primarily tasked itself with understanding the functioning of the human mind (Anderson, 2015). Cognitive psychologists posit that individuals can only acquire new knowledge when they can successfully integrate that knowledge into existing mental *schemas*, or categories of information in the mind (Dixon & Stein, 1992). Researchers in this field have developed intricate taxonomies hypothesizing how new information might integrate into existing knowledge in the mind, as well as how this knowledge might be stored in the brain (Baars & Gage, 2010). In this view, the primary vehicle driving the transition of new knowledge into long-term learning is memory. Many different kinds of memory exist, such as procedural memory or semantic memory (Shaffer & Kipp, 2013). Without being able to make new meaningful memories, humans would not be able to learn (Anderson, 2015).

Neuroscience and Learning. Research from the field of neuroscience has predominantly investigated how changes to the biology of our brains and bodies result in changes in our comportment and overall understanding of the world (Howard-Jones, 2014). Therefore, to the neuroscientist, learning can be defined as a permanent change in the cellular structures that comprise our being (Baars & Gage, 2010). Through the use of complex imaging and auditive technology, neuroscientists can provide a window into capturing biological snapshots of what it looks like for the brain to change (or to 'learn' in the neuroscientist's parlance), throughout different stages of one's life (Shaffer & Kipp, 2013). Neuroimaging technology allows one to biologically follow sensory information as it travels from physical properties (such as sound or light waves) to mechanical and/or chemical features, and eventually journeys up through the central and peripheral nervous systems, through the mid-brain, into the forebrain, and back down again to our peripheral nervous system through the use of powerful electro-chemical feedback systems (Squire et al., 2014). Capturing images of such raw data has confirmed long-held axioms that the mind cannot exist without the brain, and that learning is fundamentally biological in nature (Howard-Jones, 2014).

Because children who are born with developmental disabilities regularly exhibit atypical learning systems, these populations of students are far more likely than their typically developed peers to undergo neuropsychological evaluations that may include brain imaging (Overton, 2016; Webber et al., 2008). These circumstances have resulted in the assemblage of much biological data for this student group. Understanding the connections between the mind, the brain, and learning helps educators translate scientific evidence into praxis (Semrud-Clikeman, 2010).

Misapprehending Neurobiology. Analyzing one particularly long-standing neuromyth has caused some to argue that the way that learning itself is conceived of in academic institutions may be perpetuating misinformation about how students with developmental disabilities acquire information best (Landrum & McDuffie, 2010; Lefmann & Combs-Orme, 2013). According to Jones (2014), many candidates in teacher education programs are taught that differences in the way that our brains process information can be attributed to a person's learning styles, or their preferences of how to take in information. While research has long debunked the theory of learning styles, current literature demonstrates that many educators still believe the theory has merit (Pashler et al., 2008).

Learning Systems, not Styles. Some contemporary researchers conceptualize student learning differences not in terms of preferences or styles, but instead as atypical neurobiological differences in processing information (Owens & Tanner, 2017; Pashler et al., 2008). For example, research by Arwood (2011) has demonstrated that even though many children can demonstrate the capacity to hear acoustic sound waves, this does not necessarily mean that they can use these sound waves to learn. Similarly, some types of visual input will stimulate electrochemical signaling in the brain while other type will not (Baars & Gage, 2010; Cromwell et al., 2008). These phenomena occur because the brain is designed to filter out what is not meaningful to it – a survival mechanism called *sensory gating* (Cromwell et al., 2008). Thus, in this view students do not prefer to engage or disengage; they simply cannot attend methods of input that are not meaningful to their brains (Cromwell et al., 2008).

Arwood (2011) describes the neurobiological underpinnings connecting our brains and bodies together as our learning *systems*. Students with developmental disabilities are frequently born with atypical learning systems; therefore, they may require sensory input to be provided to them using alternative modalities in order for them to learn (Arwood et al., 2015; Robb, 2016). In sum, innovative research is starting to make the case that students who struggle to learn cannot be faulted for what their brains cannot process (Plomin, 2010). Incorporating this aphorism into pedagogical practice may transform one's approach to working with individuals who have learning disabilities.

Lack of Brain-Based Educational Interventions

The study of neuroeducation has been shown to impact teachers' conceptualizations of learning, development, and disability. Literature demonstrates that this field has increased teacher knowledge to positive ends. However, in addition to the neuromyths referenced earlier, Goswami (2006) observes that the field of neuroeducation has also experienced missteps when attempting to translate knowledge about the brain into interventive practices of working with children. For example, in a review of relevant literature Battro (2010) found that many existing learning theories, pedagogies, and interventions for students with developmental disabilities do not incorporate knowledge about the brain and human development into their design. Similarly, Levine and Barringer (2008) determined that sparse research exists that showcases interventions designed to harness latent strengths for learning in the brain. Similarly, Semrud-Clikeman (2010) argued that educators would stand to benefit from understanding more about strengths of brain and designing interventions to match these strengths. In a summary of the status of the discipline of neuroeducation, Battro (2010) observes that this emerging field has exhibited both positive contributions and missteps in the translation of research from neuroscience and psychology into education.

In the review of literature completed for this dissertation, numerous academic findings from the fields of developmental psychology, special education, disability studies, neuroscience, cognitive psychology, and language were uncovered. Though each of these fields contributes important knowledge to the study of neuroeducation, one preliminary gap in the literature was identified at the intersection of these disciplines. That is, by synthesizing findings from academic research in these areas, this investigation found an absence of educational intervention strategies for students with developmental disabilities that were derived from theory incorporating knowledge about learning and the brain into practice.

Therefore, in the spirit of following uncharted research, this study will utilize the conceptual framework of Arwood's Neuro-Education Model (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016) to investigate whether interventions inspired by this theory may help students with developmental disabilities learn and make progress in multiple developmental domains. Inherent in Arwood's Neuro-Education Model is a theory of learning that aims to elucidate how all people, including individuals with developmental disabilities, learn. Accompanying this theory are a set of educational intervention methods that are informed by research about the brain. These elements are explored in further detail in the next sections of this paper.

Arwood's Neuro-Education Model

Over the course of nearly 45 years, Arwood utilized a grounded theory approach to develop one interpretation of brain-based research-into-practice called *Arwood's Neuro-Education Model* (Arwood, 2011; Arwood & Merideth, 2017). By utilizing an investigative approach, Arwood has cataloged an extensive dossier of how students with disabilities function in the world. This knowledge has culminated into the evolvement of multiple theories regarding how humans, including those with developmental disabilities, acquire language and knowledge, as well as learn to act in a pro-social manner (Arwood 2011; Arwood et al., 2015; Lucas, 1981). In order to distinguish it from other iterations, for the purposes of this paper Arwood's Neuro-Education Model will be referred to as *Neuro-Education*.

Three Lenses of Study

Arwood sought insight from other academic fields to decipher why students with developmental disabilities behaved, socialized, and used language differently than typical children (Lucas, 1981). This search eventually led to the creation of the Neuro-Education Model, which views human learning through three overlapping lenses of study: (a) neuroscience, (b) cognitive psychology, and (c) language. By explaining students' behavior and their use of language through these three disciplines simultaneously, Neuro-Education encourages educators to take multiple overlaying vantage points in their pursuit of understanding the holistic needs of their students. Whereas previously mentioned variations of neuroeducation have officially adopted only two lenses of study (neuroscience and cognitive psychology), Neuro-Education is the only model known at this time to utilize the third lens of language in its studies (Arwood & Merideth, 2017). According to Arwood (2011), the use of this third lens of study is of paramount importance because it provides a theoretical framework that informs how research from the other two lenses can be interpreted. Moreover, carefully studying the language that a child uses affords the educator with an effective way to determine how that student functions in all five human domains. By using this approach, educators may discover new, latent strengths for learning in their students that may never have been employed before.

In addition to helping teachers discover latent strengths for learning inherent in their students' brains, Arwood (2011) also developed a system of educational interventions that are designed to conjoin with these strengths and provide input into pupils' brains through untapped means. Called *Viconic Language Methods* (VLMs), this interventive approach is the only system found in the literature to utilize theory from neuroscience, cognitive psychology, and language and translate this knowledge into practice (Arwood, 2011). Because VLMs form the cornerstone of interventions culled from Arwood's Neuro-Education Model, these methods are explored in greater detail in a later section.

Existing Research Studying Neuro-Education

Throughout a series of books spanning many years, Arwood (2011; Lucas, 1981) chronicled numerous examples of how she and other educators were able to draw from her theories for the purposes of assessing students for developmental functioning in multiple domains. Often, these methods utilized approaches outside the purview of commonly known techniques, such as the deixis method presented earlier. By finding latent strengths in students, such as their ability to record meaningful information in the brain through hand-over-hand instruction, Arwood was also able to utilize VLMs to help these students learn where previous pedagogies had been insufficient. Although the stories behind these case studies have been included in books, it has only been within the past ten years that other scholars have begun to research the efficacy of VLMs while using more rigorous, peer-reviewed research designs. Much of these studies have been conducted for the purposes of completing a dissertation for the doctorate of education (Ed.D) program at the University of Portland.

For example, Robb (2016) measured changes in students' reading scores over a five-year period before and after utilizing VLMs in her practice. Green-Mitchell (2016) assessed students in an alternative school setting for levels of antisocial development and measured any potential changes to these levels after using VLMs in one-on-one settings. Similarly, Jaskowiak (2018) analyzed the connection between levels of language function and pro-social concepts for elementary students identified with emotional and behavioral disorders. Other research measuring the impact of VLMs has been studied by Kelley-Hortsch (2018) on the topic of literacy, and by Xiang-Lam (2016) for students studying Chinese as a second language.

Gap in Literature. Multiple examples of books, conference presentations, and dissertations studying Neuro-Education were found in the literature. However, no peer-reviewed research is known at this time that has specifically measured the potential impact of Viconic Language Methods upon the learning and development of individuals with developmental disabilities. Therefore, this lack of investigation constitutes the primary gap in the research for this study and provided the impetus for this dissertation research investigation.

This section introduced Arwood's Neuro-Education Model, provided information about incorporating language as the third lens of study regarding the brain, and identified the primary research gap used for this study. Because the study of human language is integral to Arwood's Neuro-Education Model, this topic is encompassed in the following sections.

The Language Domain

Throughout time, humans have created many different configurations of language. Broadly defined, language is a system of spoken, manual, or written symbols by means of which humans express themselves in social groups (Robins & Crystal, 2018). Anthropologists have long noted that the language that a group of people uses becomes a defining aspect of their culture and ultimately shapes how individuals pertaining to this group think and communicate (Kernan, 1970). Studying these differences affords researchers a unique vantage point into the ways that generational knowledge is transferred between citizens around the world.

Linguists observe that, broadly speaking, the components that make up language can either be comprised of surface structures, such as grammar, or deep structures, such as semantics (Dore & McDermot, 1982; Vygotsky, 1962). According to Fillmore (1968), the vast majority of academic study about the topic of language involves analyzing its surface structures. However, some have argued that understanding the deep structure of language can be a powerful tool for unlocking how the brain uses such language to function (Arwood, 1983; Arwood, 2011; Pulvermüller, 1999). Because the analysis of language can be infinitely complex, further parsing of these concepts is presented.

Surface Structures of Language

Evans and Craig (1992) note that in most academic fields, language is often conceptualized in terms of the products that humans create, such as oral speech and writing. Linguists, for example, dissect and classify languages by analyzing these products and deciphering the rules behind their spelling, grammar, syntax, morphology, and other systems of organization (Saxton, 2017). Similarly, other academics such as anthropologists may attempt to pair these rules to visual depictions of the language, typically presented as words in Western cultures, or characters in some Eastern cultures (Chomsky, 1957; McBride-Chang et al., 2005). Given enough time, scholars can analyze the surface structures of most languages around the world, such as speech and writing patterns, and devise a taxonomy of these languages so that they can be taught to other pupils (Chomsky, 1957). In turn, these pupils can develop the capacity to use this language to communicate with others who already know it.

Deep Structures of Language

Other theorists have taken a more multifaceted view of what language itself might represent in the human experience (Lenneberg, 1973; Tomasello, 2009). For example, some researchers note that babies learn to adapt to their surroundings before they develop any surface structures such as sounds and letters (Brookes et al., 2001). Moreover, children who are born deaf eventually acquire the full capacity to function in the world as agents without using sound-based surface structures (Schmitz, 2008). These examples illustrate that humans learn to think before they learn how to communicate their thinking through language. Therefore, language must represent more than just the rules, surface structures, or products that humans use (McBride-Chang et al., 2005).

According to Arwood (2011), language *names* our thinking. This axiom means that: (a) by nature, humans cannot develop the complexity of their thinking without being able to use language, and (b) the language that someone uses represents the complexity of their thinking. Clark (1977) states that the language we use provides a mirror into our minds and refers to the meaning that we assign to this language as its *deep structure*. The deep structures of language are the interconnected semantic relationships between concepts. It is the deep structure of language, not its surface structures, that allows humans to understand the semantic content of language (Arwood, 2011). Being able to utilize deep structures allows one to use language to communicate their thinking.

Functional Use of Language

Taking the viewpoint that the language we use names our underlying thinking, Arwood (2011) developed a multitude of ways that researchers and educators can carefully analyze language to determine how an individual functions in the world. Arwood posits that all children learn to think by acquiring language through their social interactions with adult caregivers. As they get older, children acquire more advanced abilities to use their own language to function in the world. Arwood defines the developing proficiency of a student to be able to reason, problem solve, and socialize as that student's level of *language function*. Put more broadly, language function refers to the process – both socio-cognitive and neurobiological – by which humans learn how to think.

Over time, as children develop their own capacity for language, they also increase their functional capacity to learn on their own. In combination with the improvisational process of deixis, educators can analyze the language that students use by asking them to produce drawn, written, or oral artifacts. Students who have moderate to severe developmental disabilities and cannot produce such artifacts may nevertheless be able to use their bodies to communicate in alternative manners (Arwood, 2011). Each of these analytical processes are covered in depth in a later section. Such methods of assessment may provide educators with the kind of information that is typically missing from the use of intelligence testing or functional based assessments. However, one prerequisite before educators can learn how to perform these analyses is to understand the fundamental differences between auditory and visual properties of language. These differences are explained in the following section.

Auditory Versus Visual Properties of Language

Leading researchers from the fields of neuroscience (Moats, 2014), cognitive psychology (Anderson, 2015), and language (Saxton, 2017) have long posited that in order for a child to learn a language such as English, they must be able to: (a) process raw phonological components of a language, such as the sounds that letters make, (b) proficiently discriminate between such raw sounds, (c) make auditory connections between these raw sounds and letters, (d) combine phonological sounds together to make words, and (e) attach semantic meaning to these words. These axioms stem from the observation that humans primarily use acoustic proficiencies, such as listening and speaking, when they transmit a language from adult to child (McAnally et al., 1994).

Because this dominant viewpoint conceives of human language as primarily acoustic in nature, children are thought to need a strong ability to process sound in order to learn (Moats, 2014). By extension, those children who struggle to learn language through sound-based means are thought to have deficits in the phonological processing centers of their brains (Diaz et al., 2009). Conventional remediation for these deficits involves direct instruction in phonics and other auditory methods (Moats, 2014).

Though they are somewhat rare in the academic literature, alternative viewpoints to these axioms exist. For example, Arwood (2011) invented a system for helping children become literate that bypasses the brain's phonological processing center. This system is designed for those students who have traditionally struggled to learn by sound-based methods. Examples of these alternative standpoints illustrate that the act of learning language may be conceived as something distinct from the act of processing sound (Robb, 2016). To sufficiently understand these distinctions, one must learn to inspect the differences between auditory and visual properties of languages.

Auditory Properties of Language

English is considered an auditory, time-based language because its structure is organized around units of meaning that fluctuate with time (Pamies Bertrán, 1999; Schmitz, 2008). Examples of such units include past and present tenses, changes in word morphology to express context of actions, and a written orthography of the language that is based upon antiquated rules of oral pronunciation (Schmitz, 2008). Moreover, English is pronounced as a stress-timed language, where listeners tend to perceive equal amounts of time between stressed syllables (Nespor & Mehler, 2011).

As a result of these components, students learning English by conventional methods are thought to require the ability to attune to, and distinguish between, these auditory differences if they are to decipher meaning from spoken or written English (Schmitz, 2008).

Visual Properties of Language

Though English is an auditory language, other languages such as Mandarin Chinese are considered to be primarily visual in nature (McBride-Chang et al., 2005; Sampson & Chen, 2013). More specifically, Mandarin Chinese is considered to be an *ideographic* language that uses visual based *logograms* in the construction of meaning (Hansen, 1993). This is because semantic meaning in Mandarin is derived first and foremost from the visual aspects of their written characters (Sampson & Chen, 2013). Small alterations to these visual characters, such as adjusting lines or markings, result in substantial changes in meaning, such as determining gender or reframing situational contexts (Hansen, 1993). Though Mandarin does have an oral component to the language, this oral speech is considered secondary, or dependent upon a rich contextual understanding of the visual aspects of the language (Hansen, 1993). Lastly, the concept of time in Mandarin is primarily visual-spatial, not auditory, because changes to the space of each character result in differing understandings of when actions are taking place (McBride-Chang et al., 2005; Xiang-Lam, 2016). Individuals who process information using visual-based languages such as Mandarin tend to report 'seeing' their thoughts, akin to thinking in pictures (Xiang-Lam, 2016).

Learning Language Without Sound. Though English may be an auditory language, Arwood's (2011) investigation of the societal characteristics of English speakers revealed that people who live in Western societies tend to think in a manner more akin to those who grew up learning the visual aspects of Mandarin. That is, though most individuals learn English through auditory processing means, they primarily think by making visuals in their minds eye (Silverman, 2005). Contemporary studies about the brain confirm these findings. For example, research from neuroscience informs that our brains are able to process visual elements, such as words, or ideographic elements, such as characters, without stimulating other brain areas primarily responsible for phonological processing (Hansen, 1993; Squire et al., 2014). In other words, our brains are capable of making meaning from the shapes of objects (such as words) alone.

These findings explain in simple terms how individuals whose brains cannot process sound can nevertheless learn language. For example, children who are born blind acquire language through the process of reading braille. This process requires one to memorize the shapes that braille characters make on paper and then connect these shapes to semantic concepts (Squire et al., 2014). No attunement of sound is involved in this acquisition process. Even students with profound developmental disabilities, such as those individuals who cannot hear or see, have been shown to acquire some functional language through acquiring and internalizing the shapes that an educator's hands make when signing into their palms (Lucas, 1981).

Arwood (2011) describes the struggles of children to learn in school as a 'mismatch' between the way English is taught (through auditory methods) and the way that English speakers think using this language (through visual cognition). To succeed in the act of learning, individuals from Western cultures must translate auditory properties of language into visual brain activity, or bypass these auditory properties altogether (Hillesund, 2010).

For example, individuals who win spelling championships articulate that they do not sound out words to learn them, but instead memorize the visual shapes that English words make in their mind's eye (Gumbrecht, 2017). This process is sometimes called utilizing *orthographic memory* (Rapp et al., 2016). Similarly, some of the most proficient readers of English state that they do not utilize phonics, nor do they use subvocalization – reading aloud in their own heads (Hanford, 2019). Instead, these individuals take in written information from the page as if they were viewing a visual landscape from memory (Hillesund, 2010). Sometimes, this process is called making *grapho-semantic* connections (Ehri, 2005). Examples such as these, and countless others, illustrate that learning language is possible even when the brain cannot attune to auditory properties inherent in acoustic sound waves such as time, amplitude, pitch, or duration (Green-Mitchell, 2016; Robb, 2016).

Visual Thinking

Research conducted by Arwood (2011) suggests that approximately 95% of students think with a visual language system, meaning that they make pictures, movies, and graphics in their mind's eye as they conceptualize information. The idea of using visuals in the mind has existed in psychology research for decades (Deza & Deza, 2009). For example, Baddeley and Hitch (1974) referred to the mental symbolization of ideas as the mind's 'visuospatial sketchpad.' Additional studies today find that thinking in mental pictures is considered the norm for individuals from Western cultures (Silverman, 2005).

Examples of thinking in visuals are also abundant in the lore of popular culture. For example, many geniuses explain that they are able to perform in the top echelons of intelligence testing by creating ‘memory palaces’ in their minds, where they build complex architectural structures and affix concepts to each component of the construction (Raz et al., 2009). Other examples of visual thinking include the phenomena of having a ‘photographic memory,’ performing ‘mental rotation’ of objects in the mind, or seeing ‘movies play in one’s own head’ (Anderson, 2015; Baars & Gage, 2010). Visual thinking is so ubiquitous in society that Keogh and Pearson (2018) hypothesized that only a small group of the population thinks without using mental pictures. In fact, the psychological trait of not being able to think in mental pictures has only recently been given a name in scientific literature: *congenital aphantasia* (Keogh & Pearson, 2018). Since thinking is pictures has been established by the literature as the predominant mode of cognition for individuals from Western cultures, it stands to reason that these individuals might learn language more proficiently if they could utilize a method that prioritized the acquisition of the visual components of language, such as the edges that form the shapes that words make, rather than auditory methods, such as phonics (Robb, 2016).

Viconic Language Methods

Conventional scientific wisdom holds that students must be able to phonologically process sound in order to acquire languages such as English, as language is thought to be primarily auditory in nature and instilled in pupils through listening and speaking (Hanford, 2019; Moats, 2014). Unfortunately, much research has demonstrated that many students – and especially students with developmental disabilities – have struggled to learn language under this approach (Diaz et al., 2009; Hanford, 2019). This may be due to difficulties inherent in visually thinking students to make neurobiological meaning from sound-based instructional methods (Robb, 2016). Over time, some researchers have developed unorthodox approaches for helping children acquire language that are not grounded in sound-based instruction. For example, Arwood (2011) used knowledge about auditory and visual properties of language to invent intervention methods that overlap visual input streams into the brain in novel, untapped ways.

By overlapping the semantic properties inherent in visual languages such as Mandarin onto practical applications in English, Arwood (2011) developed a system of educational interventions called *Viconic Language Methods* (VLMs), where educators learn to help students acquire concepts in English by utilizing visual-based approaches. By design, VLMs aim to reconfigure the manner in which the components of English are taught so that they are more easily acquired by the brains of those individuals with visual thinking systems. For example, instead of utilizing time-based instructional strategies such as phonics, vocalization, or mnemonic devices, VLMs borrow learning methods from Mandarin such as asking students to draw the shapes of words in picture dictionaries and affix their own drawn concepts to these shapes to provide meaningful semantic context. In addition, educators utilizing VLMs never rely on the sound of their own voice alone when providing instruction to their students; instead, their oral speech is always accompanied by additional visual components such as cartoons, flowcharts, or other two-dimensional drawings (Arwood, 2011).

Alternative Access Points into the Brain. According to Arwood (2011), the capacity for students to acquire information through such visual access points into the brain exists on a spectrum of ability that is parallel to the spectrum of students either being mildly, moderately, or severely impacted by their developmental conditions. Students with mild cognitive impairments may be able to attune to visual information when it is presented through means they can process with their eyes, such as cartooning. Individuals with more moderate to severe developmental challenges may also require additional overlapped layers of instruction in order to provide sufficient access into their brains for the purposes of increasing the complexity of their thinking (Arwood, 2011).

One such additional component that is frequently used to help these student populations learn is overlapping visual input with multiple types of movement, such as providing hand-over-hand instruction. Research from neuroscience informs that when pupils move their hands in meaningful ways, such as tracing the edges of the shape of a word or picture, this information is first processed by the motor cortex, but then spread into other access points of the brain such as the visual cortex and the prefrontal cortex (Baars & Gage, 2010; Gallese & Lakoff, 2005). Nascent research has demonstrated that Viconic Language Methods have help those individuals learn who have traditionally struggled to process sound. This was accomplished by providing alternative access points into the students' visually symbolizing brains (Kelley-Hortsch, 2018; Robb, 2016; Xiang-Lam, 2016). Because individuals with developmental disabilities have been shown in the literature to be one of the most unsuccessful populations to learn language using conventional auditory methods, further research on the impact that VLMs might have on their ability to learn and develop is warranted.

This section distinguished between auditory and visual properties of Western and Eastern languages. In addition, Viconic Language Methods were introduced as a possible alternative route to meet the learning needs of visual thinkers. Viconic Language Methods were the primary intervention methods used with student subjects who participated in this dissertation study. The specific VLMs that were used with the participant are extensively detailed during analysis of results in Chapters 4 and 5.

Neuro-Semantic Language Learning Theory

Arwood’s Neuro-Education Model translates scientific research from neuroscience, cognitive psychology, and language into educational practice, assessment, language sampling, and Viconic Language Methods. One theory sits at the intersection among these disciplines and these practices and serves as an arbiter of how research about the brain is understood in the context of human learning. In contrast to previously held linguistic theories, the *Neuro-Semantic Language Learning Theory* (NsLLT) posits that we are not born with an innate knowledge of how to use language; rather, we must acquire the ability to use language through a series of small, incremental steps that are part of a developmentally complex process that starts at birth and progresses throughout the rest of our lives (Arwood, 2011).

The NsLLT explains that language is learned as a set of neuro-semantic steps that initially starts with the input of new information into our being. The only known method for us to receive such new information is through our sensory receptors (Arwood 2011). Beginning at birth, our brain connects us to our sensory receptors and establishes a feedback system that continuously processes raw data received through those receptors (Arwood 2011). As we begin to experience certain sensory input over and over again, our brain starts to recognize patterns and begins to organize these patterns into clusters of semantic meaning (Arwood 2011). These meaningful patterns begin to overlap, and as new information adds itself to already established, older chunks of meaning, our brain begins to form larger concepts. It is by attaching new information to older recognizable patterns that we acquire new conceptual meaning.

Language represents our brain's application of these semantic clusters to think and communicate. According to Arwood (2011), language is a system by which we name our underlying concepts and then also increase the meaning of those concepts into more advanced levels of thinking. The more developed our concepts become, the more our language abilities will evolve. Additionally, the richer and more complex our language becomes, the more advanced our thinking can become. Arwood (2011) connects our language and thinking abilities by saying, "Because language represents cognition, then language function represents how well a person thinks and therefore acts" (p. 54). Language function allows us to think meaningfully and therefore access and participate in the world around us.

Tiers of Learning

The NsLLT primarily breaks with existing theories of learning because it argues that human learning takes place in the brain using four interconnected tiers simultaneously (Arwood, 2011). Each of these four tiers represent a unique capacity inherent in the brain that allows it to function in a synergistic manner (Arwood, 1983;

Arwood & Merideth, 2017). Tiers one and two of the NsLLT are explained in the subsequent section, and tiers three and four are detailed in the section after next.

Two Tiers of Learning. In the first tier of learning, sensory input in the form of sound, light, or movement enters our bodies. Next, sensory input overlaps to form neurobiological clusters of information. As the brain processes these clusters, it forms electrochemical patterns that are represented by neurons wiring together in meaningful ways (Gallistel & Matzel, 2013). If the brain can successfully recognize these patterns during this second tier of learning, then it can extrude this information in precisely the way it was inputted (Squire et al., 2014). In simplistic terms, this process describes how the brain commits facts to memory. The ability to process memory is essential to our existence – humans must be able to recall massive amounts of stored memories just to be able to engage in routine activities of daily living (Anderson, 2015). In addition, the more information that one memorizes, the more knowledge they are thought to have obtained (Treffert, 2009).

Memorizing patterns represents the second tier of learning. The brain is highly efficient at memorizing patterns (Anderson, 2015). Humans have performed many astounding feats of committing information to memory. Academic literature has shown that even some individuals with developmental disabilities who have struggled in school can nevertheless memorize large amasses of information (Treffert, 2009). Examples of this include children with autism who can recite entire books or movies from memory, but not be able to answer simple questions about the plot (Treffert, 2009). In addition, some students can recount detailed rules about what behavior is socially acceptable, but not be able to explain why they should follow these rules

(Arwood et al., 2015). Sometimes, this ability to memorize information eclipses larger difficulties that students of this population experience in school. For example, Arwood (2011) states that some students with developmental abilities achieve high scores on intelligence tests and adaptive assessments, even though they cannot take care of themselves on a daily basis.

According to Arwood (2011), what these findings illustrate is that learning is predominantly understood in society as being a *two-tier*, input-output process. That is, students are thought to have learned something if they can output that information in the same way that was given to them (Robb, 2016). Examples of this belief are abundant in classrooms. According to Arwood and Merideth (2017), multiple choice tests, fill in the blank exercises, and even declaring answers to be ‘right’ or ‘wrong’ are all examples where displaying a correct ‘output’ is thought to be evidence of learning. The logic behind two-tier learning, however, may be fundamentally flawed. Arwood (2011) argues that knowledge does not truly belong to someone unless they can use it in novel, unscripted ways. Without being able to explain the reasoning behind their choices, students may simply be mimicking knowledge, not understanding it (Green-Mitchell, 2016; Robb, 2016).

Brain research supports the hypothesis that two-tier level learning is inherently less sophisticated than engaging in acts of higher-order thinking (Robb, 2016). For example, studies have shown that memorizing information involves only so-called ‘lower’ brain structures and relay stations (Macnamara, Hambrick, & Oswald, 2014). Research has shown that the brain will quickly ‘dump’ information stored in these elemental regions because the underlying clusters of neurons do not sufficiently attach themselves to existing biological assemblages in meaningful ways (Arwood, 2011). Despite these findings, humans can in fact surpass these less sophisticated biological operations and can learn to think critically (Kiefer & Pulvermüller, 2012). Doing so, however, requires that neurobiological information travel and spread into vastly more areas of the brain including the pre-frontal cortex and other important areas in the cerebrum (Baars & Gage, 2010; Pulvermüller, 2013).

Four Tiers of Learning. Picking up where two-tier models leave off, the Neuro-Semantic Language Learning Theory (Arwood, 2011) exposits that humans must be able to process neurobiological information at the third and fourth tiers if they wish for this knowledge to stick with them indefinitely. In this view, to truly learn something individuals must find a way to attach new incoming information to existing semantic information in a way that is uniquely meaningful to each person. When second-tier patterns conjoin together, they deepen one's understanding of a stored concept (Arwood, 2011; Baars & Gage, 2010). In the brain, this semantic attachment occurs when newly acquired neurobiological clusters of information (patterns) attach to previously acquired clusters to form circuits. Neuronal circuits can continue to connect to other neuronal circuits in an infinite number of biological configurations (Baars & Gage, 2010). Therefore, learning at the third tier – called *conceptual learning* – is by definition never finished (Burbules, 2013). Examples of conceptual learning in the classroom include asking students to come up with their own way of demonstrating their knowledge of a topic (National Research Council, 2000). While one student may create a diorama, another child might write a screenplay.

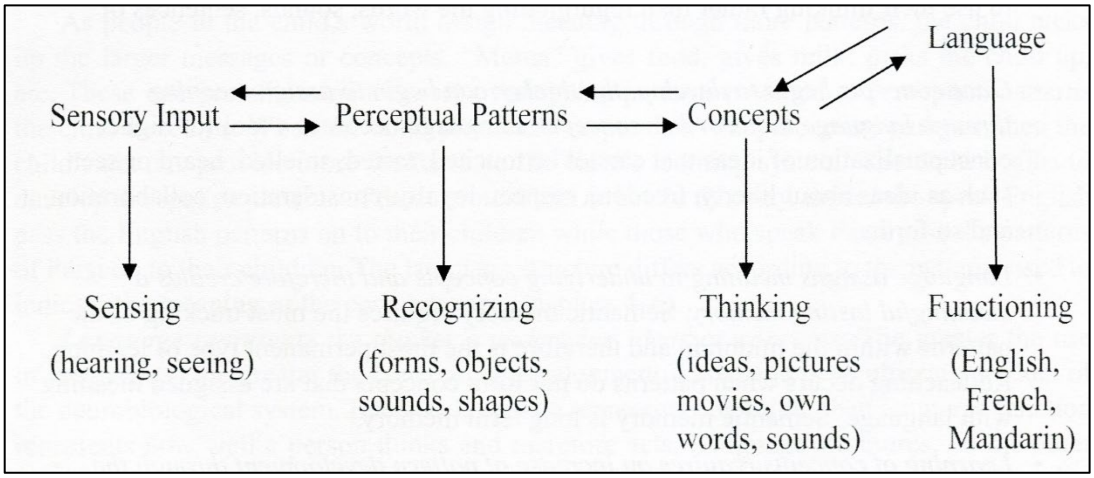
Deepening one's understanding of concepts at the third tier can be a rewarding endeavor because the emphasis is not on displaying right or wrong answers but on successfully justifying one's thinking (Thul, 2019). Arwood (2011) postulates that for someone to continue to refine their own thinking over time, the brain must be able to provide its own semantic feedback through reflection and metacognition. According to Arwood, our own mental language provides the vehicle for this metacognition to occur. For example, individuals who think in pictures must figure out a process for how to complexify these pictures to reflect a more sophisticated understanding of the world. This feedback process embodies the fourth tier of learning, called *language*. Semantic feedback occurs in a constant back-and-forth exchange of language between the third and fourth tiers (Arwood, 2011). Without such feedback, humans cannot deepen their understanding of how they connect to the reality around them.

In the brain, third-tier circuits overlap to form meaningful fourth-tier *networks*, or endlessly complex pathways of circuits for electrochemicals to flow through (Pulvermüller, 2013). Recent findings from neuroscience document that our brains consist of vast tracts of meaningful, interconnected neuronal neuro-semantic networks that allow us to process information at the most sophisticated levels of knowledge (Owens & Tanner, 2017; Pulvermüller, 2013).

Figure 1 shows a diagram depicting the four tiers of the Neuro-Semantic Language Learning Theory (Arwood, 2011).

Figure 1

The Four Tiers of the Neuro-Semantic Language Learning Theory (Arwood, 2011)



Note. Image created by Arwood (2011), used by permission.

The Neuro-Semantic Language Learning Theory fuses research from neuroscience, cognitive psychology, and language (Arwood, 2011). The rationale for each of the Viconic Language Methods documented in this study stems from the tenets of this grounded theory. Because Viconic Language Methods rely on visual strategies such as cartooning, practitioners using these interventions naturally accumulate large quantities of drawings and writings during individual sessions with children. The next section of this review introduces research methodologies designed for the purposes of investigating changes in students by analyzing these types of student artifacts over the course of time.

Student Artifacts Represent Their Thinking

Technology used in the field of neuroscience has not yet advanced to the point of being able to directly read someone else's thoughts (Squire et al., 2014). This means that the act of thinking itself cannot be directly researched or measured

(Anderson, 2015). Despite these limitations, some scholars from the qualitative research paradigm theorize that certain acts that humans do represent aspects of their thinking; therefore, these acts are worth examining carefully to determine how one learns and thinks (Cherney et al., 2006; Papandreou, 2014). For example, some scholars propose that drawings serve as literal abstractions of one's thinking (Cronin-Jones, 2005; Eisner, 1999; Looman, 2006). Other say the same for writing (Resnick, 1987; Saxton, 2017), and behavior (Arwood et al., 2015). Lastly, Arwood (2011) adds that the language someone uses represents the thinking that their mind produces. Though our thinking may be intangible in nature, humans are hard-wired to transmit their thinking to others in ways that can be seen and understood (Anderson, 2015).

Norman (1991) explains that any form of communication that a person does can be considered a *cognitive artifact* of their thinking. That is, through the transmission of ideas, humans create a product that can be observed by others, whether that be a drawing, a piece of writing, or a transcript of oral speech. In qualitative research, the products that humans create are called *documents* (Stemler, 2000). *Document analysis* is the methodological process by which researchers systematically analyze human artifacts to discover salient changes over time (Bowen, 2009). Researchers analyze such changes in the context of a *cognitive framework*, or a set of theoretical guidelines that serve as frame of reference for how to interpret the collected evidence (Allison & Allison, 1993; White & Marsh, 2006). This section briefly introduces the process of document analysis, shares literature relevant to this topic, and explores two different cognitive frameworks used in this study: (a) development, and (b) learning. More details on these methods are presented in Chapter 3.

Document Analysis

Document analysis is a systematic process of examining participant-created artifacts for the purposes of eliciting meaning from, and gaining understanding about, these participants (Corbin & Straus, 2008). Bowen (2009) adds that the process of document analysis is the most commonly used methodological approach in the qualitative research paradigm for reviewing artifacts. To provide context to a set of documents gathered for a study, researchers often start by formulating a cognitive framework that is culled from a review of related literature and designed to serve as a conceptual guide for how to interpret these documents. Bowen (2009) adds that document analysis can be used as a research approach for filtering artifacts through such a cognitive framework to search for adherence to, or deviation from, this framework.

Through the constant comparative approach (Glaser & Strauss, 1967), this filtering process takes place in the form of qualitative coding, where researchers develop a set of *a priori* codes taken from relevant literature and interrogate the artifacts such that the a priori codes are either confirmed or absent and to reveal unanticipated, emergent codes that arise (Bowen, 2009; Elo & Kyngäs, 2008). In document analysis, researchers often seek to create thick descriptions of how characteristics inherent in the data changed over time. This process is frequently described as analogous to telling a story about the data (and therefore the participant that the data represents), complete with a beginning, middle, and end (Yin, 2003). In retrospective case studies where specific interventions were provided to a participant over time, researchers can use collected artifacts as guideposts informing how that participant evolved in multiple areas of consideration (Wiebe et al., 2010).

Cognitive Frameworks

Allison and Allison (1993) define a cognitive framework as a conceptual structure of ideas that is used to understand and categorize people, the things around them, and their experiences. Researchers construct cognitive frameworks by systematically reviewing relevant literature and synthesizing knowledge that will be useful for their methods of analysis (Rocco & Plakhotnik, 2009). During this synthesis process, researchers develop a catalog of a priori codes that serve as beacons on a roadmap encompassing a topic (White & Marsh, 2006). Stemler (2000) adds that a priori codes only serve the particular cognitive framework of the study they are contained within.

Due to their specialized roles in the maturation of all individuals, this study developed a priori codes extracted from two separate and distinct cognitive frameworks: (a) development, as represented by observable changes in developmental products in the linguistic, cognitive, and social-emotional domains, and (b) learning, as represented by changes over time in the participant’s capacity to use increasingly complex language to function (Arwood, 2011). The differences between these two cognitive frameworks are detailed in the remainder of this review of literature. In addition, more information about how this study utilized these cognitive frameworks in the coding of student data is presented in Chapters 3 and 4.

Measuring Developmental Changes

As most children grow older in age, they simultaneously mature neurobiologically, meaning that their bodies and brains evolve to be capable of performing increasingly complex operations (Blatner, 2012). Scientists call this maturation process development (Shaffer & Kipp, 2013). Researchers agree that all children develop to some degree because our bodies and brains continuously change by nature of being alive (Travers et al., 2009). However, explaining how children develop has been an ever-contentious issue. This is because the concept of development itself is difficult to define. In addition, scholars disagree on how human maturation should be measured. In a meta-review of literature, de Souza and Verissimo (2015) examined 256 articles that each classified child development in slightly different ways. This search led the authors to synthesize the following definition that aimed to capture a middle-ground consensus between all perspectives: "Child development is part of human development, a unique process of each child that aims to insert him/her in the society where he/she lives. It is expressed by continuity and changes in motor, psychosocial, cognitive and language abilities, with progressively more complex acquisitions in the daily life functions" (de Souza & Verissimo, 2015, p. 1101).

Scientists know that children develop because they can measure changes in the products that children create (Sternberg & Grigorenko, 2001). For example, child psychologists observe that most children dramatically increase the quantity of their vocabulary words over the first few years of life (Saxton, 2017). Similarly, babies develop the capacity to distinguish between the voice of their mother and that of a stranger merely days after being born (Brookes et al., 2001). Through the process of capturing these data over time, scientists have been able to extensively catalogue a list of products called developmental *milestones* that children tend to exhibit at different ages. This section delves into different theories of how children develop, explores the facets that comprise each developmental domain, defines typical versus atypical development, and introduces ways that researchers measure developmental progress in the mediums of drawing, writing, and observations.

Developmental Domains

Despite disagreeing on how development unfolds in children, many scholars remain in general consensus that the study of child development can be organized into five developmental domains (Travers et al., 2009). These domains are: (a) physical, (b) motor, (c) cognition, (d) language, and (e) social-emotional. Research today acknowledges that these domains are thought to be interdependent with each other, such that changes in one area can impact differences in another (Borstein & Lamb, 2005). Furthering this idea, the concept of holistic development refers to the study of all domains simultaneously and is seen by some as a way to compile a well-rounded view of how individuals change over time (Borstein & Lamb, 2005). Despite this viewpoint, Shaffer and Kipp (2013) argue that to understand how the pieces of development fit together to form a composite person, one must also be able to look at the contributions of each domain separately – also referred as a topical viewpoint. Both together and separate, each domain serves a purpose for our ability to interact with the world.

As humans grow older, they begin to exhibit defining traits and characteristics that, taken as a whole, comprise a picture of how their body, brain, and mind function in each domain. For example, humans may exhibit differences in physical comportment and therefore may experience varying forms of able-bodiedness (Degener, 2006). In addition, individuals may be born with differences in the structures of their brains or in the neurobiological makeup of their genes (Baars & Gage, 2010; Squire et al., 2014). In addition, some children may experience biological limitations in vision or hearing. These developmental differences may result in a wide variety of outcomes for each child, ranging from noticeable difficulties in learning to challenges when trying to socialize with peers (Travers et al., 2009). These examples are but a few of the nearly infinite number of ways that variations can occur in physical or mental developmental domains. Scholars tend to study these differences by using either a stage-based lens or a continuous lens of reference. Both viewpoints hold long traditions in child development literature (Shaffer & Kipp, 2013).

Stage-Based Versus Continuous Development

Scholars studying the issue of child development have generally adhered to two different ‘camps’ of how to interpret the changes that children undergo as they grow older. Some theorists such as Vygotsky (1962) and Bruner (1975) have argued that children develop in a non-linear, continuous manner (McLeod, 2018). These so-called continuous theorists posit that development in children is noticeable, yet advancements in their skills blend together so smoothly that they are nearly inappreciable. In this view, children do advance their language, thinking, and social abilities; but, these advancements are thought to be highly individualized to each pupil and therefore challenging to generalize to the population as a whole (Shaffer & Kipp, 2013). Moreover, the changes that children experience are seen as too inconstant to be demarcated into calculable stages (McLeod, 2018).

On the other hand, stage-based theorists such as Piaget (1928, 1959) and Gesell (1933) argue that children develop chunks of skills and knowledge that are large enough to be categorized into predictable phases (Travers et al., 2009). In this view, growth in children generally occurs during specialized times, called critical periods (Siegel, 2001). Moreover, these theorists have proposed that children undergo qualitative differences in their thinking that pertain to discrete stages, rather than gradational, accumulative advancements in knowledge (McLeod, 2018). In particular, Piaget (1928, 1959) contended that cognitive development in children occurs when they reorganize their mental processes to exhibit fundamentally new ways of thinking. Importantly, for this thinking to evolve, the child must experience an interplay between both advancements in their biology, as well as a continuously enriching environment (Berns, 2016; Shaffer & Kipp, 2013).

Oswalt (2019) observes that today researchers generally find merit in incorporating knowledge from both of these camps into their study of child development. Contemporary research has found evidence confirming both schools of thought. That is, child development is thought to continuously unfold over time for most students; but, enough evidence exists to make the case that this continuity can be observed, measured, and quantified (Shaffer & Kipp, 2013). Oswalt conjoins these two schools of thought by concluding, “The real difference between the two camps is likely the degree of magnification that each applies to its study, with the stage theorists taking a more distant but broader stance and the continuous theorists viewing things from up close" (n.p.). Travers and colleagues (2009) add that both lenses continue to contribute meaningful insights into the study of child development. While both continuous and stage-based depictions of development inherently contain value to the study of the field, the stage-based developmental framework was chosen for data analysis in this study. More information regarding the rationale for this decision is presented in Chapter 3.

Developmental Stages

Over the past 80 years, stage-based developmental psychologists have tracked enough children over time to argue that most of the population develops in fairly expected ways under predictable timelines. These findings have spurred researchers to chart out roadmaps of what is considered 'typical' versus 'atypical' developmental trajectories of children as they age. Children are considered to follow typical development if they generally meet the milestones contained within these charts. As with the definition of development itself, iterations of these guides have been debated over time. Scholars generally consider Piaget's (1928, 1959) theories of cognitive development to be one of the earliest attempts to systematically organize child development into stages (Sameroff, 2010; Shaffer & Kipp, 2013). Piaget's methods have been widely incorporated into the canon of developmental psychology. Since its inception, his work has been so influential that it is still used today as a framework for understanding human development by multiple academic disciplines (McLeod, 2018; Müller & Carpendale, 2000).

Piaget's Stages of Development. One of the earliest researchers to construct a stage-based set of developmental milestones was Jean Piaget, a Swiss psychologist who worked primarily between the 1920s and 1970s. According to McLeod (2018) Piaget was fascinated with trying to understand why some children answered questioned incorrectly on the various intelligence tests that were being created at the time. Piaget disagreed with the notion the intelligence was a fixed trait in individuals and thought that intelligence testing was not capturing the myriad of ways that children's unique understanding of the world differed from each of their peers (McLeod, 2018). This led him to create relatively simple cognitive assessments designed to ascertain how children constructed an understanding of formal concepts such as time, causality, quantity, responsibility and more (Shaffer & Kipp, 2013). Piaget's ultimate goal in his early work was to develop a framework that could explain how children learned to think critically over time, as well as catalogue this developmental process into a series of age-based stages (Hesse, 1987).

Piaget (1928) observed that as neurotypical children grow in all five domains, they typically follow a set of milestones that regularly unfold in four predictable stages. These developmental stages are *sensorimotor* (0 to 2 years old), *preoperational* (3 to 6 years old), *concrete* (7 to 11 years old), and *formal* (11+ years old) (Piaget, 1928). Although these stages were originally designed to track cognitive development, Piaget (1959) later expanded these stages to describe children's social-emotional development, which he argued followed a parallel trajectory to their thinking (Hesse, 1987). According to Müller and Carpendale (2000), contemporary psychologists have also expanded the tenets of Piaget's theoretical framework to also look at linguistic, behavioral, and moral development in children.

Though Piaget's contributions have been widely influential, his work has also not been without criticism. McLeod (2018) chronicled that some of Piaget's contemporaries such as Vygotsky (1962) and Bruner (1975) challenged the claim that the stage-based framework accurately serves as an architype model for children's developmental trajectories. Vygotsky in particular critiqued Piaget's theories for not focusing strongly enough on the role that more knowledgeable adults play in helping children learn to navigate the world around them. Others claimed that Piaget's cognitive assessments were too simplistic and did not properly distinguish between performance on a task and a child's long-term competence in a targeted cognitive area (McLeod, 2018). Despite these criticisms, Piaget's four developmental stages still serve as a frame of reference in the research canon that scholars and practitioners use to determine whether a child is meeting the milestones associated with their chronological age, or if they are delayed in one or more areas. Today, developmental psychologists have conducted a multitude of studies on children designed to use Piaget's (1928, 1959) stages as a starting point for constructing more granular classifications of age-based milestones (Müller & Carpendale, 2000; Travers et al., 2009). The next sections explore milestones associated with the cognitive, linguistic, and social-emotional domains in greater detail.

Developmental Milestones

Over the last 80 years, developmental psychologists have studied large enough numbers of human beings around the world to establish a series of milestones that most people will experience if they are born typically developed in all five domains; and, they do not experience lasting damage to a part of their body, brain, or nervous system (CDC, 2019b). Dosman and colleagues (2012) describe milestones as "specific skill attainments occurring in a predictable sequence over time, reflecting the interaction of the child's developing neurological system with the environment" (p. 561). A review of literature for this study discovered numerous sets of published developmental milestones, each containing unique variations of age-based skills. The concept of developmental milestones might be considered paradoxical in nature. This is because while scholars generally agree that milestones may be determined by valid research processes, the fact that varying sets have emerged from studies over time suggests that no one set of milestones is inherently more valid than another (Dosman et al., 2012). For these reasons, some developmental scholars advise that using multiple sets of milestones in conjunction with one another may be the most prudent way to capture a multi-faceted account of tracking development over time (de Souza & Verissimo, 2015; Dosman et al., 2012). Moreover, milestones may be more accurately depicted in terms of age-based ranges of skills, rather than rigid findings (Dosman et al., 2012).

Students experience difficulties in each of the developmental domains differently, and therefore may exhibit differing ranges of milestones associated with their chronological age. Pope and Tarlov (1991) observe that while functional limitations in physical or motor domains may limit a student's mobility, challenges in these are alone are typically not sufficient to classify an individual as having a developmental disability. On the other hand, students with developmental disabilities almost ubiquitously exhibit challenges in cognition, language, and social-emotional behavior (Friend, 2018). Moreover, difficulties in these three academic domains have been shown to also negatively impact physical or motor areas of the brain (Baars & Gage, 2010). In a decision informed by relevant literature, the determination was made only to investigate developmental changes for this study in the cognitive, linguistic, and social-emotional domains. This decision is covered in greater detail in Chapter 3. In order to provide a working frame of reference for this study, the following sections depict snapshots of significant domain-based milestones.

Cognitive Domain Milestones. The act of cognition involves processing information that enters the body and brain through one's senses and organizing this information for the purposes of thinking (Anderson, 2015). In the sensorimotor period during first the few months of life, babies exhibiting typical development learn to focus their eyes on moving objects, imitate facial gestures, anticipate regular events, recognize faces, learns object permanence, and begins to understand cause and effect (Travers et al., 2009). Between one- to two-years-old, an infant learns to look at a specific picture when prompted, follow simple instructions with gestures and/or sounds, imitate an adult's actions and language, name everyday objects, and match similar objects and shapes (Dosman et al., 2012).

Entering into the preoperational stage, children at three years old identify multiple objects in one picture, pretend in imaginary ways, and begin to develop reasoning skills. At four years old children seek answers to their questions by asking 'why' or 'how.' At five years old, children understand step-by-step instructions, draw humans with greater details, count and sequence five to ten objects, and begin to understand time-based concepts such as 'today,' 'yesterday,' or 'tomorrow' (Shaffer & Kipp, 2013).

Children at the concrete stage of development base their reasoning off of society's rules and expectations (Shaffer & Kipp, 2013). Their sense of egocentrism decreases, allowing them to take another person's perspective (Epley et al., 2004). At this stage, children may ask questions about people who are not physically present in the environment. Lastly, children at the formal stage of development have typically developed enough self-awareness to explain how they learn best (Kopp, 2011). Learners engage in systems thinking, or how things influence one another within a whole (Arwood, 2011). Formal thinking also includes hypothetical and deductive reasoning, abstract analysis, advanced logic, and systematic problem solving (Travers et al., 2009).

Language Domain Milestones. Despite not being able to communicate in full logical sentences, typically developed children at the sensorimotor period exhibit many examples of language structures. Within weeks after birth, children respond to different types of sounds and adjust their cries to reflect different kinds of needs (Dosman et al., 2012). Between six and nine months, children 'babble' nonsense sounds, and between 12 and 24 months a child uses two-word utterances in varying ways to express different ideas (Arwood, 2011; Saxton, 2017). As children enter into the preoperational period, they string together simple word combinations that eventually begin to form curtailed sentences (Arwood, 2011; Shaffer & Kipp, 2013). Children at four years old practice refining the sounds of language through repeated questioning, and at five years old they may be able to tell complete stories (Arwood 2011). At the concrete level, typically developed seven-year-old children can respond to questions that require a thorough understanding of time and a full sense of grammar to convey complex ideas (Arwood, 2011).

Social-Emotional Domain Milestones. Social-emotional competence involves learning over time how to initiate and maintain healthy relationships successfully with others (Arwood et al. 2015; Rubin, Bukowski, & Parker, 1998). In the first 2 years of life, babies begin to establish important bonds of trust with their caregivers, respond positively to the presence of adults in their environment, begin to recognize family members' roles and names, laugh during social play, and begin to develop problem-solving skills (Kopp, 2011). As children enter the preoperational stage, more complex feelings begin to emerge. Typically developed children tend to learn how to build empathy and engage in pretend group play with others by four years old (Kopp, 2011). By six years old, children exhibit more care for others by acting upon their concerns, and develop an increased awareness of their abilities, preferences, and dispositions (Travers et al., 2009).

Children at the concrete stage increase their level of agency in relation to others by closely observing their emotions, feelings, and reactions (Shaffer & Kipp, 2013). Self-esteem grows by improving one's self-image. Learners can 'fit in' in multiple settings by adjusting their behavior in the home, school, and community (Berns, 2016). Concrete learners base their judgment off of another's perspective to begin to internalize a reason for doing good behavior. By 11 years old, typically developed formal thinkers develop an internal locus of control, or advanced concepts of respect, and judgment to regulate their behavior (Weiner, 1986). Social agency becomes societally based: for the greater good of society (Arwood, 2011). Formal learners develop self-advocacy, or ability to understand and communicate all needs (Travers et al., 2009).

This section introduced different theories of how children develop over time. This topic is especially pertinent to individuals with developmental disabilities, because children in this population frequently experience delays in one or more developmental domain (Travers et al., 2009). Over time, different academic disciplines have devised a multitude of ways of assessing students over time to track their developmental progress. Though the most common manner of assessing children for this information is to directly test them using norm-referenced measures, other approaches also exist (Overton, 2016). The next section outlines how researchers from the qualitative paradigm have utilized the artifacts that students create to follow their developmental maturation in their childhood years.

Developmental Mediums

Student-created artifacts make take the form of many different *mediums*, or modalities of expression (Banks, 2001). As previously described, document analysis is a qualitative method that remains flexible enough to investigate many different types of student-created artifact mediums for changes in response to phenomena (Bowen, 2009). Because the artifacts that students create represent their thinking, analyzing changes in these artifacts over time has been shown to serve as a proxy research technique for direct testing (Boyatzis, 2000). For example, Cherney and colleagues (2006) state that drawings and writings serve as symbolic representations of students' thinking processes translated onto the page. Therefore, analyzing artifacts may serve as substitute access points into participants' cognitive, linguistic, and social-emotional changes over time (Cronin-Jones, 2005; Laws & Lawrence, 2010; Kress, 2003). The following sections identify literature specific to the analysis of student-created writing and drawings, as well as the analysis of practitioner-created case notes documenting participants' progress. The evaluation these mediums simultaneously has also been advocated for by Banks (2001), as examining the synchrony of multiple means of expression may lead to a more holistic understanding of how a student functions in multiple domains.

Drawings

Analyzing student-created drawings is a technique that dates back many years and spans multiple disciplines. Papandreou (2014) documented that interpreting children's drawings can be completed using a developmental, clinical, or artistic approach depending upon the theoretical framework that the researcher utilizes. In a related review of literature, Farokhi and Hashemi (2011) chronicled how over the last hundred years the field of psychology has used the drawings that children produce as symbolic representations of their psychic functioning. Psychologists have devised ways to code the interactions of drawn symbols the child produces on the page, such as people engaging in an environment, in order to interpret the child's emotional intelligence (Farokhi & Hashemi, 2011).

Researchers analyzing children's pictures from a developmental perspective argue that these drawings provide a window into their developmental functioning in multiple domains (Cherney et al., 2006; Papandreou, 2014). According to Cherney and colleagues (2006), the drawings that children create represent how they understand the world around them. As such, researchers can closely scrutinize drawings to code them for changes in development over time (Cronin-Jones, 2005). Scholars are in consensus that as typically developed children mature, they use increasingly complex symbolic representational strategies to depict the people, objects, thoughts, and events that comprise their lives (Boyatzis, 2000; Cherney et al., 2006; Golomb, 2004). Some researchers have tracked these changes over time by coding them against developmental milestones (Boyatzis, 2000) Drawing also allows children to use their imagination to capture new ideas, as well as distinguish fantasy from reality (Papandreou, 2014).

Scholars have identified numerous reasons why assessing children's drawings is a valuable research method that may provide unique insights into their developmental functioning (Cherney et al., 2006; Papandreou, 2014). As previously discussed, some researchers have questioned whether norm-referencing testing and assessment captures an accurate picture of who students are and how they learn best (Reschly et al., 2002). Moreover, research has shown that many students with developmental disabilities are not able to take such tests as they were designed to be administered due to sensory impairments (Siegel & Allinder, 2005). Eisner (1999) argues that drawings can reveal unique insights into a student's mind in a way that multiple choice tests cannot. Papandreou (2014) adds that for visually thinking students drawing is a more accessible and intuitive way to express their thinking than through auditory modalities. Research has shown that children do not need artistic skills in order to draw (Golomb 2004). For example, Cherney and colleagues (2006) found that children with no prior drawing experience automatically drew human figures when first given a pencil and paper, thus providing researchers with immediate insights into their cognitive and social functioning.

Proficiency in drawing as a tool for symbolic representation is thought to progress through various stages (Edwards, 2016; Lowenfeld & Brittain, 1987; Papandreou, 2014). Scholars who research the evolution of children's drawings over time have evaluated enough artistic data to compile prototypical examples of the elements that typically comprise such artwork at different developmental ages. While each scholar constructs slightly different taxonomies of this evolution, general consensus holds that children progress from a 'scribbling,' or nonsensical mark-making phase, to a 'meaning-making' phase, where drawings exhibit intentionality of expression (Edwards, 2016; Lowenfeld & Brittain, 1987). Thus, because children's artistic development tends to follow archetypical trends, this means that deviations or delays from these trends can also be observed (Golomb, 2004). Figure 2 displays one example of how two different researchers have described and canonized the prototypical changes that typically developed children's artwork exhibits over time. This portrayal serves as just one example of the myriad of artistic developmental schemas that this study drew from to establish a working knowledge of how children's artwork can provide insights into changes within their developmental functioning over time.

Figure 2

Age-Based Markers of Children's Artwork

						
	2 years	**3 years**	**4 years**	**6 years**	**8 years**	**10 years**
Source: Lowenfeld & Brittain, (1987).	Scribbling stage	Preschematic stage		Schematic stage	Dawning realism	
Source: Edwards (2016).	Scribbling stage	Stage of Symbols	Pictures that tell stories	Landscape stage	Stage of complexity	Stage of realism

Note. Figure adapted from image created by Donley (1987). Used within creative common parameters for educational purposes.

Over time, children discover combinations of mark making that others can interpret and assign meaning to (Cronin-Jones, 2005). This process illuminates the fact that drawing is a social activity as well as a semiotic exercise (Kress, 2003). Drawings can be analyzed for social, linguistic, and cognitive functioning simultaneously. For example, researchers can examine whether drawn human figures are aligned together in meaningful, non-random ways; such a grouping suggests increased social agency in children (Golomb, 2004). Similarly, children who more accurately represent the spatial dimensions of people and objects on the paper are thought to demonstrate more advanced proprioceptive awareness (Cherney et al., 2006). Boyatzis (2000) summarizes that advancements in children's drawings follows an *orthogenetic* trend, where individuals depict augmented levels of intellectual complexity by using increasingly complex visual symbolization strategies over time.

Writing

Research analyzing students' written language tends to focus primarily on how proficiently the child exhibits typical conventions, such as quantities of vocabulary or accurate grammar (Dore & McDermot, 1982; Saxton, 2017). For example, linguists tend to closely examine the surface structures of language that a child produces to determine if that child uses language correctly according to established norms (Fillmore, 1968). Often, language is studied by multiple academic fields simultaneously. For example, the intersection between the disciplines of psychology and linguistics is called the study of *psycholinguistics* (Siegel, 2001). A psycholinguist will analyze the component parts inherent in the child's use of language such as the *phonology* (speech sounds), *vocabulary* (word selection), *morphology* (word formation), and *grammar* (adherence to established linguistic rules) to determine if that child is maintaining developmental progress as compared to typical milestones in the linguistic domain (Saxton, 2017). For example, by 24 to 36 months a child is typically able to assemble word patterns in combinations that are simple in structure but constitute a manner that is comprehensible to an adult (Travers et al., 2009). However, a child's behavior may show that they are not meeting this milestone in various ways, such as by not demonstrating the ability to write, or instead by using words that are non-comprehensible (Saxton, 2017). If the child's language does not change over time, the child may be at risk of ceasing to acquire language throughout their lifetime (Overton, 2016). This finding is one of many examples of how an individual may experience developmental delays throughout their childhood. These phenomena are covered in greater detail in the following section.

Developmental Delays

Students with developmental disabilities almost universally experience delays in their development, meaning that there is a gap between their chronological age and their developmental functioning in relation to age-based milestones (Overton, 2016; Walker, 2000). For example, though a student may be 12 years old, they might not be capable of writing their own name, a milestone often performed by students at four or five years old (Saxton, 2017). As typically developed children grow older, they frequently meet age-based milestones. As students with developmental disabilities grow older, however, they often experience a widening of the gap between their chronological age and their current developmental functioning (Walker, 2000). For example, at the start of their 12th year of life, the aforementioned student who could not write their name experienced an approximate eight-year gap between their age and the four-year-old milestone. If that student grew older by 1 year, but still could not write their name, that specific developmental gap would be considered to have widened by 1 year, according to developmental researchers (Travers et al., 2009; Walker, 2000). Some hypothesize that students exhibit gaps in their development primarily due to a multitude of barriers that have inhibited their capacity to learn over time (Reschly et al., 2002). Thus, more information regarding the interdependent relationship between learning and development is provided next.

Development Results from Learning

Piaget (1964) was an early scholar to challenge the notion that the processes of development unfolded naturally and automatically for children. In his view, development and learning were distinct psychological and neurobiological processes

(Gauvain & Cole, 2009). Development was seen as a spontaneous process beginning with *embryogenesis*, or the formation of the human body, and culminating in the foundation of an individual who could act and think critically on their own (Gauvain & Cole, 2009). In this view, however, for a child to learn they must have adults in their life who assign meaning to what they do through external input (Piaget, 1964). Piaget disagreed with the idea that development was a sum total of a child's learning; instead, each act of meaningful learning unlocked a new capacity for neurobiological development (Piaget, 1964). In addition, each new formation of development constructed a change to learn in a new kind of capacity. This viewpoint established the axiom that development results from learning, and not the other way around, as some had believed (Salkind, 2004). Today, learning and development are said to have a reciprocal relationship, where one cannot exist without the other (Hoare, 2006; Latta, 2019).

The application of this axiom to real-world experiences can frequently be observed in the life trajectories of individuals with developmental disabilities. For example, research is filled with examples of individuals from this population who exhibit atypical development, such as children who never progress past the sensorimotor stage of functioning despite their bodies maturing to adolescence (Walker et al., 2011). Whether they are born with irregular brain architecture, or whether they experience extreme stress such as abuse or neglect, many children are precluded from developing precisely because their neurobiological systems experience severe barriers to learning (Walker et al., 2011). Put another way, many children who do not learn do not develop (Vinter & Perruchet, 2000). Some have observed that these individuals appear to be developmentally ‘stuck in time’ in that may they never progress past milestones more associated with very young children (McCroskery, 2000). This study purposively examined the impact of Neuro-Education intervention methods on *both* learning and development. Though these two processes are inextricable, they are nevertheless distinct and therefore warrant individual exploration.

Analyzing Impacts of Interventions

Interventions for students with developmental disabilities are typically deemed to be successful or fostering growth if they help that student to reduce the gaps over time between their age and their developmental functioning (Overton, 2016). However, according to Vinter and Perruchet (2000) children develop if – and only if – they can learn. Learning and development might be described as parallel strands of a double helix, where one cannot exist without the other (Crick, 2006). Therefore, if a student with disabilities is not learning, further investigation into why this is the case is warranted. Viewing the other side of the helix – changes in capacity for learning – may further illuminate how and why these products changed from an alternative perspective (National Research Council, 2000). This perspective is explored next.

Measuring Learning

Measuring the act of learning can be a formidable endeavor. This is partly because academic literature is filled with numerous descriptions and definitions of learning, each with their own standpoints and positions. Thus, determining a consensus definition of learning can be challenging (Illeris, 2018). As previously discussed, the act of learning can be defined from the perspective of cognitive psychology as the integration of information into schemas within the mind that lead to long-term functional memory (Anderson, 2015; Dixon & Stein, 1992). From the vantage point of neuroscience, learning can be defined as the permanent changes in the brain that result in increased neurobiological capacity (Baars & Gage, 2010). Though each of these definitions hold inherent value to scientific research, certain epistemological issues arise when attempting to translate these tenets into research applications.

Learning is sometimes described as a *latent* variable because it cannot be directly seen or observed in others (Didau, 2016; Muijs, 2011). To try to circumnavigate this conundrum, qualitative researchers frequently attempt to measure learning as a process where change in a person is reflected through multiple perspectives simultaneously (Gläser-Zikuda, 2012). This is because learning is thought of by some as being comprised not of just one act or operation, but instead of many synchronous processes all acting simultaneously (Illeris, 2018).

In other types of developmental-based research, changes in learning are frequently measured through analyzing changes in the products that students create – also conceptualized as what someone has learned (Cronin-Jones, 2005; Norman, 1991; Resnick, 1987). In this view, to study how learning changes a person requires the researcher to analyze how one's products of thinking, language, and behavior evolves over time (Baars & Gage, 2010). However, although this approach is quite common in the canon of literature measuring learning, multiple scholars posit that this research method only captures a portion of how students have changed due to learning (Green-Mitchell, 2016; Jaskowiak, 2018). For example, instead of just measuring *what* a person has learned, some scholars have argued that researchers can also measure changes in *how* a person learns over time, also referred to as the *processes* that undergird learning (Arwood, 2011; Robb, 2016). The fundamental differences between products and processes of learning are further explored later.

Taking all of this into consideration, this study aimed to operationalize a definition of learning that represented multiple viewpoints simultaneously thus providing for a more robust triangulation of findings from literature. As previously discussed, the Neuro-Semantic Language Learning Theory (Arwood, 2011) sits at the center of Arwood's Neuro-Education Model which itself draws from three disciplines to establish a grounded theory of how humans learn. Thus far in this review, the act of learning has been defined through each of these three lenses. As expressed, the lens of language can be used as a vehicle for observing changes in what an individual does, which in turn represents the purported changes that are occurring within that person's mind and brain (Arwood, 2011). More specifically, changes in one's learning can be measured by observing the ways that the individual changes their use of language to function in the world.

For this study, the lens of language function was used as the operationalized metric by which changes in the participant's learning was observed over time. Specifically, this investigation analyzed artifacts that a participant created to measure for changes in language functioning throughout the duration of the study. Though the act of learning ontologically represents more than just changes in language function (for example, changes in the mind and brain), these changes cannot be measured directly. Thus, the act of learning was limited to the measurement of language functioning over time; but, additional hypotheses on what these changes might mean for the participant's mind and brain were also provided. More details on these decisions can be found in Chapter 3.

In sum, many different theories and philosophies exist that offer differing explanations for how humans learn (Illeris, 2018). However, a review of literature for this study found few models that place the acquisition of language as the core operation that drives both neurobiological, mental, and developmental advancements in humans. More specifically, scant research proposes that the acquisition of language function is the process that unlocks learning to occur in children over time (Robb, 2016). By measuring changes in language function, one is afforded the opportunity to view the changes in the products that someone creates and extrapolate these findings to understand the changes that this individual experiences in their processes of learning. As previously stated, the lens of language function was chosen to represent the cognitive framework of learning used for this study. Thus, more information regarding how to measure changes in language function is explored in the following sections.

Measuring Language Function

One academic finding that has consistently puzzled researchers is that individuals with development disabilities often struggle to learn and acquire typical language throughout their lifetimes (Pennington, Courtade, Ault, & Delano, 2016). Previous sections in this chapter identified that students from this population experience a wide range of language challenges, ranging from the inability to use any form of language to communicate, to exhibiting atypical idiosyncrasies inherent in their conversations with others (Shaffer & Kipp, 2013). However, according to Dore and McDermot (1982), scholars may not be finding language in some students with disabilities because their search attempts are misguided.

For example, Overton (2016) clarifies that intelligence testing, adaptive rating scales, and standardized assessments all look for evidence of language by searching for usage of surface structures. These efforts may be missing the point, as changes in language – and therefore learning – may yield more fruitful results when investigated via other means such as language function. Though in the minority, some academics over time have advocated for research designs to include an analysis of language function in addition to language structures. In a historical review, Green-Mitchell (2016) chronicled how scholars such as Brown (1986) argued that studying students' level of language function may provide an insightful window into how they learn. This may be because children's level of language function generally increases as they learn and grow older (Halliday, 1976). Green-Mitchell added that the concept of language function matched that of Lenneberg (1973), who stated that one thinks *through* their use of language.

Arwood (2011) incorporated findings from the fields of neuroscience and cognitive psychology into the study of language function. In a review of literature connecting these three disciplines, Jaskowiak (2018) found that language function represents the brain's underlying socio-cognitive understandings of the world (Pulvermuller, 1999). Specifically, acquiring functionality through language involves forming neurobiological meaning through the process of social interactions and life experience (Bruner, 1975; Tomasello, 2009). Arwood (2011) posits that if children acquire sufficient amounts of language throughout their lifetime, they progress through four stages of language function that correspond to Piaget’s (1928) age-based theory of cognitive development. These stages are: (a) pre-language, 0 to 2 years old; (b) restricted language, 3 to 6 years old; (c) language function, 7 to 11 years old; and (d) linguistic function, 11+ years old.

This section provides greater details regarding Arwood’s (2011) stages of language, as well as the language functions of: (a) expansion, (b) extension, (c) modulation, (d) displacement, (e) semanticity, (f) flexibility, (g) productivity, and (h) redundancy. In addition, this section outlines how practitioners can sample students’ language through oral and alternative means to measure changes in learning over time. This sampling of language is the primary mechanism that researchers utilizing a Neuro-Education cognitive framework use to measure changes of learning over time. Lastly, recent research is examined on the topics of language sampling and measuring the impact of Neuro-Education intervention methods in typical classroom populations.

Expanded Language Functions

By analyzing how individuals use language to think, Arwood (2011) identified eight functions of language that each serve a different purpose in communication. The study of purposeful communication has been taken up by many disciplines over time including anthropology (Kernan, 1970), sociology (Campbell, 2011), psychology (Anderson, 2015) and more. Bruner (1975) incorporated ideas from these fields into language analysis and noticed that all basic semantic relationships consist of an agent (person) engaging in an action accompanied by an object. Through language, children learn to *expand* upon these relationships by complexifying the connections between the who, what, where, when, why, and how surrounding a situation (Gruendel, 1977). Semantic connections between ideas can be *extended* into new, imaginative uses (Berko, 1958). These expansions and extensions occur as children learn to *modulate* their language, such as by incorporating advanced temporal or spatial understandings (Humphries et al., 2006).

As children increase their capacity for imagination, they begin to use their language to *displace* ideas away from their ‘here and now’ and communicate about concepts far from their immediate surroundings, such as a time from ancient history (Hockett, 1960). Similarly, a child’s understanding of concepts can increase in *semanticity*, meaning that they communicate about higher-order, formal ideas such as ‘compassion’ or ‘loyalty’ (Arwood, 2011; Vygotsky, 1962). Children can exhibit greater *flexibility* of language, meaning that they can converse with multiple people, on a wide range of topics, in diverse settings (Bruner, 1975; Hockett, 1960). Relatedly, children who demonstrate *productivity* of language can communicate using multiple modalities and understand content when it is presented via different means (Akhtar & Tomasello, 1997; Berko, 1958). Lastly, as children become more proficient with language, they display less *redundancy*, meaning that they are efficient in their verbiage and typically follow natural conventions of language (Akhtar & Tomasello, 1997; Hawkins, 2004).

As typically developed children grow older in age, their growth in language function may correspond to the four function levels described above. According to multiple scholars, individuals who ultimately acquire maximal levels of language function should demonstrate functionality in all different forms of literacy (Arwood, 2011; Green-Mitchell, 2016; Robb, 2016). In practice, this means that their stated language is clear and stands on its own; adults do not need to fill in critical missing details to understand the intended sentiment (Arwood, 2011; Coplan, 1985). According to Arwood (2011), many students with developmental disabilities do not match this description of language usage. That is, students from these populations most commonly demonstrate *pre-language* or *restricted* levels of language function, depending upon how impacted their learning systems are by their developmental conditions (Arwood, 2011; Akhtar & Tomasello, 1997). Specific characteristics of these two language levels are provided later.

Assessing Language Function

The practice of sampling students' natural, spontaneous language for the purpose of assessment has been used as a method in research for many years (Evans & Craig, 1992). This method is frequently employed in fields such as anthropology where a researcher samples language to determine how a culture functions (Kernan, 1970), or in speech-language pathology where a practitioner may incorporate ongoing spontaneous language sampling for the purpose of determining a child's response to an intervention (Evans & Craig, 1992). As previously described, the sampling of students' language for research purposes is most commonly completed by recording a child's oral speech and transcribing it for further analysis. However, this assessment approach may be hampered for students who struggle to produce oral language (Crepeau-Hobson & Vujeva, 2012). For example, Sattler and Dumont (2004) observe that the brains of most students with developmental disabilities struggle to process or produce sound-based language. Assessing only these students' oral language, and no other communication mediums, may perpetuate the aforementioned deficit-based model of testing decried by disability theorists (Moore & Slee, 2012). According to Crepeau-Hobson and Vujeva, 2012, researchers must find alternative methods of language assessment designed to find examples of students' strengths for learning. In referencing the process of deixis, Arwood (2011) adds that many forms of student communication go unnoticed, and therefore unanalyzed.

ANSPA. Arwood (2011) developed a series of assessment protocols that researchers and practitioners can use to sample multiple mediums of language from many different student populations, including individuals who do not produce any oral speech. One such assessment is called Arwood's Neuro-Semantic Language Learning Pre-Language Assessment Protocol (ANSPA) (2011, pg. 187). The ANSPA is designed to be administered to a student in a one-on-one setting, where a researcher writes notes regarding how students respond to the ten questions. Sample ANSPA questions include: (1) Does the child address other and expect others to respond?... (6) Does the child talk about the 'here and now?'… and (10) Does the listener understand the speaker's meaning without having to take on more than a 'shared' level of understanding?

The questions on the ANSPA are designed to first assess students' proficiency in oral language functioning (Arwood, 2011). For example, if practitioners predominantly answer 'no' to most of the assessment questions, the student may be considered to function at a pre-language or restricted level. If students' responses to the ANSPA indicate that they have difficulty communicating ideas orally, researchers can subsequently sample a student's drawn and written language to ascertain more information about their language usage. More details about assessing language function through these two mediums are provided next.

Drawings. Utilizing oral speech is the most common method of communication in our auditory culture; yet, many students with developmental disabilities appear unable to process sound in meaningful ways (Conners et al., 2001). According to Arwood (2011), the fact that these students may not process sound does not mean that they do not possess other strengths, such as the ability to use mental pictures to symbolize the world around them. Surveying the drawings that these students create may be a more accurate representation of the complexity of their visual thinking, as depicted by their mental pictures translated on to the page. Since the mind is seen as the gateway to the brain (Fischer, 2009), then analyzing these drawing samples assesses that student's use of language function, or their capacity to use their brain to produce language in order to think (Arwood, 2011; Cronin-Jones, 2005).

Through an analysis of this visual medium, an educator can function as an anthropologist of sorts by looking at the drawings a child produces to see whether they contain any of the relationships between humans and their environments that are considered universal (Arwood, 2011; Kernan, 1970). Specifically, children whose drawings depict more clearly defined relationships between agents, actions, and objects are thought to function at higher social, cognitive, and linguistic levels of language function (Arwood, 2011; Bruner, 1975). In contrast, in examples where students' drawings consist of illogical scribbles, the researcher may suspect that the student lacks clarity to their visuo-cognitive symbolization (Arwood, 2011). In this sense, students' drawings can become proxy for conventional forms of language, and thus allow the educator to extrapolate how socio-linguistically advanced the child conceptualizes the world around them (Arwood, 2011; Green-Mitchell, 2016; Van Sommers, 1984). Put another way, though many moderately to severely disabled children may not write or produce intelligible oral speech, they still may produce evidence of thinking via other mediums (Arwood et al., 2015).

In a review of literature, Green-Mitchell (2016) extrapolated additional rationale for analyzing student-created drawings for language function. The author noted that in some cases, students' use of oral speech can be determined to be merely 'echoed' or 'borrowed' language, meaning that it does not represent their actual thinking (Arwood, 2011; Lenneberg, 1969). Asking students to depict the relationships between agents in a picture may expose previously unidentified gaps in their conceptual understanding of the world (Arwood, 2011; Green-Mitchell, 2016; Robb, 2016). In general, the behavior that the child represents in drawn form mirrors their behavior in real life (Arwood, 2011; Laws & Lawrence, 2010). Consequently, the drawings they create can provide a reference point to compare their level of concept functioning to their relative positioning on the four developmental stages originated by Piaget (1928).

Writing. As previously discussed, scholars note that the majority of research studying writing is designed to measure students' proficiency in utilizing correct structures of language, such as grammar, spelling, vocabulary, or reading comprehension questions design to elicit right or wrong answers (Dore & McDermot, 1982; Saxton, 2017). This approach may only elicit a superficial understanding of how the child uses language (Dore & McDermot, 1982). As mentioned, Green-Mitchell

(2016) and Robb (2016) observed that students can just as equally borrow written patterns as they can oral speech, thus rendering a falsely elevated understanding of semantic content through uncareful analysis.

In response to these concerns, Arwood (2011) expanded the assessment of language function to include an examination of how students use their writing to communicate, as well as how proficiently they use their written words to match the semantic content depicted in their drawings. Because children think first and foremost in visual pictures (Deza & Deza, 2009), it stands to reason that translating these mental graphics into drawings on the page would be the most expedient use of cognitive resources (Kraemer et al., 2009). On the contrary, converting visual ideas into written words would require an additional cognitive step in the mind, which would be expressed by the use of additional neurobiological resources in the brain (Kraemer et al., 2009). One caveat to this has been found when visual thinkers learn alternative methods for acquiring language, such as when writing is taught using shapes or pictures of ideas without the accompanying sound-based components (Arwood, 2011; Robb, 2016). Literature reviewed for this study suggests that visual thinkers possess greatly varying proficiencies in their ability to translate such visual thinking into words (Kelley-Hortsch, 2018; Robb, 2016; Xiang-Lam, 2016). Arwood (2011, 2017) summarized this phenomenon by stating that words are not the units of analyses used by the brain; that is, visual thinkers may instead heavily rely on connecting visual channels of the brain together to form meaningful circuits and networks (Pulvermüller, 2013).

Therefore, the study of writing through a language function lens attempts to determine how accurately an individual expresses the semantic content of their drawings with their use of written language. According to Arwood (2011), to possess functional written literacy students must be able to meaningfully connect their visual patterns (words) with visual concepts (drawings) and/or their visual concepts into the shapes of writing ideas. Temple and colleagues (2013) add that the writing that attaches to a student-created drawing should incorporate appropriate vocabulary and convey an understanding of the content to a reader. Any semantic irregularities inherent in the pattern-to-concept linkage requires further inspection to determine which categories of language function are being inaccurately expressed (Wright, 2007). Notably, the accuracy of these semantic connections have been shown to improve over time in some populations after receiving Neuro-Education interventions (Kelley-Hortsch, 2018; Robb, 2016; Xiang-Lam, 2016).

Pre-Language Learners

If during the administration of the ANSPA the practitioner answers 'no' to all, or nearly all of the questions, the student being assessed is likely to function at the pre-language level (Arwood, 2011). Students at the pre-language level most closely align with the cognitive, linguistic, and social characterizations of the sensorimotor and preoperational stages of development (Arwood, 2011; Piaget, 1928, 1959; Vallacher & Wegner, 1989). Individuals at this stage utilize thinking and language that is egocentric (Vygotsky, 1962) and limited to the immediate 'here and now' (Arwood, 2011). Other indicators of pre-language function include the use of severely restricted grammar and overall lack of clarity in ideas, thus requiring the listener to make educated guesses about what they are attempting to communicate (Akhtar & Tomasello, 1997; Hockett, 1960).

In a study measuring language function, Green-Mitchell (2016) observed that students at the pre-language level did not construct logical arguments or form connected propositional ideas. This was reflected in their writing that demonstrated a lack of extension, expansion and modulation regarding the story they were trying to tell. Similarly, these same students' drawings did not connect agents, actions, or objects together in a systematic way, thus forcing the researcher to guess at their meanings. In a related study, Jaskowiak (2018) found that the oral stories of pre-language students contained numerous structures that, once translated onto the page, became immediately apparent as borrowed language. Lastly, in numerous case studies measuring language function, Arwood (2011) discovered that some populations of students did not exhibit any communication via oral, written, or drawn means. The author identified this population as functioning at the pre-production level, most frequently used to describe individuals who are profoundly disabled and exhibit cognition matching criteria for children zero- to two-years-old (Arwood, 2011; Wyn Reimers Johnson, 2010).

Learners with Restricted Language

By eight years of age, students on a typical development trajectory should be operating at the concrete level of development (Piaget, 1928, 1959) and exhibiting usage of functional language that allows their ideas to be clearly understood by others (Arwood, 2011). As previously mentioned, many students with developmental disabilities instead demonstrate a pre-language or restricted level of language function

(Arwood, 2011; Debreczeny, 2019). Students exhibiting restricted language may produce oral, written, or drawn products, but the meaning behind their communication is often unclear to an observer (Arwood, 2011; Robb, 2016).

Jaskowiak (2018) analyzed students' oral, written, and drawn language samples and discovered that all of the participants in the study between the ages of eight and nine exhibited restricted language function. Upon analyzing participants' language samples, the author found that students often used borrowed language structures that conveyed no logical meaning when they were translated into drawings. The author also found that the reverse was true – that students could draw a detailed picture but could did not use oral language to match the depicted content. Similarly, Robb (2016) surveyed an entire class of seven- to eight-year-old students and found numerous examples of restricted language function. For instance, the author noted that many students were able to articulate language patterns orally without understanding their underlying deeper meaning. Arwood (2011) summarizes this phenomenon by stating that a students' language is restricted when it fails to communicate intention clearly, thus requiring the observer to take on more than a shared responsibility for understanding. Students whose language is restricted have been shown to manifest numerous difficulties in life, such as attempting to learn in typical school environments, performing activities of daily living, arriving on time for events, and sufficiently organizing their thinking for functional purposes (Arwood et al., 2015; Arwood & Merideth, 2017).

Products and Processes

As previously referenced, many studies measuring development attempt to analyze characteristics in student-created artifacts and match this evidence to a range of developmental milestones (Cronin Jones, 2005; Saxton, 2017). This approach provides valuable information that marks changes in development to specific age-based metrics (Boyatzis, 2000). From the language lens perspective (Arwood, 2011), this process focuses primarily on analyzing changes in the products that students create over time. Some scholars observe that while measuring growth in developmental products illuminates important insights, this approach may not provide explanations as to why or how an individual becomes capable of evolving these products over time (Siegel, 2001).

To answer these questions Arwood (2011) contends that researchers must also take efforts to measure changes in participants' processes of learning. Individuals evolve these learning processes by increasing their capacity to think, exhibit pro-social behavior, and use language to function (Arwood et al., 2015; Robb, 2016). Neuroscientists refer to changes in these metrics as someone changing their capacity to learn, meaning that their mind and brain have fundamentally evolved in transformational ways (National Research Council, 2000). In turn, these learning processes are reflected by the brain inhibiting and integrating information in a more efficient manner (Gallistel & Matzel, 2013).

As brains become more efficient, they can acquire more meaningful information at a faster rate of learning (Gallistel & Matzel, 2013). This faster rate of learning allows the brain to 'do more with less' amounts of sensory input, and over time unlocks a plethora of new nebulous neuronal pathways (Squire et al., 2014). As these pathways cluster together to form circuits and networks, the brain increases its capacity to provide itself with greater 'cascades' of neurobiological feedback where one can now more proficiently reflect upon their own learning (Baars & Gage, 2010). In psychology literature, this reflection is called metacognition (Anderson, 2015). Through the language, lens self-feedback is referred to as one refining their own thinking through their language (Arwood, 2011). And, as previously discussed, development results from learning; therefore, literature informs that these transformational changes to one's functionality of learning should be reflected in the products that one creates, as well as the processes reflected in how they use increasingly complex language to function (Arwood, 2011; Salkind, 2004; Latta, 2019).

As previously explained, the four levels of the Neuro-Semantic Language Learning Theory (NsLLT, Arwood, 2011) were designed to provide reference points for how one's thinking processes and language can evolve over time, and how these transformations are reflected by neurobiological changes in the brain. Thus, the NsLLT – and Neuro-Education as a whole – provides researchers with a cognitive framework for understanding how changes in language products are undergirded by evolvements in one's capacity to use language to increasingly process the world around them in meaningful ways. Specifically, researchers can measure changes in students' thinking by sampling their language over time and closely analyzing these artifacts for changes in all of the eight language functions.

Summary

This chapter presented literature relevant to the many topics covered in this study. Chapter 2 began with an introduction defining who students with developmental disabilities are and how they are classified in the literature. Next, the history of how students from this population have struggled to be meaningfully included in educational settings was addressed. The lens of disability theory was introduced as a possible route to inform educators about finding strengths for learning among their students who have languished in socially excluded settings. Multiple gaps in the literature were presented, including a dearth of strengths-based, brain-based educational intervention strategies, and a specific gap in the literature measuring the impact of intervention methods derived from Arwood's Neuro-Education Model on the learning and development of individuals with developmental disabilities.

Chapter 2 outlined information from the two cognitive frameworks – learning and development – used in this study to measure changes reflected in student artifacts over time. The framework of learning was explored through the lens of Arwood's (2011) concept of language function. Many different functions of language were examined in the context of oral, written, and drawn mediums. Next, this chapter explored the framework of development stemming from the fields of developmental psychology and pediatric medicine. These sections identified how changes in students can be reflected in developmental maturation in multiple domains and by measuring progress using developmental milestones. As a whole, measuring student changes through the lenses of both learning and development was conceptualized as a holistic approach to understanding how intervention strategies such as Viconic Language

Methods might impact students who experience them with a knowledgable practitioner.

This concludes Chapter 2. Chapter 3 documents the methodological processes that were used in this study.

Chapter 3: Methodology

Chapter 3 outlines the methodological processes used to investigate the research question for this study. The chapter begins with an explanation of the conceptual framework used to guide the purpose statement and research inquiries. Next, the research design is introduced and rationale for this design is provided. The setting is described and the process for sampling the participant is defined. Two cognitive frameworks, learning and development, are examined as lenses through which collected data were analyzed. Data analysis processes are explored in greater detail. Next, steps taken towards ensuring methodological trustworthiness are stated. Lastly, ethical considerations are presented, and the role of the researcher is introduced.

Conceptual Framework

This study utilized the conceptual framework of Arwood's Neuro-Education Model (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016) to frame the problem, purpose statement, and research question guiding the investigation. Miles and Huberman (1994) describe a conceptual framework as a structure that organizes ideas and describes the relationships between the concepts that are critical to the understanding of a topic. Embedded into the conceptual framework of Arwood's Neuro-Education Model is a theory of learning called the Neuro-Semantic Language Learning Theory (NsLLT - Arwood, 2011) that draws from three disciplines: neuroscience, cognitive psychology, and language. The NsLLT also proposes educational intervention strategies called Viconic Language Methods that practitioners can use to help struggling students learn. Importantly, though this study utilized the

NsLLT theory to undergird these core inquiries, the objective of this investigation was not to *test* this theory. Instead, this investigation aimed to create a thick description of how the participant in this study changed over time (Geertz, 1973). For these reasons a conceptual, not theoretical, framework better suited the aims of this study (Rocco & Plaknotnik, 2009).

Research Question

The purpose of this study was to measure the impact of Neuro-Education methods upon the learning and development of one student with developmental disabilities.

Specifically, the following research question guided this inquiry: What impact do intervention methods derived from Arwood's Neuro-Education Model have upon a young individual with developmental disabilities' cognitive, linguistic, and social-emotional functioning over time?

Research Design

This study investigated the impact that Neuro-Education methods had upon the learning and development of one participant with developmental disabilities who received this intervention over the course of multiple years in a 1-on-1, private clinic setting. This study utilized a retrospective single case study design to investigate its research question (Creswell, 2003; Wiebe et al., 2010). Creswell (2003) defines a case study as "a problem to be studied, which will reveal an in-depth understanding of a 'case' or bounded system, which involves understanding an event, activity, process, or one or more individuals" (p. 61). Wiebe and colleagues (2010) add that a retrospective case study is a type of longitudinal inquiry where the majority of the data to be analyzed has already been created. In a retrospective design the activities under study have already occurred, and the artifacts those activities produced have been accumulated. Hess (2004) adds that retrospective data were collected by someone related to the original setting for purposes other than research. Engaging in retrospective analysis typically involves recreating a timeline of events depicting how the individuals under study changed over time (Wiebe et al., 2010).

While receiving Neuro-Education intervention methods in the clinic setting, the participant created numerous drawings and pieces of writing that were gathered into case files. In addition, one practitioner who provided these intervention methods wrote brief memo-style case notes about the participant at the conclusion of each session. These data served as the retrospective artifacts analyzed for this study. Because these data were collected over the course of multiple years, they are considered in the research canon as longitudinal sets (Gay, Mills, & Airasian, 2012).

According to Price, Chiang, and Jhangiani (2018), analysis of case studies situated in the qualitative research paradigm typically involves constructing a detailed description of how individual participants changed over time. Bowen (2009) adds that the process of document analysis is commonly utilized to examine artifacts that have already been created and can lead to rich descriptions of the phenomena being investigated. As such, this study utilized iterations of document analysis methodology to investigate the research question.

Rationale for Methodology

Creswell (2003) outlines numerous steps that qualitative researchers can take when conducting a study to help ensure that rigorous protocols are followed. In general, maintaining a strong adherence to the protocols that a researcher establishes for their study increases the trustworthiness of their work and allows the quality of their methodological process to be assessed (Lietz, Langer, & Furman, 2006). Additional steps taken to uphold trustworthiness are examined later. This section provides rationale for each component of the research design selected for this study. In particular, rationale for the following elements are explored: (a) single case study design, (b) group versus individual research design considerations, (c) measuring the impact of clinical practice, and (d) retrospective design.

Specific protocols for how each of these elements was enacted in this study are covered in the Cognitive Frameworks, Data Collection, and Data Analysis sections presented later in this chapter.

Single Case Study Design

A single case study design was selected as the best approach for investigating the research question of this study for numerous reasons. Neuman and McCormick (1995) state that case studies are primarily used to describe the processes that individuals undergo in response to experiencing a new phenomenon. Eckstein (2002) adds that studying a case may include examining the impact that a relevant variable has upon the individuals within that case. Yin (2003) describes this type of examination as ethnographic in nature, where the researcher attempts to understand the chronology of participant change from beginning to end of a timeline. Finally, Yin (2009) states that case study analysis can be used to simultaneously explore new topics, describe data, and explain salient findings. As such, the case study approach has been described as particularly suitable for generating new research from a lesser-known field of study, such as Neuro-Education (Price et al., 2018).

Group Versus Individual Designs. According to Wixson (1993), research studying individuals with learning differences has gradually shifted over time from primarily utilizing group-based behaviorist designs to incorporating more individualized case examinations that draw from the social science episteme. This is because the individualized case approach allows for a more intensive analysis of participants than studies that use larger group comparisons. For example, statistical testing in group studies is often designed to report group means, or an averaging of results across people (Neuman & McCormick, 1995). Neuman and McCormick (1995) argue that this approach may mask unique characteristics of intelligence inherent in each participant. In addition, students whose testing performance results place them at the extreme ends of the normed bell-curve are described as outliers, and their scores are often cut from a group-based study (Price et al., 2018). Neuman and McCormick (1995) argue that cutting out these outliers from a study also erases their identity, leaving their stories for someone else to tell.

Individualized case studies can logically follow group designs to provide a deeper, richer understanding. This approach may be the most direct and effective way of understanding students' learning needs. Moreover, according to the review of literature provided in Chapter 2, students with developmental disabilities are more likely to have been studied using norm-based testing approaches, not individualized qualitative assessments (Harry & Klingner, 2007; Siegel & Allinder, 2005). Therefore, the case study approach provides the best opportunity to investigate their needs in more detail. Lastly, VanWynsberghe (2007) describes the exploration of research through the case study approach as holding the potential to be multidisciplinary and *transparadigmatic,* meaning that multiple worldviews can be used simultaneously to analyze data. This study was informed by literature from a wide range of disciplines including neuroscience, psychology, language and more. For the various reasons outlined here, using individualized qualitative assessment embedded in the single case study approach best suited the research needs of this study.

Impact of Clinical Practice. At its core, this study measured the changes that the participant underwent upon receiving a novel intervention in a clinical setting. According to Kazdin (1982), case study research can be a valuable tool for measuring the impact that clinicians using interventions derived from a particular theoretical perspective have upon individual clients. Moreover, Neuman and McCormick (1995) argue that participants may respond to the same type of intervention in many diversified ways. Case study designs are inherently flexible, allowing for individual differences in response to intervention effects to be measured (Kazdin, 1982). However, being able to see these differences reflected in participants may require access to a longitudinal data set (Wiebe et al., 2010). A retrospective research design best met this need.

Retrospective Single Case Design. Measuring changes in both learning and development requires the analysis of multiple recurrences of data (Yin, 2003). This is because these processes unfold in the mind and brain over the course of one's lifetime (Baars & Gage, 2010; Travers et al., 2009). Maturation in individuals with developmental disabilities has been shown to occur slowly in part due to inherent difficulties in their learning systems to process environmental stimuli (Shaffer & Kipp, 2013).

To allow for changes in this population to be observable, and therefore marked, priority was given to a data analysis process that would sort through multiple years' worth of data. According to Wiebe and colleagues (2010), one benefit of a retrospective design is to be able to apply a longitudinal timeframe upon a data set without having to wait for the passage of time. Yin (2003) adds that using pre-collected document artifacts provides broad coverage of data, meaning that the gathered evidence spans a long length of time and multiple events. For these reasons, a single case approach using a retrospective design best allowed for multiple recurrences of data to be collected and analyzed.

This section identified the rationale behind the methodological decisions used for this study, as well as steps that were taken to ensure trustworthiness in analysis procedures. Gay and colleagues (2012) conclude that in addition to establishing clear reasoning behind their methods, researchers can help take steps to ensure construct validity is followed in their study by ensuring that the rationale for their chosen methodology aligns with their stated conceptual framework. Trochim (2001) states, "Construct validity refers to the degree to which inferences can legitimately be made from the operationalizations in [a] study to the theoretical constructs on which those operationalizations were based" (n.p.). In this sense, researchers ensure construct validity is upheld when the findings that they report adhere to the way knowledge was originally conceptualized in their study. Gay and colleagues (2012) add that researchers must take steps to cross-analyze both convergent and divergent evidence to determine whether the defined constructs or phenomena of the study are what were actually measured by the researcher. The remainder of this chapter expands upon how this investigation utilized a methodological process that would closely uphold construct validity associated with the conceptual framework of Arwood's Neuro-Education Model.

Setting

The setting for this study was bound to one private clinic located in the Pacific Northwest where one practitioner worked providing Neuro-Education intervention methods to clients over a time frame ranging from a few months to multiple years. This practitioner had studied a large amount of knowledge related to the field of Neuro-Education, had written multiple books on these topics, and had been utilizing Viconic Language Methods for nearly 30 years by the time they first began working with the participant in this study.

Students were referred to this clinic largely by word-of-mouth, and little if any advertising was done for services. Parents paid for intervention services out-of-pocket, as this clinic was not able to accept any form of insurance for reimbursement. This clinic served a wide variety of student populations, ranging from individuals with profound disabilities to students who had experienced neurotypical development. Nonetheless, one overarching impetus for parents to decide to send their children to this clinic was that these individuals had frequently struggled to learn in their routine school environments. Many of these parents understood that this clinic offered alternative approaches to helping children learn.

Clients also received services at this clinic for a variety of durations, ranging from multiple times per week over the course of years to services that were provided much more sporadically. The amount of time that each client spent receiving therapy services in this setting was mutually agreed upon by parents and the practitioner. The fluctuations characterizing these differences in durations of therapy reflected the philosophy of the clinic that intervention services should be customized to the needs of each individual, as every child experiences a range of learning exigencies.

This setting was chosen specifically due to its wealth of findings regarding the emerging discipline of Neuro-Education. Literature presented in Chapter 2 demonstrated that the field of Neuro-Education is relatively new, and few educators use pedagogy or intervention techniques informed by this discipline. In particular, little research has been conducted on practitioners providing intervention methods derived from Arwood's Neuro-Education Model. Though some teachers in the Pacific Northwest self-identify as using Neuro-Education theory and methods in their classrooms (Green-Mitchell, 2016; Robb, 2016; Xiang-Lam, 2016), a review of literature did not find any teacher who had accumulated the quantity of artifacts and case note observations that the practitioner had collected in the setting for this study. Therefore, the selection of this setting best allowed for the investigation of the research questions guiding this study.

Participant

This study utilized purposive sampling to select the participant and include their case file for analysis. Gay and colleagues (2012) define purposive sampling as the process of determining specific participants based upon pre-established criteria necessary for inclusion in a study. This process is also referred to as criterion sampling (Patton, 1990). Often, these criteria are formed for the purpose of locating participant data that will match the desired population under study (Gay et al., 2012). For this study, access was granted to multiple case files; however, these files varied greatly in the age of each student and overall duration of intervention services.

Gay and colleagues (2012) state that researchers using purposive sampling frequently to draw upon prior knowledge about the topic or data set when selecting specific participants. Moreover, when performing document analysis, Bowen (2009) states that files should be prioritized for selection that will best help the researcher answer the primary questions under investigation. For the parameters of this study, a case file was sought out that would meet five inclusion criteria designed for this purpose. These inclusion criteria were: (1) the student was identified as having a developmental disability by an outside testing institution such as a school of medical provider, (2) the student contained a recorded history of struggling to learn in multiple environments prior to starting services at the private clinic setting, as documented by parental report, (3) artifacts in the student's case file documented the Neuro-Education intervention process for a minimum of 2 years' time, (4) the students' intake file contained a functional language assessment completed by the practitioner, and (5) the student was a minimum of eight years of age at the beginning of services. The rationale for establishing each of these five criteria is explained in further detail in the following sections.

Participant Selection Criteria 1-2

When prospective clients first began services at the clinic setting, their parents were asked to complete an intake survey consisting of multiple components. Many of the questions on this intake survey consisted of informal measures that were designed to elicit a preliminary understanding of the child's learning needs. Some of these questions included basic demographic information, past services received from other professionals or agencies, and whether or not the child was taking any medications. In addition, parents were asked to identify whether their child identified as having any particular medical diagnosis or educational label, such as a learning disability, autism, communication disorder, Downs syndrome, or others. During the informal interview portion the practitioner asked parents to provide their perceptions of how much language their children exhibited in their daily lives. In addition, parents provided their perspective on how well their children academically and socially integrated into their school settings. Parents were also asked to state the reason they had initiated services at the clinic, thus establishing a preliminary agreed upon treatment plan.

Though many of the components of this interview process were informal assessments by nature, parents were also asked to complete a semi-formal measure called the Temporal Analysis of Propositions Behavioral Checklist (TemPro). According to Arwood and Beggs (1992), the TemPro Behavioral Checklist is designed to determine whether a child exhibits behavior that is significantly different from what would be expected of someone their chronological age – also referred to as restricted social functioning (Debreczeny, 2019). Of a possible 13 descriptions, parent respondents are asked to check which statements in the series apply to the student. For an example of this checklist, see Appendix B.

During the intake process to the clinic setting, parents provided a plethora of useful information of the specific learning characteristics of their child. Thus, every case file began with a wealth of information about each client. To find students meeting the first two inclusion criteria, only the initial pages in each case file were browsed to read what parents had written on intake surveys they had completed during this initiation process at the clinic. By surveying only these initial pages to scan for participants' diagnoses, files could be grouped as either meeting, or not meeting, the first two criteria for inclusion in the study. More specifically, browsing through parent responses on the intake surveys allowed for the determination of which students were identified as having a developmental disability by an outside organization, as well as which of those students had struggled to learn in previous environments, based on parents' reporting.

Importantly, the clinic setting did not perform any educational or medical diagnostic testing. Instead, the practitioner asked parents to answer the aforementioned proprietary survey to understand about educational or medical diagnoses of the students. It should also be noted that while access was granted to the paper documents containing parents' reporting of their children's identification status, these diagnostic labels were not able to be independently verified, as access to students' outside school cumulative files was not obtained for this study.

Participant Selection Criterion 3

Once files were selected meeting these first two criteria, the beginning and end dates of services that had been recorded by the practitioner who provided intervention services were scanned. Students receiving services for two or more years met the third stipulation of the inclusion criteria. Priority was given to select a case file for analysis that would meet this criterion thereby providing access to a longitudinal data set, a stipulation previously established by the review of literature as an important consideration when seeking to identify the impact of educational intervention methods (Wiebe et al., 2010).

Participant Selection Criterion 4

Intake files were browsed to determine whether a participant met the fourth selection criterion of participating in a comprehensive functional language evaluation upon starting services at the private clinic. Specific components of this language assessment are identified later in Chapter 3. Obtaining access to the information contained in this intake language assessment allowed for in-depth characterization of how the participant functioned in multiple domains prior to the neuroeducation intervention starting – a constellation of components frequently referred to as an assessment of baseline functioning. Understanding how a student functioned at baseline before intervention services began allowed for later findings to be interpreted with greater levels of analytical clarity.

Participant Selection Criterion 5

Lastly, a case file was prioritized for inclusion wherein the student was a minimum of eight years old at intake. The rationale for this decision was manyfold. Literature presented in Chapter 2 established that at seven years old, most typically developed students begin to function at the concrete stage, meaning that they exhibit agency, can answer questions pertaining to their daily functioning, and can communicate shared ideas through multiple means of expression, among other considerations (Epley et al., 2004; Kopp, 2011; Shaffer & Kipp, 2013). However, Chapter 2 also established that many neurobiologically impacted students do not reach these milestones by eight years old; and, as many of these impacted students grow older, the gap between their chronological and functional age may widen (Travers et al., 2009; Walker, 2000). Analyzing the language and development of an older child may illuminate these gaps in a more noticeable manner than evaluating younger children, where literature shows that even some typically developed young students experience temporary delays that eventually level out towards age-based expectations over time (Travers et al., 2009).

The last rationale for inclusion of criterion 5 seeks to prioritize a line of inquiry that analyzes the potential clinical ramifications of Neuro-Education based intervention methods. One limitation briefly presented here involves a lack of control to the participant's exposure to additional educational interventions outside of the clinical setting, such as schooling. More succinctly, this study was not designed to control for, or account for, the impact of traditional schooling being offered in the participant's life simultaneous to clinical interventions. However, the inclusion of criterion 5 provides a partial methodological buffer against this limitation. For example, literature from Chapter 2 established that students with developmental disabilities generally receive the same types of pedagogies throughout their entire schooling careers, and that many of these pedagogies have been shown to ineffectively meet their learning needs (Ayres et al., 2011; Vaughn et al., 2002). Some have argued, therefore, that by age eight parents frequently know if these schooling pedagogies are providing sufficient learning for their children; and, if they are not, then these parents seek out supplemental interventions similar to the one described in this study (Yell, 2015). Therefore, neuroeducation intervention methods could be considered the primary variable under study; and, any outside schooling could be considered a secondary, extraneous variable outside of this study's control. As literature has suggested, it could be argued that the influence of this extraneous variable would remain constant – and inadequate – throughout the duration of the study (Muijs, 2011).

In sum, findings from the primary variable under study may be enhanced from selecting an older student for analysis, as by this age literature suggests that schooling either is, or is not, effective for meeting their learning needs. If schooling has not been effective for them in the past, logic stands that it may continue to be inadequate for them in the future. Thus, the impact of this extraneous variable might be characterized as weak in the findings of this study (Muijs, 2011).

Final Case Selection

A total of 15 case files were made available for possible inclusion in this study. Of these, 12 case files met inclusion criterion one: receiving an outside diagnosis of developmental disability. Of these, all 12 case files also met criterion two: containing a documented history of struggling to learn in school. One case file did not meet criterion three: receiving services for two or more years, bringing the possible total to 11. Of these, only four total case files met both criteria four and five: containing a functional language report and being a minimum of eight years old upon intake, respectively. Of these four case files meeting all five criteria, one file was removed from the study *due* to the researcher having prior knowledge of the student, and one file was removed from the study due to the researcher having a pre-existing relationship with the student’s guardian. After these removals, two case files remained meeting all criteria for the study, as well as ethical best practices regarding anonymity. Final determination of the participant was made through a randomized selection process. In addition, to preserve confidentiality of the participant, a gender-neutral pseudonym was randomly selected to serve as the name of the participant. More information about this process is explained in Chapter 4.

This section described the methodological procedures used to select the sole participant for this study. The next section identifies how literature presented in Chapter 2 was used to establish two distinct cognitive frameworks for the purposes of interpreting the changes that this participant experienced over time.

Cognitive Frameworks

Allison and Allison (1993) define a cognitive framework as a conceptual structure of ideas that is used to understand and categorize people, the things around them, and their experiences. Literature from Chapter 2 established that learning and development are distinct processes in the body and brain that stand to benefit from being measured both separately and together (Masadeh, 2012). Though a myriad of definitions exists in the literature attempting to describe both learning and development, this study chose to operationalize the investigation of these two phenomena in the following ways.

The cognitive framework of development was informed by the meta-holistic description established by de Souza and Verissimo (2015) who posited, “Child development is part of human development, a unique process of each child that aims to insert him/her in the society where he/she lives. It is expressed by continuity and changes in motor, psychosocial, cognitive and language abilities, with progressively more complex acquisitions in the daily life functions" (p. 1101). This definition of development served as a conceptual guide through which additional relevant literature from the field of developmental psychology was interpreted.

The cognitive framework of learning was informed by Arwood's Neuro-Education Model, which itself synthesizes literature from the disciplines of neuroscience, cognitive psychology, and language. More specifically, the Neuro-Semantic Language Learning Theory (Arwood, 2011), which sits at the epicenter of Arwood's Neuro-Education Model, posits that learning can be measured in others by analyzing how they change their use of language functioning over time. In turn, these changes in language function represent the phenomenological changes occurring in one's mind and brain. As this study utilized the document analysis methodology, this in turn meant that these changes in language functioning over time were represented by changes inherent in the products that the participant created during the duration of the study. Chapter 2 further identified how researchers can develop hypotheses regarding how an individual's learning processes evolve by closely analyzing the oral, written, and drawn products that they create.

As stated, though learning and development can be conceptualized as distinct processes they nevertheless overlap in substantial ways. Thus, Borstein and Lamb (2005) hold that measuring both operations is necessary for a researcher to comprise a holistic depiction of who a student is. Learning and development might be described as parallel strands of a double helix, where one cannot exist without the other (Crick, 2006). As such, measuring changes in the participant through both cognitive frameworks was warranted by the review of literature.

The longitudinal retrospective single case design allowed this investigation to code for changes in student-created artifacts over the course of numerous years. Artifacts were coded using both cognitive frameworks independently, but also synchronously when one code informed another (Fereday & Muir-Cochrane, 2006). In addition, a priori codes were also established by closely reviewing relevant literature presented in Chapter 2. This process is explained in greater detail in the Data Analysis portion of this chapter. While predetermined codes culled from both of the cognitive frameworks guided much of the coding process, sufficient latitude was also taken in analysis in order for findings to emerge that pertained to neither cognitive framework. White and Marsh (2006) advise that in the coding process researchers must allow for newly formed codes to emerge that transcend what may have been expected based off of relevant literature. Findings not accounted for by information in the cognitive frameworks were described as emergent results and are explained in greater detail in Chapter 5.

Data Collection

Data were collected by one practitioner who worked in the setting used for this study. These data consisted of multiple types of language and drawing based artifacts that were created by the participant over the course of numerous years. These artifacts were compiled into a single case file consisting of multiple folders corresponding to time periods spanning thirteen weeks each. Access was provided to this case file to investigate the research question for this study. The following sections outline the different types of data that were collected by the practitioner, identify which artifacts were selected for further analysis, describe the time period used for this study, and explain the rationale behind these decisions. Lastly, the decision to include a semi-structured interview with the practitioner who had provided the intervention is discussed and substantiated.

Artifact Selection

Reviewing the participant's case file uncovered approximately 500 documents that were created by the participant and the practitioner during the first 2 years of working together. Three primary types of artifacts were created during this time: (a) transcribed samples of the participant's oral language, (b) written language samples created by the participant, and (c) drawing samples created by the participant. Of these, approximately 30 documents contained markings made exclusively, or nearly exclusively, by the participant. In the majority of the remaining documents, marks made by the practitioner far exceeded the marks made by the participant. This finding was consistent with the operations of a Neuro-Education based intervention, where an adult engages in a consistent process of visual feedback during each clinical session. By drawing and writing on top of the participant's own mark-making, the practitioner provided ongoing semantic refinement of their ideas.

In addition to these primary artifacts, clinical case notes were written by the practitioner after the conclusion of each session. These clinical notes were brief memos that primarily described what the practitioner did with the participant in each session, such as what stories they read together or what they hoped to work on with the participant in the future. In addition to these routine descriptions, however, the practitioner also recorded salient observations from time-to-time, such as whether they noticed any clinical changes on behalf of the participant and how these changes manifested in the participant's learning or behavior. As such, including these notes for investigation provided a recount of happenings written close in time proximity to when the events occurred.

Phases of Analyses

Further review of the case file revealed that during the first 2 years of working together, the practitioner collected an oral language sample from the participant only three times: once during the intake into the clinic, once approximately seven months from the start of services, and once 2 years after the participant had begun services. To provide for maximum consistency in evaluating changes exhibited in the participant over time, priority was given to include these oral language samples for analysis. The same rationale was used to include one additional writing sample and one additional drawing sample to accompany these two collected oral language samples. These drawing and writing samples were chosen from the 30 documents in which the participant exclusively made marks so that their work could be evaluated solely on its own. In addition, consideration was given towards selecting drawing and writing samples that were created closest in date to the oral samples. In both collections, the creation date of the drawing and writing samples did not exceed two weeks past the creation date of the oral sample.

The timing of these artifact selections provided natural inflection points for the chronology of this study; therefore, the decision was made to divide the analyses conducted of the artifacts in this study into three distinct phases: (1) pre-intervention,

(2) mid-intervention, and (3) end-point intervention. Changes in learning and development were analyzed between phases 1 and 2, between 2 and 3, and also between 1 and 3 in order to see total accumulated changes. The following sections provide greater detail on how including the pre-intervention samples provided a baseline assessment of the participant before intervention began, and how ongoing assessment allowed for mid and end points of the study to be determined.

Baseline Assessment

Surveying the participant's case file began with a review of case notes that the practitioner recorded upon first meeting the participant face-to-face and intaking them into the clinic setting. These notes consisted of the aforementioned parent survey and interview, as well as a functional language evaluation designed to elicit an understanding of the students' use of language at the time of intake.

During the functional language evaluation process the participant first completed a semi-structured interview with the practitioner in order to collect an oral language sample and establish their baseline use of oral language functioning. As described in Chapter 2, this solicitation of an oral language sample from each prospective student followed the theoretical guidance provided by Arwood's Neuro-Semantic Language Learning Pre-Language Assessment Protocol (ANSPA) (2011, pg. 187). While the ANSPA did not provide the specific questions that the practitioner utilized in their interview, it offered a theoretical lens through which the participant's responses could be interpreted as either meeting age-based expectations or restricted to a pre-language level (Arwood, 2011). Moreover, the ANSPA provided guidance to recommend that if a student's responses indicated that they had difficulty communicating their ideas orally, then practitioners could subsequently sample that student's drawn and written language to ascertain more insights about their overall levels of language functioning.

After the semi-structured oral interview was completed, the practitioner subsequently asked the participant to orally read a passage from the Sucher-Allred Reading Placement Inventory, a screening inventory designed to determine an appropriate instructional reading level for students (Sucher & Allred, 1986). According to Hollingsworth and Reutzel (1988), research has shown that the Sucher-Allred Reading Placement Inventory can be considered a reliable measure, as results from this inventory have strongly positively correlated with similar measures. Nevertheless, the authors also expressed that this inventory should most appropriately be used for the purposes of informal initial reading placement screenings and not for formal diagnoses of reading disabilities (Hollingsworth & Reutzel, 1988). Accordingly, this clinic setting used this inventory only to ascertain estimates of new clients' reading comprehension levels; these measures were not designed to be formal by nature. In fact, this inventory was chosen by the clinic setting for reading screenings because each passage was designed to convey the beginning, middle, and end of evocative stories in a short amount of time. Put another way, each story contained enough information to establish basic semantic relationships among agents, actions, and objects. Because each passage on the inventory was designed to provide simple yet intelligible stories, this meant that students with typical language functioning should be able to read a grade-level text and comprehend it sufficiently enough to re-tell the elements of the story using their own language. Accordingly, the practitioner next asked the participant to orally re-tell the story contained within the Sucher-Allred passage while using their own language.

After the participant orally re-told the story from the Sucher-Allred passage, they were asked to draw a picture about what occurred in this passage. As previously expressed, asking the participant to draw out their understanding provided alternative insights into whether this modality yielded greater quantity and quality of language functioning. Next, the participant was asked to write a story about the original passage using their previously-drawn picture as a reference point. This process assessed the participant for their current capacity using writing as a communication modality. Lastly, the participant was asked to orally re-tell a story about the original passage while using their drawings and writings together as references. Throughout this process, the practitioner wrote down the participant’s responses verbatim on the intake form, and memoed additional noteworthy impressions.

The purpose of this multi-faceted intake process at the clinic was to elicit a baseline assessment of the participant’s learning and development before intervention began. In sum, this baseline assessment captured a natural sampling of the students’ oral, written, and drawn language at time of intake. This in turn allowed for the practitioner and any subsequent researchers to analyze these oral, drawn, and written language samples completed by the participant through the guided theoretical questions contained within the ANSPA (Arwood, 2011). A complete set of ANSPA questions can be found in Appendix C.

Ongoing Assessment

After the intake assessment was completed, the practitioner in this study provided ongoing Viconic Language Method intervention for the participant in many academic areas. These sessions varied in frequency and duration, typically consisting of two sessions per week totaling 1 to 3 hours each. As previously discussed, the parameters regarding the amount and duration of intervention sessions were agreed upon between the practitioner at the participant's parents to represent the participant's unique learning needs.

Inherent in the design of Viconic Language Methods is the philosophy that any intervention provided to a student must be continuously accompanied by an ongoing assessment of that pupil through the process of deixis (Arwood, 2011). In this way, VLMs do not follow the typical approach of remediation where interventions instill knowledge in a one-directional process from adult to child. Instead, VLMs exist primarily as a series of visual language *strategies* that adults can use with a student and ascertain how they respond to each approach (Arwood, 2011). Moreover, because these strategies typically involve asking a student to draw and write to represent their thinking, there is a natural tendency for a practitioner using Neuro-Education to accumulate troves of jointly-created artifacts over time while engaging in ongoing interventions.

This ongoing assessment of the participant provided regular snapshots of how their learning and developmental functioning changed over time. Though only some (approximately 10%) of the artifacts were hand-dated by the practitioner, deciphering the creation date of the remaining documents was made feasible by reading the practitioner's dated clinical notes and determining what artifacts had been completed during each session. By following this process, fidelity could be ensured that an artifact represented its original creation date and therefore corresponded to the correct phase of analysis.

The decision was made to stop all analyses after the two-year mark concluding with the end-point phase. As previously mentioned, experts recommend designing a case study to align to an arch of investigation that intuitively conforms to a beginning, middle, and end of a story (Wiebe et al., 2010; Yin, 2003). Because the inclusion of any additional years to this investigation would have added an estimated 200-300 pages per year to the total document tally, continuing the story of this case study beyond the two-year mark was deemed to be prohibitively expansive and time-consuming for the purposes of this investigation.

Semi-structured Interview

As mentioned, the practitioner in this study recorded brief observations of their clients at the conclusion of each intervention session. Though these observations were of value to this study, they were notably limited in that they contained recorded accounts only of what the practitioner themselves thought significant. Conducting a semi-structured interview with the practitioner allowed for the asking of clarifying questions about how specific interventions were administered, how the participant responded to those interventions, and how to interpret changes in collected artifacts over time (Gay et al., 2012). Wiebe and colleagues (2010) add that these interviews are especially beneficial to guide the researcher in instances when evidence in the documents veers off of the expected trajectory that established a priori codes had suggested. Asking clarifying questions provided additional layers of interpretation for unexpected findings in terms of developmental, temporal, and semantic deviations from relevant literature. A full list of questions asked during the semi-structured interview can be found in Appendix A.

This section outlined how the practitioner in the setting for this study collected student-created data that were utilized for this investigation. The following section documents the processes of analysis that were used to examine these artifacts.

Data Analysis

This investigation was interested in determining how one participant's artifacts changed over time from the initial baseline assessment given by the practitioner to the final artifacts collected in the setting, all the while providing exemplars from the data to demarcate these findings. The changes inherent in these artifacts in turn informed how that individual changed in their learning and development from the beginning to the end of the study. This section explains how data were analyzed through the process of document analysis and elaborates on how the coding approach unfolded. In particular, the following processes are addressed: (a) document analysis, (b) phases of coding, (c) a priori codes, and (d) artifact mediums.

Document Analysis

Artifacts collected for this study were analyzed using the qualitative method of document analysis. Corbin and Strauss (2008) state that document analysis is a systematic process by which a researcher examines artifacts to gain insights into their meaning. Labuschagne (2003) adds that as researchers gain a deep understanding of the significance of documents, they organize their findings into categories and themes that are typically supported by exemplars from the data. Bowen (2009) specifies that the aim of document analysis is not to focus on accumulating a specific quantity of data, but rather to curate a selection of documents that best match the research objectives of a study.

Multiple experts in qualitative methodology (Stake, 1995; Yin, 2003) exposit that the process of document analysis is a particularly fruitful method of analysis in case study designs because it allows for an intensive examination of data that can lead to rich, detailed descriptions of the phenomena being studied. According to Bowen (2009), historically document analysis had merely been used as a complementary procedure to other methods; however, many contemporary studies now utilize document analysis as the sole research mechanism. One strong benefit of document analysis is that the data are considered stable because they have already been collected and the researcher did not impact the accumulation by their presence (Merriam, 1988). Bowen (2009) concludes that document analysis allows for examination of many different types of recorded mediums, which makes it a flexible approach to study multiple types of evidence simultaneously.

Performing document analysis requires the researcher to engage in the highly recursive process of coding, where the researcher attempts to make sense of the data through multiple cycles of analysis (Bowen, 2009; Merriam, 1988; Saldaña, 2015). Coding is a highly iterative process, meaning that each repetition of analysis is designed to guide the researcher closer to an authentic interpretation of the data (Saldaña, 2015). Scholars tend to use different names for the steps involved in coding. This study primarily utilized Bowen's (2009) two phase coding process of *content analysis* leading to *thematic analysis*. Of note, these two phases closely aligned with

Saldaña's (2015) multi-part process of first phase *holistic* coding cycle, second phase *pattern* coding cycle, and third phase *theming* of the data. These phases are described in greater detail next.

Phases of Coding

Bowen (2009) describes content analysis, the first phase of coding, as a process of organizing evidence from the data into categories that center around the primary research question in a study. Saldaña (2015) splits Bowen's first phase of coding into two parts: holistic and pattern coding. Holistic coding is described as a broad stroke method of lumping a chunk of data to describe it in a few words (Saldaña, 2015). For example, a researcher may scan a drawing and label it with a few concise descriptions of the setting, human figures present, and many other elements. In this phase, as the researcher combs through data they may also look for any noteworthy exemplars such as the first time a student ascribed a name to a human figure (Boyatzis, 2000). Holistic coding helps identify which documents stand out and may ultimately merit inclusion for further analysis (Saldaña, 2015).

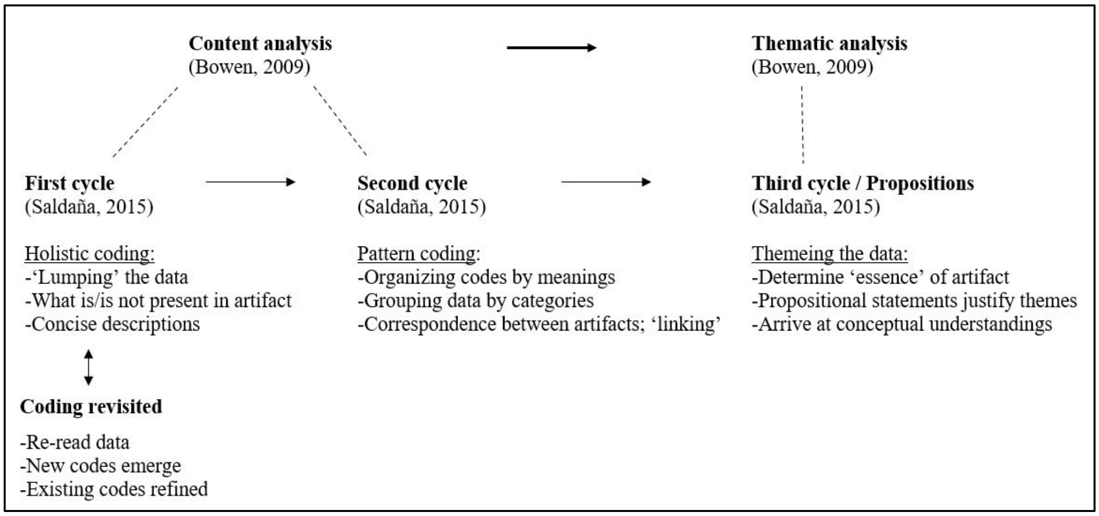
The next part of the iterative coding process aligned Bowen's (2009) content analysis with Saldaña's (2015) pattern coding. Bowen describes content analysis as organizing the data into categories. Saldaña clarifies that researchers can use many different ways to group the data together such as by similarity, difference, frequency, sequence, correspondence, and causation. For numerous reasons, this investigation especially focused on pattern coding for correspondence inherent in the data, described by Hatch (2002) as evidence in documents that meaningfully relate to exemplars from other sources of evidence. For example, correspondence determined how closely the writing in an artifact aligned with its corresponding drawing. Greater alignment between these two modalities has been described in the literature as evidence of synchrony between multiple neurobiological processes in the brain (Arwood, 2011; Xiang-Lam, 2016).

Next, Bowen's (2009) thematic analysis was aligned with Saldaña's (2015) third-cycle theming of the data to further analyze the artifacts. Fereday and Muir-Cochrane (2006) describe thematic analysis as a process of discovering how patterns and categories become overarching themes that capture the most salient features depicted in the data. Saldaña (2015) adds that themes develop as outcomes from first and second cycle coding processes. Thematic analysis requires a more focused re-reading of data to identify larger motifs depicting how a subject relates to the phenomena under investigation (Bowen, 2009). Saldaña (2015) describes this process as transcending the reality of the data advancing towards conceptual or theoretical interpretations.

Figure 3 visualizes the phases of coding used for this study and includes brief synopses describing the purpose of each phase.

Figure 3

Phases of Coding Visualized



On the whole, the methodology of coding becomes analytically stronger when multiple recursive passes through the data circumnavigate findings closer to an embedded authenticity (Merriam, 1988). As such, utilizing the coding process depicted in this section required the use of inductive reasoning to unify potentially disparate findings into a meaningful composite of *who* the student actually was (Fereday & Muir-Cochrane, 2006). Ultimately, the coding processes outlined here allowed for the creation of thick descriptions documenting how the participant being studied changed over time (Geertz, 1973). To make these determinations, however, this investigation relied on the use of a priori codes that had been carefully established through the review of literature. This process is further outlined next.

A Priori Coding

After researchers have engaged in first, second, and third cycle coding processes, some findings gleaned from the data may be best understood by examining them within a specific ontological context (White & Marsh, 2006). For example, some fields such as cognitive psychology may attempt to decipher how a person's thinking evolves over time, while a different field such as applied linguistics may investigate a person's use of language to measure these changes. As previously mentioned, this investigation accumulated knowledge corresponding to the cognitive frameworks of learning and development by surveying relevant literature pertaining to each of these fields. The purpose of acquiring this knowledge was manyfold. However, from a methodological standpoint obtaining a deep understanding of these fields led to the establishment of *a priori codes*, or predetermined codes that served as epistemological metrics guiding each academic discipline (Oleinik, 2010).

The use of a priori codes during cycles of data analysis has been well established in the literature (Elo & Kyngäs, 2008; Miles et al., 2014; Stemler, 2000). Bowen (2009) explains that predetermined or a priori codes may be used as references to interpret emerging codes and themes that surfaced during the process of document analysis. According to White and Marsh (2006), a priori codes should be drawn from the literature based upon how well they allow the researcher to investigate the specific aim of their study. Put another way, identifying codes used for analysis depends upon how a researcher operationalizes what they are searching for (Bowen, 2009). Because this investigation was primarily interested in examining the changes that the participant underwent in response to an intervention, this study drew codes from the literature that fit two different *logic models* (Oleinik, 2010) surrounding the concept of changes in learning and development. These logic models are explained in the following two sections.

Developmental A Priori Codes. Chapter 2 established that scholars working within the discipline of developmental psychology frequently utilize age-based milestones as reference points that chronicle the developmental trajectory that most typically developed children experience (Dosman et al., 2012; Shaffer & Kipp, 2013). As explained, milestones have been generated to corroborate developmental progress in the linguistic, cognitive, and social-emotional domains (Travers et al., 2009). In addition, milestones have been generated that document progress within the mediums of oral language, drawing, and writing (Dore & McDermot, 1982; Papandreou, 2014; Saxton, 2017). A thorough search of the literature revealed that many sets of developmental milestones exist. Moreover, most of these sets have been shown by researchers to hold internal and external validity, as their findings have been normed against sufficiently sized populations (Dosman et al., 2012).

However, while many sets of developmental milestones were found in the literature, no one single set could be substantiated as more epistemologically valid than any other. The reasons for this are complex, including the fact that many of these sets contain proprietary information that cannot be easily substantiated by others. More generally, many experts contend that at most, sets of milestones should serve as guideposts for researchers, not as definitive solitary sources (de Souza & Verissimo, 2015; Dosman et al., 2012). While much effort was expended in searching for a normed set of milestones that would meet the specific research needs of this study, no such set could be found. For these multitude of reasons, many sets of milestones were continuously cross-referenced to establish the a priori codes used for this study. In sum, each developmental finding presented in Chapter 4 was referenced to identify the original source of information from the literature that was presented in Chapter 2.

Learning A Priori Codes. As discussed, the measurement of learning was operationalized in this study to the observation of changes inherent in the participant's language functioning over time. These changes were reflected through the artifacts that the participant created, the case notes taken by the practitioner about the participant during intervention sessions, and the semi-structured interview conducted with the practitioner. Chapter 2 established that investigating student-created products through the cognitive framework of language function involves many interconnected analytical inquiries (Arwood, 2011). For this investigation, each artifact medium was examined for evidence of basic semantic relationships of agents, actions, and objects. In addition, these semantic relationships were further probed to determine whether these embedded ideas were expanded, extended, or displaced. Moreover, the language and drawings that the participant produced was inspected to ascertain their level of capacity for engaging in the functions of semanticity, flexibility, productivity, and redundancy (Arwood, 2011). Furthermore, the aforementioned ANSPA (Arwood, 2011) and TemPro Behavioral Checklist (Arwood & Beggs, 1992) was used to provide additional theoretical guidance. Each of these elements listed in this section that comprise Arwood's (2011) analysis system of language function served to inform the a priori coding process associated with the cognitive framework of learning in this study.

The processes of learning are best understood by utilizing all three lenses of Arwood's Neuro-Education Model simultaneously (Arwood, 2011; Arwood &

Merideth, 2017). Thus, while Arwood's (2011) system of language function analysis served as the primary a priori codes for the learning cognitive framework, these primary codes were also supplemented by secondary a priori codes from the fields of cognitive psychology and neuroscience when it was needed to provide additional context about the mind and the brain, respectively. As previously presented, this study was not designed to directly measure changes to the participant's mind and brain. However, through the direct study of the participant's language function, changes to both of these components of cognition could nevertheless be hypothesized and extrapolated.

Lastly, as previously expressed this system of language function analysis stems from the tenets contained within Arwood's (2011) Neuro-Semantic Language Learning Theory. Filtering composite findings from this study through this grounded theory made it possible to determine which language level most closely aligned with the evidence contained within each artifact. These levels were: pre-language, restricted language, language function, or linguistic function.

In summary, the use of a priori codes allowed this investigation to determine how closely findings from artifact analysis adhered to what would be expected based upon literature relevant to each cognitive framework. In terms of development, these a priori expectations corresponded to age-based milestones associated with each medium. For learning, Arwood's (2011) language functions and Neuro-Semantic Language Learning Theory provided age-based expectations of typical trajectories. As a multitude of a priori codes were generated during the course of study, listing them in their entirety was not practical. A priori codes were utilized and, when supported through document analysis of artifacts, included in the second cycle coding that generated categories and themes for this work. Table 1 displays the two cognitive frameworks used for this study and includes a few examples of the seminal authors whose literature informed the a priori coding process.

Table 1

A Priori Coding by Cognitive Framework

Cognitive framework	Development	Learning
Contributing academic disciplines	Developmental psychology Art education Psychological sciences	Language (primary) Cognitive psychology (secondary) Neuroscience (secondary)
Seminal authors	Piaget, 1959 Vygotsky, 1962 Bruner, 1975 Kohlberg 1983 Edwards, 2016	Arwood, 1983, 1991, 2011 (primary) Anderson, 2015 (secondary) Pulvermüller, 1999, 2013 (secondary)
Metrics used to track progress	Developmental milestones Normed-referenced data Art exemplars	Basic semantic relationships Expansion, extension, modulation Language functions
Examples of a priori code categories	Grammar, syntax, vocabulary Artistic alignment Environmental awareness Psychological operations	Semanticity Flexibility Productivity Redundancy

Comparing findings from first, second, and third cycle coding against the expectations informed by the a priori codes was achieved through the constant comparative approach established by Glaser and Strauss (1967). Methodologically, this allowed for this investigation to compare what was actually found in these data versus what a priori expectations would have suggested. Comparing evidence from student artifacts with practitioner case notes also provided an additional opportunity to analyze multiple strands of data for alignment of pattern codes (Bowen, 2009).

Artifact Mediums

As mentioned, direct access was not granted to the participant for this study. However, many studies over time have demonstrated that analyzing artifacts may serve as a substitute access point into participants' cognition, one of the primary changes measured in this study (Cronin-Jones, 2005; Eisner, 1999; Looman, 2006). Indeed, much literature expounds that the artifacts that students create, such as drawings and writings, serve as symbolic representations of their thinking processes translated onto the page (Cherney et al., 2006; Papandreou, 2014). In addition, Bowen (2009) advises that analyzing multiple types of artifacts simultaneously may provide a more multi-faceted account of changes in measured phenomena. Banks (2001) concludes that qualitative researchers generally utilize different protocols when analyzing each specific medium.

For example, assessing the drawings that a student creates in response to a prompt may provide a valuable manner of revealing the unique understandings that they hold in relation to many facets of knowledge (Cronin-Jones, 2005). Researchers have shown that as children develop they use increasingly complex representational strategies to express different mental phenomena including novel ideas, emotions, actions, spatial awareness, and artistic renderings of known or imaginary objects (Cherney et al., 2006; Papandreou, 2014).

Similar to the process of drawing, research has shown that the writing that students exhibit represents additional dimensions to their thinking and social understanding (Resnick, 1987; Saxton, 2017). One illuminative method of assessing children's writing may be to see how well the words children use semantically match their drawings (Arwood, 2011; Green-Mitchell, 2016). A change over time towards a greater alignment of these two thinking mediums may suggest that the child is successfully integrating neurobiological feedback systems in their brain in order to synchronize competing thought processes into a unified expression (Arwood, 2011; Ghazanfar & Schroeder, 2006). To provide for a comprehensive assessment of the participant, writing contained in the case file was analyzed for adherence to structures, language function (Arwood, 2011), and alignment of visual symbolization mediums.

Lastly, Price and colleagues (2018) explain that a qualitative study of an intervention given in a clinical practice strongly benefits from including an account of the participants from the point of view of the practitioner. The sole practitioner providing intervention in this study recorded such brief clinical impressions at the conclusion of each session with clients; these notes served as observational artifacts for this study. Wiebe and colleagues (2010) stipulate that in study designs such as retrospective analysis where the researcher was not present in the collecting of data, the notes that practitioners take about their students are of value in that they may serve as a proxy for researcher-led observations. Gay and colleagues (2012) add that though the primary focus of case studies may be on the participants themselves, including others' accounts of those participants' lives before the study begins may provide a valuable narrative context to the researcher, especially when the participants are youth or children.

Coding the Practitioner Interview

Lastly, one semi-structured interview was conducted with the practitioner who had provided Neuro-Education based interventions to the participant. This interview was recorded and then transcribed. Data gleaned from conducting the semi-structured interview with the practitioner were coding using a two-cycle inquiry process where first cycle open coding led to the establishment of second cycle patterns and themes (Saldaña, 2015). These two rounds of coding were then compared for consistency.

This section outlined how data were analyzed in order to meet the research aims of this study. Preceding sections explicated how analyses were conducted within the retrospective single case research design. Though this design held numerous advantages for this investigation, some disadvantages were also noted. These considerations are elucidated in the following section.

Ensuring Trustworthiness

Lietz and colleagues (2006) explain that findings in qualitative research hold higher levels of trustworthiness when they reflect the original meanings that the participants ascribed them. Creswell (2003) adds that trustworthiness in research is upheld when scholars maintain rigid adherence to established procedures. This section documents the steps that were taken to uphold trustworthiness in the methodological process for this study. In particular, the following elements are addressed: (a) ensuring credibility, (b) accounting for transferability, (c) documenting dependability, (d) confirmability, (e) potential disadvantages of document analysis, (f) triangulation, and (g) potential disadvantages of retrospective designs.

Ensuring Credibility

Creswell (2003) explains that researchers must take steps to ensure that analyses are credible, meaning that interpretations derived from the research methods reflect a valid account of the contents of the data. Typically, researchers utilize the process of member checking to solicit participants' views of a study's interpretations (Merriam, 1988). In the absence of direct access to participants, one semi-structured interview was conducted with the practitioner who had provided Neuro-Education intervention strategies. The purpose of this interview was to include a more multi-faceted viewpoint of how and why students changed over time, as reflected through their created artifacts. Stake (1995) adds that this validation strategy adds an additional critical observation of the phenomena being studied and leads to a more consistent description of themes derived from the data.

Accounting for Transferability

This study compiled a thick description of how the participant changed over time using two different cognitive frameworks and three different developmental domains (Geertz, 1973). Merriam (1988) explains that providing the reader with sufficient amounts of details allows them to make their own interpretation of whether findings are transferable to additional environments. Moreover, when results are written with enough salient details findings they may increase in social validity (Wolf, 1978). Social validity, closely related to the concept of transferability refers to how informative findings from a study can be for future researchers and educators (Miles et al., 2014).

Documenting Dependability

Researchers take steps to uphold dependability in a study when they document the steps used to arrive at their conclusions (Creswell, 2003). Miles and colleagues (2014) add that increasing dependability involves ensuring that data are reliable in their given context, and that participant sampling procedures are justified. In response, this study established an audit trail of recorded findings to extensively document and make visible these analytical processes (Gay et al., 2012). Specifically, a logical path was traced in analyses between the experiences, recollections, and understandings reflected in the case. Much of these processes were recorded in the researcher's daily journaling.

Confirmability

Confirmability is achieved when the researcher ensures that interpretations and analyses could be reasonably drawn from the collected data (Miles et al. 2014). This study provided clear rationale for selected methods and procedures, and considered alternative explanations when appropriate (Gay et al., 2012). In addition, care was taken to connect the findings of this study with theory contained within the conceptual framework of this study. This process also increased the level of construct validity, to be explained in a subsequent segment.

Potential Disadvantages of Document Analysis

According to Bowen (2009), using document analysis as the sole method of inquiry for a study may expose the researcher to a few potential methodological disadvantages. Because documents accumulated for a study were gathered for purposes other than research, they may not provide the analyst with a level of detail that is sufficiently tailored to answer their research questions (Bowen, 2009). Moreover, analyzing the entirety of documents in a data set may be impractical for the study design. Yin (2003) clarifies that utilizing only a portion of the total available documents may suggest a biased selectivity on behalf of the researcher. In addition, because the events under study in a retrospective design already happened, the research may not be able to revisit participants to gather additional artifacts (Wiebe et al., 2010). To provide a buffer against these cautions, researchers can incorporate additional data or information sources into their study through the process of triangulation (Patton, 1990). These efforts are covered next.

Triangulation

Lietz and colleagues (2006) inform that qualitative studies may take steps towards increasing the trustworthiness of the methodological process by utilizing a combination of data and knowledge sources in an investigation. This process is referred to as triangulation, and is defined as combining multiple methodological approaches into the singular pursuit of the phenomena under exploration (Denzin, 1970; Patton, 1990). Yin (2003) states that in addition to the primary data set, qualitative researchers are encouraged to seek out at least two additional viewpoints of the research phenomena being studied to provide for a more multi-faceted account of how events took place.

This investigation utilized triangulation of knowledge pertaining to the investigated phenomena by including: (a) the review of literature presented in Chapter 2, (b) document analysis procedures examining the participant’s case file, and (c) a semi-structured interview with the sole practitioner providing Neuro-Education intervention methods to the participant. Patton (1990) argues that the use of triangulation may reduce the bias of researcher upon the findings in a study. Bowen (2009) adds that findings from multiple sources may complement each other, or even converge, leading to a greater sense of reliability to the analytical process. Price and colleagues (2018) further comment that including an account of the data that is supplemental to that of the researcher often increases the quality of a study.

Potential Disadvantages of Retrospective Designs

Hyde (2017) notes that researchers utilizing the retrospective approach may be constrained because they cannot revisit the past episodes in order to accrue additional data points in real time. Thus, analysts must reconstruct events by relying solely on others, hoping that these individuals kept original records with fidelity. As such, the author states that temporal relationships between studied phenomena may be difficulty to verify. Moreover, researchers using this design are limited in their ability to attribute noticeable effects in the participants to the provided intervention, in part due to a lack of control of exposure to additional confounding variables outside of the clinical environment (Hyde, 2017).

In conjunction with these cautions, Wiebe and colleagues (2010) observe that retrospective study designs may be susceptible to additional threats to validity in research. Two particular threats include the *recall* effect and the *spoiler* effect. Because events related to the phenomena under investigation may have occurred in the far past, interviewees may be subject to certain gaps in ability to accurately recall all information. Similarly, in research designs where data have already been collected, analysts may unwittingly emphasize artifacts that most pertinently address their specific research questions; and, inadvertently omit analyzing documents that contain important, yet tangential data (Wiebe et al., 2010). Similarly, Gay and colleagues (2012) note that qualitative researchers must take efforts to minimize sampling bias, or selecting participants in a way that deviates from pre-established research criteria.

Researchers can practice reflexivity to confirm that the process of data collected is neutral and impartial (Guba, 1981). Incorporating ongoing reflexivity into the methodological process has also been identified as a strategy to ensure that construct validity is upheld between findings and conceptual framework (Guba, 1981).

To address these potential issues and help ensure trustworthiness was upheld in the analytical process, the proceeding advice of Wiebe and colleagues (2010) was followed: (a) objectivity was prioritized when selecting and analyzing data, (b) pre-established analysis procedures were adhered to as much as possible, and (c) a member check was completed to verify accuracy in the recorded interview. Collectively, these steps helped this investigation utilize best practices for analysis of qualitative data (Gay et al., 2012; Lietz et al., 2006; Price et al., 2018).

Ethical Considerations

Throughout this study, all names and identifying information of the participant, their parents, and the practitioner were kept confidential. Steps were taken to ensure confidentiality by using pseudonyms to describe real-life students, scrubbing artifacts of any recorded names, and storing case files in a secure, locked facility when not in use. This study was approved via Institutional Review Board (IRB) on September 3rd, 2020.

Role of the Researcher

At the time of this study, this researcher was enrolled as a doctoral candidate studying the topic of neuroeducation at a university in the Pacific Northwest. This researcher has studied the topic of neuroeducation in many different contexts including theory and educational applications. This researcher has observed how neuroeducation theory has been translated into teaching practice to benefit many different types of student populations. In a previous teaching position, this researcher personally utilized neuroeducation theory and methods with various groups of diverse learners. In addition, this researcher previously worked as an independent contractor for a few months during the 2013 school year for the company that owns and operates the private clinic that was used for this study. However, this researcher was not involved in gathering any of the data that was used for this study, nor did this researcher personally know the participant selected for further investigation.

Galdas (2017) states that researchers in the qualitative paradigm must takes steps to acknowledge that bias is always present in studies where the researcher is intimately involved in sorting and analyzing data. The author adds that researchers can take steps to address these biases by being transparent in their methodological structuring and analytical processes. Therefore, the aforementioned practice of reflexivity was used in this study to be critically self-reflective about any preconceptions and relationship with the topic. Galdas (2017) concludes that separation from the creation of the final results in a qualitative study is not desirable nor possible. In addition, the subjectivity inherent in qualitative analysis is the greatest strength of that field. Thus, this investigation attempted to utilize this epistemological guidance whenever possible during the sorting, analysis, and discussion of data collected for this study.

Summary

This chapter presented the methods that were used to conduct this study and explained how this investigation utilized a retrospective single case study design to explore the research questions for this study. The process of document analysis was used to analyze student-created artifacts for adherence to and deviation from the cognitive frameworks of learning and development. This chapter also outlined how relevant literature was surveyed to find a priori codes pertaining to these two cognitive frameworks. In addition, this chapter explained how the participant was selected using a purposive sampling technique, and the case were singly bound to the files pertaining to that student. Lastly, this chapter described how analysis of data were completed under the guidance provided by literature pertaining to both frameworks.

Literature contributing to the creation of the conceptual framework of Neuro-Education established that multiple gaps in research exist in terms of measuring the impact of strength-based interventions – and the impact of Neuro-Education interventions in particular – on students with developmental disabilities. Creswell (2003) argues that qualitative research is especially well-matched to the pursuit of understudied topics that may lead to innovative practices or theories. Because status quo methods of teaching students from this population have been shown to be largely ineffective (Ayres et al., 2011; Vaughn et al., 2002), and because few studies show viable alternative pedagogies to these default practices (Hastings, 2005; Klaver et al., 2016), results from this investigation may hold social importance to the field of education.

Findings from this investigation may hold social significance in educational settings; therefore, according to Wolf (1978) this study fits under the umbrella of applied research because results may relate to the real-life functioning of individuals in school settings. Although the setting of this study consisted only of one private clinic, any significant findings may influence practitioners in any location to re-examine their current practices to determine how well they are meeting the learning needs of students with developmental disabilities.

This concludes Chapter 3. Results from this study are presented next in Chapter 4.

Chapter 4: Results

The purpose of this retrospective case study was to investigate the impact that Neuro-Education intervention methods had upon the learning and development of an individual with developmental disabilities. Previously collected oral, written, and drawn artifacts were coded and analyzed to determine the following research question: What impact do intervention methods derived from Arwood's Neuro-Education Model have upon a young individual with developmental disabilities' cognitive, linguistic, and social-emotional functioning over time?

This chapter begins with a demographic description of who the participant was at the onset of the study. This description was constructed by reviewing case notes taken by the sole practitioner who provided Neuro-Education based intervention methods to this participant while in the private clinical setting used for this study. While receiving this intervention over the course of 2 years, the participant created a multitude of drawn and written artifacts. These participant-generated artifacts corresponded to three phases of the study: (1) pre-intervention findings, (2) mid-intervention findings, and (3) end-point intervention findings. During these three phases, the participant completed 229 clinical sessions with the practitioner, culminating in 458 hours of therapy.

The results of coding these artifacts corresponded to the three phases of this study. As described in Chapter 3, participant-created artifacts were coded using two different cognitive frameworks: (a) development, represented by literature culled from developmental psychology, and (b) learning, represented by language function. Though learning and development form an inextricable, reciprocal relationship within each individual, these phenomena nevertheless represent distinct psychological and neurobiological processes (Arwood, 2011; Piaget, 1964; Walker et al., 2011). To maintain epistemological fidelity to each of these cognitive frameworks, artifacts were coded separately and findings specific to each framework are reported under partitioned sections.

While working with the participant, the practitioner recorded weekly clinical case notes. These case notes were also coded to provide clinical observations of the participant at the conclusion of each of the three phases. In addition, to provide for a more triangulated viewpoint upon the data collected for this study, one semi-structured interview was conducted with the practitioner who had provided the Neuro-Education intervention. The results of coding this interview are presented in the penultimate section of Chapter 4. Lastly, this chapter concludes with a summary of results where global findings are tied to linguistic function indicators and age-based developmental milestones.

Chapter 4 is designed to form a complementary synergy with Chapter 5, where the intersection of both of these chapters ultimately investigates the research question through a holistic model of inquiry. Put another way, Chapter 4 explains *what* changes the participant experienced, while Chapter 5 reexplores these findings to hypothesize *why* the participant changed in the way that they did by reexamining findings through the Neuro-Education paradigm. By adding additional lenses of examination – namely cognitive psychology and cognitive neuroscience – Chapter 5 aims to present an alternative description of *how* the participant began to exhibit evidence of learning again after remaining psychologically quiescent for the majority of their childhood and adolescence.

(Of note: to protect the confidentiality of the participant, the gender-neutral name of Kerry was randomly selected to serve as a pseudonym. In addition, all names of Kerry's family members and teachers have been redacted to preserve confidentiality).

Description of Participant

Upon intake into the clinic setting for this study, Kerry and their family engaged in a series of assessments and questionnaires designed to understand more about their goals for intervention and overall learning needs. The description of the Kerry that follows was gleaned from surveying these intake documents.

At the time of intake, Kerry was a 16.2-year-old individual who was beginning their ninth-grade year of school. According to their mother, Kerry was diagnosed as having attention deficit disorder (ADD), as well as described as being an individual on the autism spectrum (ASD). In school, Kerry was described as attending classes specifically established to serve individuals who are moderately-to-severely impacted by developmental disabilities, frequently referred to as "life skills" classrooms. When asked why the mother was seeking out services for her child, the mother wrote that she was looking to "build learning skills."

As a part of standard intake protocol, all parents fill out a Temporal Analysis of Propositions Behavioral Checklist (TemPro) describing their child's behavior and learning characteristics (Arwood & Beggs, 1992). The TemPro is designed to determine whether a child exhibits behavior that is significantly different from what would be expected of someone their chronological age – also referred to as restricted social functioning (Debreczeny, 2019). Of a possible 13 descriptions, respondents are asked to check which statements in the series apply to the student. Kerry's mother checked the following statements:

- "Has difficulty following a schedule."
- "Has difficulty following directions."
- "Has difficulty paying attention in class. Seems to "tune out".
- "Does not finish work in class."
- "Does not get homework assignments done."
- "Is disorganized."
- "Talks at inappropriate times. Interrupts or 'blurts out.'"
- "Moves around the room at inappropriate times."
- "Has difficulty working with other students and/or adults."
- "Is reading significantly below grade level."
- "Is writing and/or spelling significantly below grade level."

After the intake packet was completed, the practitioner engaged in an informal interview with the parent, asking her to elaborate on the history of Kerry's problems with learning that had led to the decision to seek intervention services. During this interview, the practitioner took the following notes:

- "[Kerry] was severely autistic with colitis and Crohn's [disease]. Stomachaches."
- "[Kerry] thinks things are hard. School is difficult. Work is hard."
- "[Kerry] [has] no spark, no excitement."

- “[Kerry] is compliant, but doesn’t enjoy learning.”
- “At age 6, began to talk. At age 9, [started] talking – real language came.”
- “School is for friends and relationships. Interested in long-term relationship.”

These notes concluded the informal interview portion of the intake process. After the intake forms and parental interview were completed, the practitioner began engaging with Kerry in order to sample their functional language in multiple academic areas. These samples provided a baseline level of developmental and learning functioning and are displayed in the following section.

Pre-Intervention Findings

To compile an authentic assessment of Kerry’s baseline levels of functioning before intervention began, the practitioner completed a comprehensive language evaluation consisting of multiple components including: (a) an oral language sample, (b) an assessment of reading comprehension, (c) a writing sample, and (d) a drawing sample. Documents collected during this intake session comprised the first phase of analyses conducted for this study, referred to as pre-intervention findings.

This section first displays the artifacts that resulted from each component of the functional language assessment that was conducted by the practitioner. These artifacts are initially displayed before the coding process commenced to provide an unabridged context for the reader of Kerry’s language samples at baseline before intervention began. Then, after these artifacts are presented, they are subsequently analyzed through the developmental and learning frameworks and results from these analyses are displayed in corresponding sections. Lastly, results are presented from analyzing the clinical notes that the practitioner took while performing the functional language assessment, which were compiled into an eight-page evaluation report.

In the first part of the functional language assessment, the participant asked Kerry a series of prompts pertaining to topics that might be familiar to them, such as their age, where they went to school, and what classes they were taking. Figure 4 displays the written transcript of this interview.

Figure 4

Pre-Intervention Oral Language Sample

Practitioner:	Do you go to school?
Kerry:	Probably in [name of city redacted]. I did high school. [Name of city redacted], [Name of state redacted]. Teacher. [Name of city redacted].
Practitioner:	This year, do you attend [name redacted] High School?
Kerry:	Probably.
Practitioner:	What are the names of some of the classes you are taking, enrolled in, at [the high school]?
Kerry:	[Name of city redacted]. Graduation. After the graduation ceremony.
Practitioner:	Do you have brothers and sisters?
Kerry:	A few. Brother in [name of city redacted] and a few in [name of city redacted].
Practitioner:	When you are not at school, what is your favorite activity?
Kerry:	Probably at science lab.
Practitioner:	What do you do in your science lab?

Kerry:	We study the science. We use popcorn seed and set it on fire and I hate fire ... make my skin melt off...
Practitioner:	Do you have pets?
Kerry:	I have one dog and the other dog is in [name of city redacted] with [name of person]. [This person] massages my bones and leg bones. Don't get problems. Massages hips and that body stuff.
Practitioner:	Do you read?
Kerry:	Sometimes I like to read. Sometimes my books in movie actions. I like comic books.
Practitioner:	Which ones?
Kerry:	Batman vs. the Ten-Eyed Man. He sees things through his eyes connected to his fingertips like this. (Pantomimes seeing from his eyes down his arms through his outstretched fingertips).
Practitioner:	What time do you wake up to go to school?
Kerry:	Mom keeps waking me up.
Practitioner:	Ask your mom what time you wake up.
Kerry:	Kerry: Mom, what time do I wake up? 8:00. The barking dog ... throw the pillow ... come on [name of dog]... cut it out ... I'm trying to get some sleep.

Note. Certain redactions have been made to protect against display of confidential information.

Next, Kerry was asked to orally read Selection G from the Sucher-Allred Reading Placement Inventory, a passage designed to be read by students in the fourth grade, according to the authors (Sucher & Allred, 1986). This passage is depicted in its entirety in Figure 5 below.

Figure 5

Pre-Intervention Reading Passage

Selection G

Jim White had spent a hot, dusty day on the range. Suddenly the cowboy brought his horse to a stop. "Look at that!" he cried in excitement. "There is smoke coming out of that mountain!"

Jim started his horse at a gallop straight toward the smoke. Out here where ranch houses were far apart and there was little water, a fire could mean real trouble.

"The entire hillside over there must be on fire!" Jim cried to his horse.

When he reached the top of the slope, Jim stopped his horse and stared in surprise. The smoke was coming directly out of a hole in the side of the mountain!

As Jim drew near the mountainside, he heard the deafening sound of wings beating the air. It seemed to be coming right out of the cloud of smoke.

Suddenly Jim stopped again. "That isn't smoke!" he laughed. "It's bats, thousands of bats flying out of the hole in the mountain. They are coming out for food."

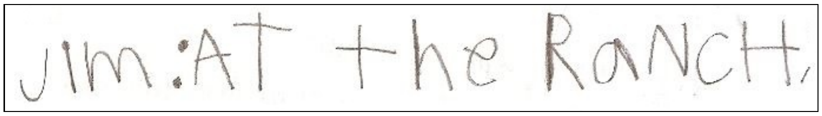
Source: Sucher & Allred, 1986.

According to the evaluation report, Kerry read the first paragraph slowly and hesitantly. Kerry also performed certain reading miscues such as saying "dizzy" instead of "dusty" and "exterment" instead of "excitement." After Kerry read the first paragraph, the practitioner asked them to orally tell about what they had just read. Kerry stated, "Jim at the horse ranch."

Next, the practitioner asked Kerry to write a summary of what they had read in the first paragraph of Selection G. In response, Kerry wrote the following, as depicted in Figure 6: "Jim: AT the RaNCH."

Figure 6

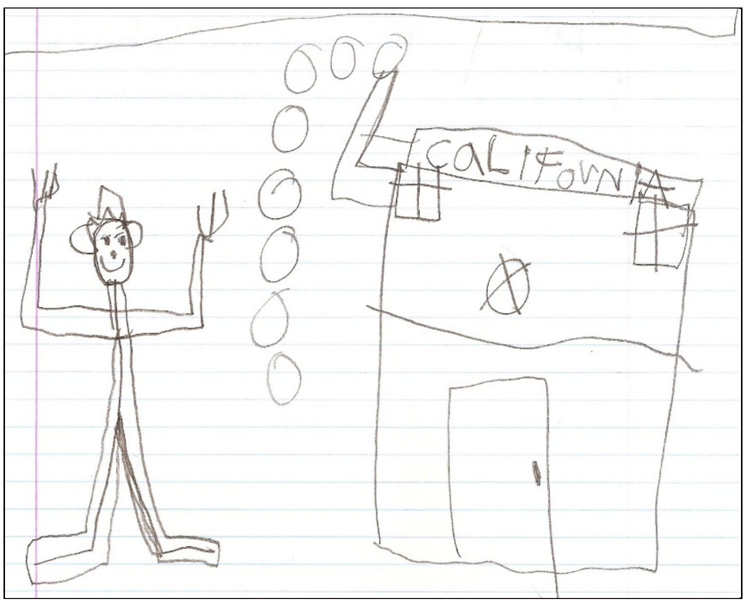
Pre-Intervention Writing Sample



After the writing sample was completed, the practitioner asked Kerry to draw the events that had taken place during the first paragraph of Selection G. In response, participant drew the image depicted in Figure 7, as well as wrote "caLiForNiA" on a portion of this image.

Figure 7

Pre-Intervention Drawing Sample



Figures 4, 6, and 7 above depict the oral, written, and drawn products that Kerry created during the functional language assessment. These artifacts represented Kerry's baseline functional language samples at the time of intake into the clinic. Next, the following sections display the results from coding and analyzing these artifacts through the developmental and learning cognitive frameworks, respectively.

Coding and analyzing these artifacts allowed for Kerry's baseline levels of learning and development to be ascertained before they began experiencing the intervention.

Description of Developmental Functioning

The previous sections depicted multiple language sample artifacts that were collected by the practitioner during the intake process. This section displays the results of coding these artifacts through the developmental cognitive framework. Results from this coding and analysis process are categorized into linguistic, cognitive, and social-emotional findings.

Language Development. Each of the artifacts collected during the intake process portrayed multiple examples of irregular language usage by Kerry that was limited in structure with restricted meaning. For instance, in the oral language sample Kerry's oral language contained numerous grammatical errors. Examples of these errors included starting and stopping sentences incorrectly and vocalizing incomplete or run-on sentences, such as by stating "Probably at the science lab," and "Don't get problems." Kerry's language in the oral language sample also lacked many connector words such as "and," "a," and "the." When these words were included, they were used incorrectly, such as in the example "the science." Other irregularities of language that were present in these samples included incorrect verb tense usage, such as "I hate fire… make my skin melt off." Kerry also omitted numerous parts of speech resulting in few adjectives, conjunctions, prepositional phrases, or adverbs used. Lastly, although Kerry vocalized a few advanced vocabulary words such as "graduation," "ceremony," "connected," and "melt," these words were not used in the correct context, nor did their ideas directly answer the practitioner's stated questions. Initial analysis of Kerry's use of oral language through the developmental lens established that Kerry exhibited oral language that was markedly different than what would be expected of a typically developed individual who was 16 years of age (Buckley, 2003; Nelson, 1981).

Reviewing the written sample artifact illustrated that Kerry's ungrammatical language usage also extended to their writing. For example, in the short artifact sample Kerry presented an incomplete idea, did not use a verb to express an action, and demonstrated incorrect rules of letter capitalization. Young adults 16 years of age who have developed typical proficiencies in written grammar would be expected to write grammatically correct sentences that express a fully formed idea that is comprehensible to others (Nelson, 1981). Evidence contained within Kerry's written sample substantially deviated from these a priori expectations. Taken together, the oral and written language samples demonstrated that at the time of intake Kerry did not understand correct conventions of language at a level that would be expected for their age (Nelson, 1981; Saxton, 2017).

Cognitive Development. During the intake process, Kerry was asked to read and summarize Selection G from the Sucher-Allred Placement Inventory, depicted in Figure 5 above. Chapter 3 explained how this inventory was designed to provide informal grade level reading placement screenings for children (Hollingsworth & Reutzel, 1988). According to the teacher manual for this inventory, Selection G was designed to be read and understood by students in the fourth grade, or approximately nine- or ten-years-of-age (Sucher & Allred, 1986). An independent Flesch-Kinkaid Grade Level Readability Score analysis found this passage to be written at the 1.97 grade Lexile level, roughly corresponding to a seven- or eight-year-old equivalent (Solnyshkina et al., 2017). As presented in the language evaluation report, Kerry did not successfully read and comprehend Selection G at a sufficient level for comprehension. Because Kerry read slowly and multiple auditory miscues were made, the practitioner decided to stop Kerry from reading past the first paragraph and skip ahead to other elements of the functional language assessment.

Kerry's severely curtailed oral and written summaries of Selection G demonstrated that they did not read the second-grade passage proficiently nor did they adequately understand the content in order to retell the embedded story through oral, drawn, or written means. This finding indicated that Selection G was too developmentally challenging for Kerry to understand. Similarly, analyzing the drawing artifact in Figure 7 established that Kerry did not understand the passage sufficiently enough to recreate the Selection G story via drawing the concepts. For example, though Kerry made an effort to draw a setting, the details were very basic and did not match the content of the passage. Specifically, the drawing contained a house and chimney with smoke coming out, while these details were not included in the story. Such findings suggested that reading the passage out loud was not a modality conducive for Kerry to sufficiently understand the content.

When comparing the drawing sample that Kerry produced in Figure 7 to developmental expectations from relevant literature, results demonstrated that Kerry drew in such a manner as would be expected of a much younger child (Edwards, 2016;

Lowenfeld & Brittain, 1987; Papandreou, 2014). In one example of this finding, Figure 7 shows that Kerry drew images that were disproportionally large and filled up the vast majority of the white space on the page. Literature indicates that at around eight years of age children typically advance in their artistic capacities and therefore tend to draw smaller, more detailed images that are often segmented to show action or cause and effect (Cox, 2015). Similarly, children with a more thorough awareness of the environment or setting of a story include greater numbers of granular details such as defining landmarks, labels, descriptive words, or identifying features (Cronin-Jones, 2005). Evidence was not found corresponding to either of these a priori expectations thus suggesting that Kerry experienced a pronounced difficulty in using drawings as a means of representing their cognition (Boyatzis, 2000).

Graphonomically, Kerry's use of mark making on the page showcased some developmental strengths, but also many challenges. For instance, though Kerry took time to draw a human figure and even retrace certain lines so that the portrayed body was representationally complete, their uneven line making showed evidence of the type of choppy and uncontrolled hand movements more typical of younger children approximately 3- to 4-years of age (Van Gemmert, & Teulings, 2006). Similarly, the manner in which Kerry scribed their written letters did not convey an organized filling of formed space or exhibit correct rules of capitalization. One milestone associated with children seven years of age is that typically by this age most young individuals have smoothed and honed their written orthography to match accepted conventions of form, grammar, and syntactic conventions (Sharp, Sinatra, & Reynolds, 2008). Upon comparing the pre-intervention writing samples against developmental a priori expectations, evidence contained within these artifacts suggested that Kerry did not meet numerous cognitive milestones associated with their chronological age (Cox, 2015; Papandreou, 2014; Sharp et al., 2008; Van Gemmert, & Teulings, 2006).

Social-Emotional Development. Evidence compiled from the language sample artifacts indicated that Kerry exhibited behavior associated with atypical social-emotional development. For example, by age 16 typically developed students would be expected to engage in a back-and-forth conversation where ideas are mutually shared and understood (Fernandez, 2011). Analyzing the oral language sample, however, demonstrated that Kerry did not answer the practitioner's questions in a conventional manner but instead talked primarily about their own ideas and topics only they would understand. Literature explains that by age five many typically developed children have acquired the capacity to share autobiographical memories in such a manner that their content can be comprehended by others (Fivush, 2011). Findings from pre-intervention language artifacts showcased a lack of evidence for this quality of social communication.

The manner in which Kerry portrayed the human figure in the drawing sample suggested that they struggled to conceptualize the thoughts, feelings, and perspectives of others (Edwards, 2016). Specifically, in the artifact a stick figure was drawn encased in a hollow body, where appendages were atypically rendered and disproportionately formed. Developmentally, such incongruous and unlifelike depictions suggested that the drawer lacked the capacity to see other people as individual agents who possess their own unique ideas (Deguara, 2015). On the whole, evidence from the language artifacts suggested that the social-emotional development of Kerry was atypically impacted and delayed below age expectations at time of intake (Catte & Cox, 1999).

Summary of Pre-Intervention Developmental Findings. Research demonstrates that by age 16 most typically developed children will have acquired a full grammar and be able to use that knowledge to produce language that is understood by others (Nelson, 1981). Evidence contained within the pre-intervention artifacts that Kerry created at the time of intake indicated that Kerry did not express complete, intelligible thoughts resulting in others needing to consistently guess as to Kerry's intended meaning. Kerry's oral language artifact also demonstrated that they repeatedly used ungrammatical language. This finding, among additional evidence, established that Kerry was not meeting numerous age-expected linguistic and cognitive milestones during the pre-intervention intake into the clinic setting. For example, at four-years of age most children understand the purpose of "why" and "how" questions, and by age five many children become proficient at re-telling plots to simple stories (Evans & Craig, 1992). Artifacts provided no evidence as to meeting either of these conditions.

In addition, Kerry's drawn depiction of the Selection G passage significantly deviated from a priori developmental expectations (Sucher & Allred, 1986). Key details from the reading passage were either altered or omitted, and additional features were added that were not part of the story. Although Kerry's mark making on the page exceeded the kinds of scribbles associated with children under the age of three, their formed representations of figures and objects were basic enough as to be classified as *preconceptual*, or more closely associated with four-year-old proficiencies (Looman, 2006; Malchiodi, 1998). Other literature describes this four-year-old cognitive stage as *preschematic*, typified by drawings containing early forms of humans and quasi-recognizable objects (Lowenfeld & Brittain, 1987). Moreover, not aligning figures into a logical order/sequence/action has been described by others as more typical of a child functioning at the three-to four-year-old stage (Cherney et al., 2006).

Though the included language samples were limited in scope, these artifacts nevertheless contained ample evidence to determine that Kerry functioned at a low preoperational level of development at the time of intake. Comparing Kerry's progress at the time of intake against a priori expectations culled from the developmental cognitive framework suggested that Kerry functioned at levels that most closely matched developmental milestones associated with a three-year-old level of linguistic development, a three-year-old level of cognitive development, and a four-year-old level of social-emotional development (Catte & Cox, 1999; Cherney et al., 2006; Edwards, 2016; Fivush, 2011; Nelson, 1981; Sharp et al., 2008).

This section examined the results of coding Kerry's pre-intervention artifacts through the developmental cognitive framework. The next section displays the results of re-examining these artifacts through the learning cognitive framework, as represented by language functioning.

Description of Language Function

In addition to coding the pre-intervention artifacts through the developmental cognitive framework, artifacts were also analyzed to determine Kerry's capacity for learning at the time of intake, as coded through the learning cognitive framework. This section describes the results of analyzing these artifacts in terms of Kerry's baseline language, cognitive, and social-emotional functioning before they began the targeted intervention.

Language Function. The oral language sample collected during the intake interview process established that Kerry greatly struggled to engage in a reciprocal conversation with the practitioner where information was mutually understood by both individuals. Evidence for this was seen in Kerry's responses to open-ended questions about their life, where Kerry replied with ideas that were not situated in the context of the conversation. For instance, when asked "When you are not at school, what is your favorite activity?", Kerry replied, "Probably at science lab." This reply indicated that specifying semantic knowledge to a specific setting in their life was a substantial challenge for Kerry (Ayres et al., 2011). Similarly, in replying to other questions during the interview Kerry shared one-word utterances such as "teacher," or "probably." Neither of these utterances answered the original question asked.

Analyzing the characteristics inherent in Kerry's language usage during these pre-intervention oral conversations illustrated that at the time of intake Kerry exhibited a lack of relational function (Arwood, 2011). Students who struggle with this capacity of language typically face difficulties when attempting to stay on topic within the context of a shared conversation (Kelley-Hortsch, 2018). In addition, Kerry's oral language during the intake conversation with the practitioner also exhibited a lack of shared-referent function, in that the language used was not sufficient for sharing understanding between the two parties (Arwood, 2011). Furthermore, evidence from this oral language sample suggested that Kerry did not use oral language to successfully function in the world around them because they could not share a linguistic task at a conversational level. Put another way, though Kerry might be able to produce oral language, this language was not sufficient for their needs to be understood by others. The propensity for children to use language to communicate their needs with others begins to commence in most young individuals during toddlerhood, and has been described as a prerequisite for children to develop the kind of agency that ultimately leads to self-autonomy (Bruner, 1975). The lack of evidence for shared-referent and relational functions found within Kerry's oral language sample suggested that this trajectory towards acquiring functional oral language proficiency may have been severely interrupted during Kerry's young childhood (Ahern, 2011).

Additional evidence from pre-intervention samples indicated that Kerry did not reply to time-based questions in a semantically accurate manner. For example, when asked, "Do you go to school?" in the present tense, Kerry instead responded in the past tense by saying, "I did high school." Similarly, when the practitioner asked what classes Kerry was currently taking, Kerry responded with the names of cities they had inhabited in the past. These findings suggested that Kerry struggled to orient themselves in time, resulting in the inability to acquire more than rudimentary understandings of concepts displaced out of the immediate present (Arwood, 2011). Research in neuroscience has established that in order for humans to understand and internalize the passage of time, they must be capable of attuning to specific acoustic parameters inherent in auditory language, such as acoustic pitch, frequency, and duration (Grondin, 2010). Visual thinkers, however, have been shown to lack the intuitive capacity to internalize time, and must instead represent time visually as taking up quantities of space (Grondin, 2010). The fact that Kerry could not orient to time-based language suggested that they used their visual learning system to acquire events but not internalized time concepts (Rappleye & Komatsu, 2016). Moreover, literature shows that children who do successfully orient to time begin to accurately use time-based words such as “today,” “yesterday,” or “tomorrow” between the ages of four and six years old (Tillman et al., 2017). Evidence of meeting these a priori expectations was not found within the pre-intervention language samples.

Additional evidence from the oral language sample indicated that Kerry used borrowed phrases, such as “come on,” “cut it out,” or “I’m trying to get some sleep.” Speakers frequently use borrowed language as if it were their own but lack the understanding of what they are communicating (Arwood et al., 2015; Lenneberg, 1969). Much of the oral language sample could also be characterized as telegraphic and redundant, meaning that a listener would need to guess at the speaker’s intent and ask questions multiple times in an attempt to arrive at an understanding (Coplan, 1985). On the whole, analysis of pre-intervention language samples established that at the time of intake Kerry exhibited significant challenges in language function in multiple areas, thus characterizing their language as restricted in function and limited to form typical of children ages 3-7 (Arwood, 2011).

Cognitive Function. Evidence accumulated from the pre-intervention artifacts revealed that, though Kerry did exhibit a few cognitive strengths, their thinking could be characterized as significantly constrained in multiple areas. For example, one strength found within Kerry’s use of language was that they exhibited some flexibility function in mentioning a variety of topics in conversation. This indicated that Kerry might have been imaginative in their ideation when speaking on matters of interest

(Bland, 2012). However, other examples from the pre-intervention artifacts portrayed Kerry as an individual who struggled to complete academic material at an elementary school grade level – an academic level far below their ninth-grade status at the time.

Evidence for Kerry's academic struggles was found when they were not able to understand and summarize a second-grade text when reading it out loud. Though Kerry verbalized the word "range" when orally reading the passage, they did not draw a mountain range but instead drew a ranch with smoke coming from the building structure. Similarly, Kerry's writing sample also failed to address any of the expected constituent questions from the reading passage, such as who was in the story, what they were doing, where they were, why they were there, and when the action was taking place. Such a lack of understanding of the basic semantic agent-action-object relationships within the passage suggested that Kerry did not generate sufficient mental pictures to understand the content by merely reading it out loud (Arwood & Beggs, 1992).

On the whole, the limited grammar and restricted function displayed by Kerry was consistent with a lack of linguistic expansion, extension, and modulation (Arwood, 2011; Gruendel, 1977). These findings provided further evidence that Kerry may have struggled during their life to acquire meaning through the use of auditory modalities such as speaking and listening (Conners et al., 2001). Kerry may have required additional levels of visual neurobiological input to adequately process written text in a manner that was conducive for their brain to learn (Gainotti et al., 2009; Gallese & Lakoff, 2005). These cognitive function findings, combined with the absence of basic agent-action-object semantic relationships inherent within Kerry's oral language, writing, and drawings characterized their language functioning as significantly delayed below cognitive a priori expectations (Arwood, 2011; Buckley, 2003; Coplan, 1985; Tillman et al., 2017).

Social-Emotional Function. A multitude of evidence contained within Kerry's pre-intervention artifacts signified that Kerry struggled to understand the thoughts, feelings, and perspectives of others. As previously mentioned, Kerry repeatedly failed in conversation to understand the expressed intention behind numerous interrogative questions about their life. In addition, the manner in which Kerry drew the human figures in the artifact sample suggested a restricted understanding of social thinking (Grenier & Yeaton, 2019). For example, Kerry drew the human figure in the drawing artifact in an atypical manner by flattening their body, facing them straight ahead, not engaging in any speech or action, and portraying their facial emotions as incongruent with the events of the story. This absence of meaningful semantic features suggested an attenuated capacity for conceptualizing human-to-human semantic relationships (Golomb, 2013). Indeed, aligning human figures into a logical order and sequence in drawings has been described as a competency more associated with four-year-old behavior (Cherney et al., 2006). Thus, the absence of these social qualities signified that Kerry greatly struggled to process social-emotional functioning through the language modality of drawing (Kress, 2003).

Lastly, evidence from the pre-intervention drawing and writing samples signaled that during the intake session Kerry may not have been proprioceptively 'grounded' in the environment of the clinic setting, thus indicating further differences in social-emotional functioning (Kimmel, 2013). Proprioceptive functioning refers to how individuals meaningfully interact with the environmental space around them and process stimuli (Kooiker et al., 2016). Learners are characterized as socially grounded when their bodies and brains are proprioceptively primed to attune to provided sensory input (Arwood, 2011; Mostofsky & Ewen, 2011). Evidence for Kerry's struggle in this capacity was found in their uneven line making on the page, where letters were irregularly shaped and spaced apart and lines became more crooked as they reached the right side of the page.

These findings portrayed a lack of spatial-dimensional alignment between Kerry and the workspace in front of them (Kooiker et al., 2016). Specifically, Kerry appeared to experience a functional disconnect between where their eyes were looking on the page and how their hands entered that space to mark the paper. For writing and drawing to become smooth, controlled and uninterrupted, children must acquire the ability to use all four quadrants of the eyes to see and successfully internalize what is in front of them (Kooiker et al., 2016). Evidence of irregular spacing between words and drawings indicated that Kerry's brain may have been experiencing a pronounced difference connecting visual mental representations from their ocular-motor input to output, potentially explaining the aforementioned social-emotional differences (Arwood & Merideth, 2017).

Summary of Pre-Intervention Language Function Findings. In order to ascertain Kerry's level of language functioning in the linguistic, cognitive, and social-emotional domains at the time of intake, findings from pre-intervention samples were coded and compared against a priori expectations culled from the learning cognitive framework used for this study. Analyses of language functioning were further informed by Arwood's Neuro-Semantic Language Learning Pre-Language Assessment Protocol (ANSPA) (Arwood, 2011) and the Temporal Analysis of Propositions Behavioral Checklist (TemPro - Arwood & Beggs, 1992) completed by Kerry's parent during intake.

Globally, the results of these analyses indicated that at the time of intake Kerry exhibited severely restricted language and thinking with semanticity function of total responses not sufficient for shared understanding. In restricted language function, the listener or observer must continuously infer the original intended communication (Arwood, 2011; Coplan, 1985). Indeed, evidence from Kerry's oral, written, and drawn language samples indicated that the language contained within these artifacts was not able stand to on its own for successful interpersonal communication.

Analyzing Kerry's production of the pre-intervention artifacts also revealed multiple insights into their capacity for learning at the time of intake. From the perspective of the Neuro-Semantic Language Learning Theory (Arwood, 2011), evidence from the pre-intervention samples indicated that Kerry was in fact capable of learning, though this learning was highly attenuated by nature. Kerry could produce some restricted oral, written, and drawn language in response to the practitioner's prompts. However, the capacity for learning that Kerry exhibited could only be categorized as lower-level, pattern-based, and corresponding to tiers 1 and 2 of the NsLLT model (Arwood, 2011). Though Kerry could produce language and therefore learn, the semantic content of this language did not represent meaningful conceptual understanding for conversation or shared academic literacy (Arwood, 2011; Fernandez, 2011).

Extrapolating findings from the pre-intervention artifacts further revealed that Kerry did not appear to learn best through auditory means such as orally reading or listening. When asked to read Selection G out loud and summarize it via writing, Kerry did not sufficiently generate detailed mental pictures to understand the passage, thus suggesting that the auditory input of word-calling did not result in meaningful learning (Conners et al., 2001). This finding suggested that Kerry required additional neurobiological layers of sensory input for their brain to sufficiently process the provided information; and, eventually, begin to learn academic material over time in a way that would lead to greater functionality and self-determination (Duffau et al., 2014; Poeppel et al., 2012).

Findings from analyzing pre-intervention samples also determined that Kerry remained highly restricted in their social thinking (Grenier & Yeaton, 2019). For example, as depicted in the oral language sample (Figure 4) as well as in the drawing sample (Figure 7), Kerry did not indicate the capacity to think *pro-socially*, meaning that they did not consider another person's needs or thoughts, nor did they possess the level of conception required to understand social relationships (Hockett, 1960; Vallacher & Wegner, 1989). To learn how to act as an agent in society, an individual with restricted social thinking would need to acquire a multitude of pro-social concepts such as rules, expectations, customs, and more (Arwood & Young, 2000; Goldstein, 1998). Findings from pre-intervention artifact data indicated that Kerry had not acquired these concepts in the manner in which they had been presented to them thus far; namely, through being taught by example or oral directions, as is the default method of instruction in schools (Kelley-Hortsch, 2018; Robb, 2016).

Evidence from the pre-intervention oral, written, and drawn language samples demonstrated that Kerry exhibited markedly restricted language function in linguistic, cognitive, and social domains. Specifically, the findings from the pre-intervention samples showed evidence of restricted language function in the areas of semanticity, efficiency, shared-referent function, displacement, productivity function, and relational function. Baseline language samples placed Kerry as operating at the pre-language level of language function and preoperational level of social functioning at the time of intake (Arwood, 2011). Age-based estimates of functioning in each domain suggested a three-year-old level of language function, a three-year-old level of cognitive function, and a three-year-old level of social-emotional function (Arwood, 2011; Buckley, 2003; Cherney et al., 2006; Coplan, 1985; Gruendel, 1977; Kimmel, 2013).

This section documented the results of coding the pre-intervention artifacts through the learning cognitive framework. Findings from coding the practitioner's clinical impressions taken during the pre-intervention phase are presented next.

Findings from Practitioner's Clinical Impressions

After the conclusion of the pre-intervention functional language evaluation that was completed during the intake process the practitioner wrote an eight-page report documenting their findings. Coding the practitioner's clinical notes of Kerry at the time of intake resulted in numerous insights, many of which ran parallel to the previous conclusions drawn during the analyses of pre-intervention artifacts.

According to the evaluation report, during the intake process Kerry struggled to accurately match their behavioral actions to their oral language. For example, the practitioner observed that Kerry was able to repeat certain grammatical rules but did not understand what these rules meant, nor were they able to apply them appropriately through their actions. In one instance of this, the practitioner observed that Kerry was able to vocalize rules for correct writing such as "put a period at the end of a sentence," and "use capital letters for names." However, Kerry was not able to implement these rules correctly, as evidenced by the random upper and lower letter combinations as previously depicted in Figure 6.

Kerry's use of unsystematic alphabetic script in these instances suggested that they had not acquired the capacity to spell and scribe words correctly using traditional phonics-based methods (Diaz et al., 2009). It can reasonably be concluded that Kerry had only learned the shapes of either upper- or lower-case letters individually, as would be required of students undergoing typical phonics-based instruction (Kuhn et al., 2010). According to Arwood (2011), many children struggle with phonics-based spelling pedagogies because these methods break down words into individual letters and corresponding sounds. Instead, visual thinkers like Kerry tend to acquire word patterns more efficiently by perceiving the uniquely bordered shape that each word form makes rather than attempting to memorize sound and letter orderings (Arwood, 2011; Hillesund, 2010). More information about this finding is explored in Chapter 5.

Multiple sections of the practitioner's evaluation report also provided clinical descriptions of Kerry's social behavior during the intake process. One primary takeaway culled from these observations was that the practitioner classified Kerry as acting as an *agent*, described as someone in charge of their own decision-making processes. On this topic, the practitioner wrote the following observation, "While working with [the practitioner], [they] observed that [Kerry] exhibited behaviors that would be appropriate in other settings and at other times, but not while being assessed. For example, [the practitioner] observed [Kerry] doing the following: 'open-wide-mouth-yawning, burping aloud, wide-reaching arm stretching, arching and twisting [their] back, complaining about being tired/not sleeping, etc.'" In a summary of these social-emotional findings, the practitioner wrote, "[Kerry] is having difficult moving past the preoperational level of agency…[Kerry] acts on [their] feelings, wants, and needs. [They] talk about what [they] care about... [Their] ideas are about [their] life, [their] world. [They] do not talk much about what [they] do with others… [They] state that [they] do not care about something or other people… [They] know [they] are an agent but struggle to understand [themselves] as an agent amongst other agents." This finding mirrored the previously drawn inference that Kerry's social thinking was restricted to reflect the preoperational level of development (Grenier & Yeaton, 2019).

According to the evaluation report, Kerry exhibited behavior indicating that they struggled to fully see the perspectives of others. For example, the practitioner observed that Kerry may have appeared to be able to engage in a back-and-forth conversation, but in actuality Kerry "[did] not process well what someone [said] to [them]." As a recommendation for how to promote growth in social-emotional functioning, the practitioner wrote the following, "[Kerry] will benefit from therapy that uses drawn and written visual language to assign meaning to [them] as an agent in relationship to other agents. [They] will benefit from seeing on paper the impact that [their] actions have on others, e.g., drawn facial postures, thought bubbles and speech bubbles depicting what others need, feel, or think." These suggestions were included as a way for future intervention efforts to take into account Kerry's visual learning system, where the brain could access information if it were provided in a manner that could be neurobiologically processed by the body's sensory receptors and organized into meaningful patterns that transcended lower, subcortical brain modules (Arwood, 2011).

Taken as a whole, these observations provided in the language evaluation report portrayed a young adult who struggled to act independently, listen to cues regarding tasks that were asked of them, and socially speak with another individual in a one-on-one setting. At the terminus of the language evaluation report, the practitioner concluded Kerry functioned at the preoperational level in language, cognitive, and social-emotional domains.

Summary of Pre-Intervention Findings

A plethora of insights were discovered about Kerry's learning and development by coding and analyzing the pre-intervention artifact samples. Tables 2 and 3 summarize the levels of development and language function that Kerry was exhibiting at the time of intake into the clinic setting. Baseline results demonstrated that Kerry functioned at levels of learning and development that were severely delayed below what a priori expectations would suggest for their chronological age of 16 years old (Arwood, 2011; Coplan, 1985; Diaz et al., 2009; Grenier & Yeaton, 2019; Gruendel, 1977; Kimmel, 2013). Specifically, both developmental and language function findings indicated a 12- to 13-year gap between expected developmental functioning and observed abilities at baseline.

Table 2 displays a summary of pre-intervention developmental findings.

Table 2

Summary of Pre-Intervention Developmental Findings

	Development Framework		
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-Irregular oral and written language usage -Profuse grammatical errors -Incompletely expressed ideas	-Lack of reading comprehension -Atypical artistic representation of people and places -Absence of orthographic control	-Inability to engage in shared oral conversation -Attenuated mark-making capacity -Ill-defined relationships between drawn characters
Evidence from samples	-"I hate fire… make my skin melt off." -Irregular verb tenses -Random capitalization of letters	-Incorrect summary of Selection G -Overly large drawn figure and setting did not match reading passage	-Talked only about topics of interest -Stick figure drawn inside hollow body -Unlifelike depictions of humans
Practitioner impressions	-"[Kerry] talks [only] about what [they] care about..."	-"[Kerry] acts on [their] feelings, wants, and needs."	-"[They] know [they] are an agent but struggle to understand [themselves] as an agent amongst other agents."
Developmental stages	-Preoperational development -Preconceptual artistic stage	-Preoperational development -Preconceptual artistic stage	-Preoperational development -Preconceptual artistic stage
Estimate of developmental age	3 years old	3 years old	4 years old

Table 3 displays a summary of pre-intervention findings from the learning framework.

Table 3

Summary of Pre-Intervention Learning Findings

	Learning Framework		
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-Lack of shared-referent function -Abundance of borrowed language -Telegraphic and redundant language	-Lack of cognitive displacement -Inability to use time to function -Absence of constituents from reading passage	-Absence of shared and relational functions -Lack of perspective taking function -Learner not proprioceptively grounded in time and space
Evidence from samples	-No shared meaning in conversation -"Come on," "cut it out." -Listener must guess at speaker's intent	-Mixing present/past tenses in conversation -Does not orient to concepts beyond "here and now" -Does not address who, what, where, when, why, or how	-One-word utterances: "teacher," "probably." -Flattened drawn figure with incongruent facial expressions -Letters unevenly spaced, crooked lines outside of visual quadrant
Practitioner impressions	-"[Kerry] did not process well what someone said to [them]."	-"[Kerry] struggled to accurately match [their] actions to [their] speech."	-Kerry did "open-wide-mouth-yawning, burping… complaining about being tired/not sleeping" and more.
Developmental/ Functional stages	-Preoperational -Pre-language -Restricted language function	-Preoperational -Pre-language -Restricted language function	-Preoperational -Pre-language -Restricted language function
Estimate of functional age	3 years old	3 years old	3 years old

Mid-Intervention Findings

To investigate how Kerry's learning and development had changed since pre-intervention baseline findings, three additional artifacts were analyzed from Kerry's case file that represented an approximated midway point in the total duration of time investigated for this study. These artifacts were produced by Kerry after engaging in the Neuro-Education intervention sessions for approximately seven months of time. During these seven months, Kerry completed 46 one-on-one sessions lasting two hours each for a total amount of 92 hours logged in the clinic setting. At this midway point, Kerry had aged to 16.75 years old.

The artifacts collected to represent this midway point in the intervention included: (a) an oral language conversation sample, (b) an oral language sample describing the story contained within a picture, (c) a drawing sample, and (d) a writing sample. These artifacts are first depicted in Figures 8, 10, and 11, with typed transcriptions provided, to provide unaltered reference points. Next, the subsequent sections analyze these mid-intervention artifacts through the developmental and language function cognitive frameworks. Efforts were made to investigate these language samples both on their own attributes at the midway point in time, as well as in relation to the characteristics found during the pre-intervention analysis.

Figure 8 displays a transcript of Kerry's oral conversation sample taken and originally transcribed by the practitioner.

Figure 8

Mid-Intervention Oral Language Sample

Practitioner:	What do you do on a typical day?
Kerry:	I don't know.
Practitioner:	What do you do on a school day?
Kerry:	What I did on a school day I don't know. I work. I did really good. What are you writing?
Practitioner:	What did you do this morning?
Kerry:	After that I'm not so sure. I got out of bed in a jiffy. And then I ate breakfast and everything.

Figure 9 presents the event-based picture that was utilized by the practitioner to elicit an oral summary from Kerry of the depicted contents.

Figure 9

Mid-Intervention Event-Based Picture

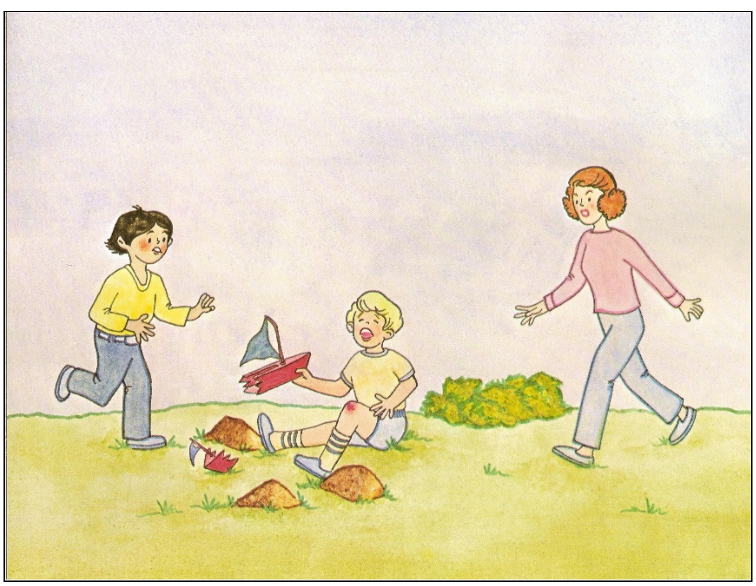


Figure 10 displays a transcript of Kerry's oral language when asked to explain what events had occurred in the picture.

Figure 10

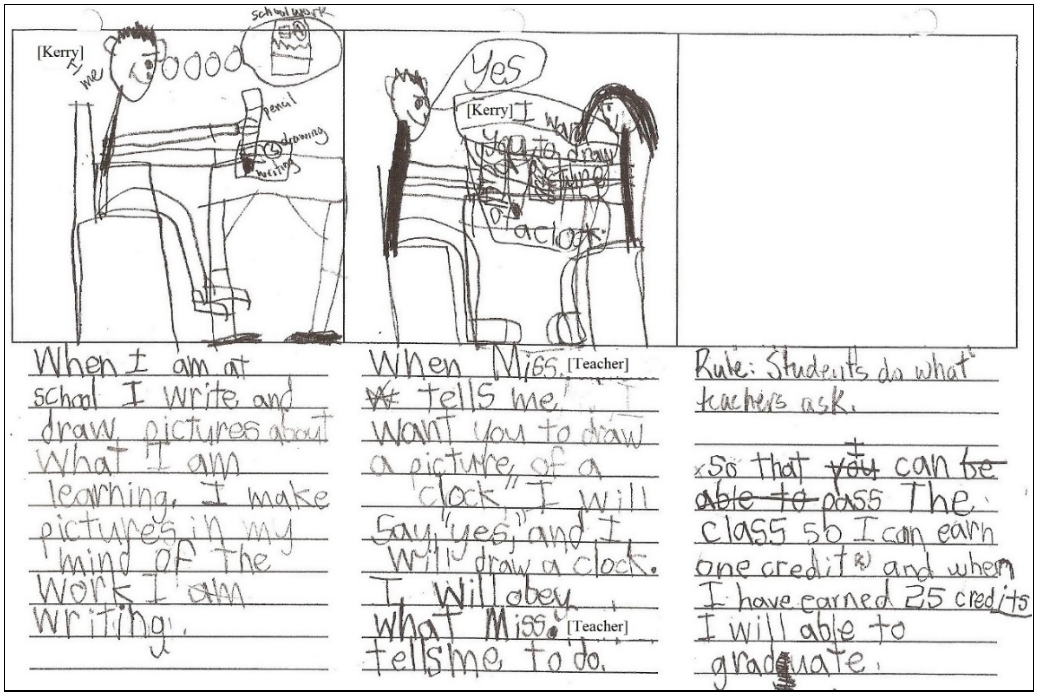
Mid-Intervention Description of Event-Based Picture

"Charlie was playing with his boat, but he forgot to watch where he was going. Then he jumped on a rock and broke his boat. Ted is his brother and his mother is Michelle. When Charlie cried because his brand new boat was broken, he ran to see what's going on and sees his mother."

Figure 11 provides an example of a drawing and writing sample that was predominantly completed by Kerry alone, with a few minor refinements provided by the practitioner.

Figure 11

Mid-Intervention Drawing and Writing Sample



Transcription of written language sample.

"When I am at school I write and draw pictures about what I am learning. I make pictures in my mind of the work I am writing. When Miss [Teacher] tells me "I want you to draw a picture of a clock," I will say, "yes" and I will draw a clock. I will obey what Miss. [Teacher] tells me to do. So that you I can be able to pass The class so I can earn one credit (c) and when I have earned 25 credits I will able to graduate."

Note. Names have been changed and redacted to preserve confidentiality.

Description of Developmental Functioning

Mid-intervention artifacts presented in Figures 8, 10, and 11 were first coded using the developmental cognitive framework. Results from these analyses were categorized into findings related to linguistic, cognitive, and social-emotional domains.

Language Development. In contrast to linguistic findings from the pre-intervention phase, mid-intervention artifacts exhibited numerous examples of Kerry using correct conventions of language when telling a story or communicating their ideas. For example, the oral language sample contained far fewer uses of incorrect grammar, such as run-on or incomplete sentences. Moreover, Kerry's oral language included more parts of speech utilized, such as prepositional phrases ("on a school day," "after that,"), adverbs ("I did really good"), possessive nouns ("his boat," "his foot,"), and adjectives ("brand new"). These … suggested that Kerry had notably progressed in their capacity for integrating advanced grammar in their oral language (Nelson, 1981).

Analyzing the written artifacts showed that at the midway phase Kerry wrote longer, more complex sentences with an increased amount of words used to portray phrasal verbs and clauses. Additionally, the writing sample included more correct punctuation in the form of commas, quotation marks, and periods. Orthographic evidence also showed notable improvements in written conventions, as most of the depicted words used correct upper- and lower-case capitalization. While much evidence in the samples demonstrated significant progress in language development compared to baseline, some errors of language were still evident. For example, some verb tenses were inaccurately expressed, and other verbs were missing their auxiliary component, such as in "be able." In sum, though Kerry still exhibited some challenges in their implementation of correct grammar, mid-intervention artifacts indicated an overall rise in proficiency for using conventions of language to express desired communication – a progression that exemplified developmental evolvement (Saxton, 2017).

Cognitive Development. Analysis of mid-intervention artifacts also portrayed Kerry as more capable of using drawings to symbolically represent increasingly complex mental concepts. For example, in Figure 11 Kerry drew multiple recognizable objects such as chairs, tables, pencils, and paper. Compared to pre-intervention samples, these images also displayed higher-order acts of cognition such as drawing, thinking, listening, and speaking (Halliday, 1976). These objects and actions were also constructed with greater attention to detail as evidenced in the thought bubble encapsulating a picture of schoolwork with an “A” letter grade written on top. These drawn objects were developmentally appropriate for the setting of the classroom, thus suggesting a more refined alignment between Kerry’s empathic imagination and their awareness of the needs of others (Bland, 2012).

Written and drawn artifacts also displayed evidence of greater hand-motor control in using mark-making to depict visual ideas. For example, Kerry drew most horizontal and vertical lines relatively straight from one side of the page to the other. This finding suggested that the paper was arranged for Kerry in a quadrant that was above their eye level and placed on their writing side thus resulting in more coordinated proprioceptive-motor connections (Arwood, 2011; Mostofsky & Ewen, 2011). Moreover, artifacts showed that written words fit within the horizontal ledger lines provided on the paper, thus suggesting a greater amount of control in conservation of spaces (Morton & Munakata, 2002).

Though many cognitive strengths were depicted in the artifacts, some evidence of challenges still remained. For instance, some shapes such as speech bubbles were drawn overlapping, and some irregular horizontal spacing of letters was observed. These elements demonstrated that Kerry was still refining their mental relationship with the act of drawing (Kress, 2003). In all, these cognitive findings characterized an individual engaged in the non-linear process of learning, where complexification of concepts often results in unpredictable cognitive development over time (Gallucci et al., 2010). Put a different way, evidence indicated that Kerry's cognitive development began to flourish in changeful ways precisely because they were now learning in a manner that appeared to be meaningfully changing their brain (Perlovsky, 2011). Because learning is inherently non-linear, this means that children may experience cognitive growth in unplanned areas and in unpredictable ways (McLeod, 2018).

Social-Emotional Development. In multiple mid-intervention artifacts, Kerry demonstrated the capacity to meaningfully interact with another individual, a social-emotional quality lacking from the pre-intervention artifacts collected during intake. This finding was demonstrated in the oral language sample presented in Figure 8 when Kerry directly inquired "What are you writing?" to the practitioner who was transcribing their words onto the page. Such a direct interaction signified greater environmental awareness of others (Berns, 2016). In addition, the drawing sample depicted two agents having a shared – albeit short – conversation regarding a requested schoolwork task. These examples displayed Kerry taking interest in what other people were doing, a progression shown to be a precursor for the development of perspective taking (Edwards, 2016).

The human figures presented in Figure 11 were portrayed as mostly proportional to themselves and to each other, and symbolically representative of real-life human characteristics. The main individual was shown facing to the right while displaying an expression that was consistent from panel to panel. This main individual was also drawn with outstretched hands as they socially engaged with the other figure. According to some developmental scholars, the depiction of an agent with outstretched hands towards another individual may indicate their desire to socially connect with others, or a willingness to engage in the task at hand (Boyatzis, 2000; Farokhi & Hashemi, 2011). Social findings from these artifacts signified a learner acquiring greater awareness of the value of other people, where interactions with others can allow for the type of meaningful social connections that transcend the self (Charleroy et al., 2012). In all, evidence from mid-intervention artifacts showed notable social-emotional developmental growth for Kerry in many areas.

Summary of Mid-Intervention Developmental Findings. Coding and analyzing the mid-intervention artifacts and comparing these results against a priori expectations from developmental literature demonstrated that at the midway point of this study Kerry had made noticeable progress in linguistic, cognitive, and social-emotional development (Boyatzis, 2000; Charleroy et al., 2012; Edwards, 2016; Halliday, 1976; Morton & Munakata, 2002). During this phase the products that Kerry created began incorporating conventions of oral, written, and drawn language at a level more closely associated with the behavior of a four-to five-year-old child (Travers et al., 2009). Age-based milestones at this stage involve learning how to write in complete sentences and utilize correct capitalization, punctuation, and syntax (Petty, 2016). Developmentally, Kerry also exhibited certain language proficiencies corresponding with four-to five-year-old skills, such as speaking in complete sentences, understanding and using question words orally, articulating simple pronouns and prepositions, and using specific action words to convey intended meaning (Saxton, 2017). Notably, however, Kerry did demonstrate some irregularities of language such as being unable to answer basic constituent questions and omitting auxiliary verbs, thus suggesting some lagging linguistic competencies during this phase.

Analyzing mid-intervention artifacts for changes in cognition revealed evidence linking the findings to mental competencies associated with four-to five-year old milestones. For example, by this developmental age children typically have begun to increase their abstract thinking (Anderson, 2015). Evidence for this was found in the drawing artifacts where greater precision was used to symbolically represent people and actions (Malchiodi, 1998). Moreover, drawings during this phase showed particulars representing certain five-to six-year-old competencies, such as demonstrating logical order, sequence, and step-by-step instructions (Lowenfeld & Brittain, 1987). Human figures were also displayed engaging in more complex imagination, as represented by the use of intratextual thought bubbles used to portray the contents of their minds (Wright, 2007).

Socially, by age five children begin to draw multiple people in their drawing with greater realistic detail, representing a pronounced capacity for identifying and classifying the different types of relationships in their lives (Looman, 2006; Malchiodi, 1998). Evidence for this type of progress was found in Kerry's oral language sample, where Kerry named the brother and mother of the main character. In another example of Kerry's social-emotional progress, the interactions depicted between the drawn agents in the environmental context reflected a shift towards higher preoperational social thinking, with some concepts bordering on concrete symbolization (Halliday, 1976). The mere fact that Kerry displayed themselves logically conversing with their teacher on a logical topic suggested a readiness to begin engaging in concrete thinking (Meilinger & Vosgerau, 2010). Relatedly, Kerry drew themselves successfully completing a task in school; by the age of five many children begin to use drawing as a way to tell stories from their lives or work out social problems (Edwards, 2016). It may be inferred that the impetus for the drawing/writing sample arose out of an event occurring in Kerry's real life, where drawing the event visually on the page may have allowed for greater therapeutic clarity during the intervention sessions (Birch & Carmichael, 2009).

Composite analysis of artifacts demonstrated that during the time frame from intake to mid-intervention Kerry experienced a shift in artistic capacity from the *preconceptual* stage to the *early schemata* stage (Lowenfeld & Brittain, 1987). Whereas children in the preconceptual stage often lack the capacity for clearly depicting people and objects, in the early schemata stage children begin to develop proficiency for acquiring more complex mental schemas based upon their life experiences and advance in their ability to represent their active knowledge of a concept onto the page (Malchiodi, 1998). Developmental scholars observe that as children undergo these transformations, they expand their own self-concept, or conceptual understanding of agency (Popkewitz, 1998). This finding could be seen through the complexification of the developmental products that Kerry created as represented by parallel changes in their language, cognitive, and social-emotional artifacts over time (Morcom & Cumming-Potvin, 2010).

In sum, though evidence was found of many intellectual advancements from the pre-intervention to mid-intervention sessions, overall findings suggested that Kerry still functioned at the preoperational stage of development at this phase of the study. Comparing Kerry's progress at this midway point against developmental a priori expectations suggested that Kerry functioned at a level that most closely matched developmental milestones associated with a four-to five-year-old level of language development, a four-to five-year-old level of cognitive development, and a five-year-old level of social-emotional development (Edwards, 2016; Looman, 2006; Malchiodi, 1998; Morcom & Cumming-Potvin, 2010; Petty, 2016).

Description of Language Function

Artifacts presented in Figures 8, 10, and 11 were also coded using the learning cognitive framework, as represented by changes in language function over time. Results from coding these analyses were categorized into findings related to linguistic, cognitive, and social-emotional domains.

Language Function. Findings indicated that between the time of intake into the clinic and the midway point of this study, Kerry experienced notable increases in multiple areas of language functioning. Kerry's oral language exhibited greater referential function or clarity, as demonstrated by their effort to understand and answer the specific questions of the practitioner rather than just talking about topics of interest. This finding indicates an increase in Kerry's capacity to reflect the who, what, where, why, and how of a social situation by expanding, extending, and modulating their language functioning (Arwood, 2011). By responding “I don’t know” to the questions asked of them instead of straying into unrelated tangents, Kerry also showed greater ability to recognize another agent in the conversation (Nicholson, 1983). Kerry demonstrated stronger use of shared-referential functioning by successfully composing a dynamic story from the event-based picture that was complete with a beginning, middle, and end suggesting an increase in displacement and semanticity for greater flexibility and productivity. Despite these progressions, some components of Kerry’s oral language still displayed disfluencies such as using borrowed phrases (“in a jiffy”) and utterances requiring interpretation (“and everything”). Using oral language for functional communication still appeared to be a challenge for Kerry at this time (Todisco et al., 2020).

Other examples from the mid-intervention drawing samples depicted further evidence of Kerry beginning to acquire multiple processes of literacy, such as drawing their character engaged in thinking, listening, speaking, viewing, and more. Assuming the drawing indeed represented a real-life event from Kerry’s life, it may be inferred that Kerry began seeing themselves more successfully taking ownership in the types of psychological processes that scaffold towards higher-order thinking and learning (Cooper, 2006). According to Clark (1973), the evolution of these kinds of psychological processes occur only when individuals begin acquiring sufficient language to represent these concepts in the mind. Specifically, the acquisition of this kind of higher-order thinking results only when individuals’ *percepto-cognitive* system can meaningfully process sensory input and use it to scaffold towards ongoing learning (Illerbrun, 1975). Evidence for this progress in learning was found in Kerry's more complex usage of literacy functions as well as their drawings containing greater semantic details.

Lastly, the drawing and writing samples that Kerry created during the midpoint of the study further portrayed them as getting more in touch with understanding their own visual learning system; that is, making pictures in their head. Acquiring an awareness of how one learns best has been described as a precursor to helping individuals begin to direct their own learning as a self-empowered pupil (Robb, 2016). On the whole, evidence from mid-intervention artifacts portrayed Kerry beginning to engage in the intertwined processes of learning language and thinking (Chatterjee, 2010). In turn, this finding suggested that Kerry's neurobiological learning system had begun to process provided sensory input at levels sufficient enough to start inhibiting and integrating this information in the brain for greater functional usage (Arwood, 2011; Gallistel & Matzel, 2013).

Cognitive Function. Evidence from mid-intervention artifacts portrayed an individual acquiring greater capacity for cognitive productivity, displacement, and flexibility. For example, in the oral re-telling of the event-based story, the practitioner utilized seven different action verbs ("Playing," "watch," "jumped," "broke," "cried," "ran," and "sees") to invent a narrative of what the main character did before, during, and after the moment in time captured on the page. On the whole, Kerry's use of action words semantically matched logical depictions of what would be expected to occur based off of the provided image. However, some inaccuracies were noted, such as utilizing the verb "jumped" when the verb "tripped" would have been more appropriate. Improvising such a narrative required Kerry to project their thinking into the setting from the picture, thus demonstrating increased proficiency in cognitive displacement (Greisdorf & O'Conner, 2002). Thinking becomes increasingly displaced as referenced ideas represent concepts further outside of the here-and-now (Arwood, 2011). Composite mid-intervention samples created by Kerry also demonstrated an increase in their use of flexibility function in being able to coordinate multiple communication modalities to align with their internal thinking (Arwood, 2011). Put more simply, the drawings and writings that Kerry created showed synchronous expression of ideas – a hallmark of advancement in cognitive functioning (Banks, 2001; Xiang-Lam, 2016).

Other exemplars from mid-intervention data depicted an individual making some cognitive progress on understanding time-based concepts, yet still struggling to fully grasp temporal chronology. For example, Kerry failed to answer what a "typical" day looks like, providing evidence of their inability to use time to successfully function in multiple environments (Arwood & Beggs, 1992). Answering what a typical day looks like is a formal auditory proposition; therefore, individuals like Kerry who think with a visual system have been shown to routinely struggle with questioning that stems from an auditory conceptualization of time (Arwood, 2011). In spite of this incompetency, however, Kerry's oral and written language demonstrated an increased capacity for sequencing events logically, purportedly by mentally rewinding and fast-forwarding mental pictures in their mind in order to translate these images into words (Schacter & Addis, 2007). As previously presented, visual thinkers lack the intuitive neurobiological capacity to internally mark the passage of time, an acoustic function of the hearing mechanism (Arwood & Beggs, 1992; Debreczeny, 2019). To compensate, individuals like Kerry can learn how to visually mark time as taking up different amounts of space depending upon the action, and this marking of time can be depicted through a sequencing of events (Moore, 2006). More specifically, instead of conceptualizing such temporal metaphors as 'future' and 'past,' visual thinkers can attune to 'preceding' or 'ensuing' relationships between moments related to specific events (Debreczeny, 2019; Núñez et al., 2006). These findings may explain the rationale for the teacher in the artifact asking Kerry to draw out the workings of an analog clock, as hands on the clock take up varying amounts of space and can be visually attached to sequences of events (Arwood et al., 2015). In sum, during the mid-intervention phase Kerry made numerous noteworthy advancements in their cognitive functioning in relation to time-based concepts and overall displacement of their thinking.

Social-Emotional Function. Multiple elements from midpoint artifacts depicted progress in Kerry acquiring increasingly complex understandings of social-emotional agency. For example, the dialogue spoken by the teacher in the drawing sample portrayed the speech act of requesting, in that the initiator requested the listener to perform a task with the understanding that this action would be performed (Searle, 1969). In addition, when Kerry stated, "I work… I did really good [in school]," they communicated ownership of their role as a student, an overall aptitude lacking from pre-intervention findings. Drawing artifacts also portrayed further referential function, in that Kerry drew themselves engaging in the kind of thinking and talking that would be socially appropriate for the school setting (Arwood, 2011).

In the drawing sample, Kerry exhibited greater capacity for the kind of higher-order thinking that scaffolds towards pro-social behavior over time (Arwood et al., 2015; Pulvermüller, 2013). For example, by making efforts to 'fit in' the school environment, Kerry demonstrated progress in learning within a pro-social context, where positive value was acquired through the outside agent (the practitioner) assigning meaning to Kerry's actions (Morcom & Cumming-Potvin, 2010). Research demonstrates that children acquire pro-social concepts through the act of neuro-semantic learning, where such socialization and cognition form reciprocal neurobiological processes (Tomasello, 2009). Such neurobiological learning occurs through the acquisition of pro-social language function, in which learning is social and embedded within cultural contexts (Arwood et al., 2015; Kuhl, 2007). More simply, Kerry's oral, written, and drawn language demonstrated the capacity to begin thinking of others as agents, a prerequisite needed to bring about concrete pro-social thinking over time (Arwood et al., 2018; Green-Mitchell, 2016).

Further analysis of orthographic evidence from the mid-intervention drawing and writing samples indicated that Kerry had significantly gained in their capacity to function as a socially grounded learner while in the clinic setting (Arwood, 2011; Mostofsky & Ewen, 2011). For example, Kerry's drawing and writing during this time neatly fit within the provided frames, mark making did not spill over the edges of the paper, images represented predefined spatial relationships, and human figures were grounded on the base line. Developmentally, these progressions indicated greater synchrony between ocular, visual-cerebral, and somatosensory functioning of the hands to depict ideas in a controlled manner (Faivre et al., 2017). Artistically, this proprioceptive grounding resulted in an increased capacity to match visual drawn realism to real life materiality (Cox, 2015; Papandreou, 2014). Lastly, in the oral telling of the story Kerry portrayed the main character as “crying,” which semantically matched the provided representation in the event-based picture. Describing emotions in this manner suggested social-emotional evolvement, as vocalizing greater awareness of different types of feelings frequently coincides with the acquisition of understanding internal social states (Squire et al., 2014).

Summary of Mid-Intervention Language Function Findings. Comparing mid-intervention findings against a priori expectations from relevant literature demonstrated that Kerry made many notable intellectual and social-emotional progress in many areas since intaking into the clinic (Arwood, 2011; Faivre et al., 2017; Mostofsky & Ewen, 2011; Papandreou, 2014; Searle, 1969). Analysis indicated that these changes inherent in the products that Kerry created during this time resulted from a global shift from pre-language functioning into preoperational language functioning. Whereas pre-intervention language samples showed Kerry as an individual yet to utilize language for successfully meeting the needs of themselves and others, evidence from mid-intervention artifacts portrayed an individual now fully engaged in the process of refining their own thinking, a prerequisite aptitude for humans to continue learning on their own (Vygotsky, 1962).

Much evidence for this global shift was found in the artifacts. For instance, Kerry crossed out words that were phrased incorrectly and wrote them again to be semantically accurate. These specialized marks depicted the actions of a learner engaged in the process of refining the redundancy of their own language, albeit with help from the practitioner (Hawkins, 2004). Such actions frequently result from increased semanticity over time, where learners internalize the changes of meaning which is also seen in their language (Arwood, 2011; Robb, 2016). In addition, Kerry exhibited stronger productivity function in their drawings in that they were able to semantically match their written ideas to drawn concepts (Arwood, 2011). In linguistic analysis, the drawings that one creates represents their conceptual understanding of the world, while the accompanying writing narrates that understanding in the form of visual patterns or structures (Arwood, 2011; Barthes, 1969). Scholars describe greater alignment between the visual patterns and concepts of language as evidence for cognitive synchronization of these two mediums of visual symbolization (Arwood, 2011; Temple et al., 2013; Wright, 2007). A change over time towards a greater alignment of these two thinking mediums suggested that Kerry was now successfully integrating neurobiological feedback systems in their brain in order to synchronize competing thought processes into a unified expression (Arwood & Merideth, 2017; Ghazanfar & Schroeder, 2006).

In the social domain, analysis of mid-intervention artifacts established that Kerry still functioned within preoperational parameters, also referred to by Kohlberg (1983) as the preconventional level. Evidence for this was provided in the drawn sample where the main figure obeyed the teacher, or rather did what was told of them without articulating clear reasoning why this was expected. According to Kohlberg (1983), children functioning in the preconventional level follow external rules, such as obedience, that have yet to be internalized in their psyches. However, some findings from the mid-intervention artifacts suggested that Kerry may have begun acknowledging that successfully functioning in society requires an understanding of its rules, as depicted in the main figure completing the requirements expected of them while in the classroom (Kuhl, 2007). For example, by documenting the steps needed to do well in school and eventually graduate, Kerry demonstrated preliminary capacity for future orientation planning, a competency typically not developed until early adolescence (Steinberg et al., 2009). Continuing to move to a concrete level of socialization would require Kerry to identify their own rationale for acting as an agent in all environments (Arwood et al., 2015). Rotter (1966) similarly refers to this process as shifting one's own locus of control from external to internal constructions.

In relation to the Neuro-Semantic Language Learning Theory, mid-point evidence suggested that Kerry had begun to surpass the mere pattern-based learning associated with tiers 1 and 2, also referred to as input-output learning (Arwood, 2011). Findings indicated that Kerry possessed a movement access to their learning system, meaning that they required an overlap of meaningful motor-based movements (such as hand-over-hand drawing and writing) in order for sensory input to be recognized (Gallese & Lakoff, 2005). Now that Kerry's brain had begun to successfully process sensory input in the form of visual-motor methods (tier 1), findings suggested that these patterns (tier 2) could be neurobiologically organized into more meaningful concepts (tier 3), such as in the example in Figure 11 depicting what learners are expected to do at school in order to graduate. Neurobiological learning at the conceptual level has been described as a necessary building block in the long-term acquisition of language, which ultimately allows an individual to function as an empowered agent in the world (Arwood, 2011; Robb, 2016).

Despite the progress documented in these sections, Kerry's overall language function at the midpoint in the study exhibited restricted function to late preoperational thinking, with occasional concrete levels of thinking, in that the listener or observer needed to take on more than a shared level of understanding to interpret Kerry's intended communication (Arwood, 2011; Coplan, 1985). Age-based estimates of functioning in each domain suggested a four-year-old level of language function, a four-year-old level of cognitive function, and a five-year-old level social-emotional function.

Findings from Practitioner's Clinical Impressions

Coding the practitioner's clinical case notes recorded between the time of intake and the creation of mid-intervention language samples confirmed many findings from the previous artifact analyses, but also uncovered additional insights not initially established from the documents. Over this course of time, the practitioner described how Kerry increased in proficiency for translating their ideas into written sentences that utilized correct conventions. This process of developing their capacity for language often began with the practitioner writing Kerry's ideas first and then helping Kerry to refine their thinking through the adding of semantic corrections such as relational words. As Kerry's writing gained in precision, they were noted as increasing their understanding of the purpose behind language conventions. By the time the mid-intervention drawing and language samples were created, the practitioner memoed that they had expected Kerry to start making their own refinements rather than having these edits done for them.

Similarly, over this time frame the practitioner described Kerry as significantly increasing the quantity and quality of their drawings from only being able to draw "a little" at first to eventually creating "multiple" drawings per two-hour session. Cognitively, the practitioner memoed that they thought Kerry held "lots of pictures in [their] head," but overall "lacked vocabulary to describe certain objects or ideas." The practitioner described this discrepancy as a "gap" between their level of thinking and their level of language. In a related entry Kerry was portrayed as having "more patterns than concepts," potentially explaining their frequent use of "borrowed phrases" that were ultimately devoid of meaning. Over time, clinical entries described Kerry as becoming more "present" in their sessions by asking more questions about the stories they were reading and inquiring of the practitioner "why" certain social conventions existed.

Socially, Kerry was described as developing their sense of agency over time, resulting in them at times "questioning" the practitioner in a "vocally volatile" manner by repeating phrases such as, "What? What? What?" During these moments Kerry was described as "dropping developmental levels" as they challenged the practitioner with inquiries such as, "Why do I have to do this work?", and "What is this work for?" As the sessions went on Kerry was described as exhibiting "calmer, more appropriate" behavior and "making fewer excuses" about having to do academic work in the meetings. These findings align with descriptions from literature of individuals who develop their capacity for pro-social thinking over time (Goldstein, 1998; Jaskowiak, 2018). More specifically, individuals acquire a greater conceptual understanding of pro-social behavior only when their brains begin to learn through higher-order neuro-semantic and socio-cognitive processes (Green-Mitchell, 2016). The practitioner explained that they used these opportunities to draw Kerry successfully engaging in tasks in order to show them that scholastic achievement was attainable. In addition, intervention sessions frequently involved drawing out social expectations for Kerry to "learn why not to cover their face with their hands," or why it is "not appropriate to blurt out words when entering a room." In summary, an analysis of case notes identified multiple ways in which Kerry had grown in each developmental domain as a result of conceptual learning taking place.

Summary of Mid-Intervention Findings

Coding mid-intervention artifacts and analyzing these through a priori expectations from both cognitive frameworks established that Kerry had experienced notable growth in the learning and development since the onset of the study. Many of this observed growth was echoed and elaborated upon by coding the practitioner's clinical impressions that they had written during this time. Tables 4 and 5 display the levels of development and language function that Kerry was exhibiting when the mid-intervention artifacts were created. Though much progress was made between intake and this time period, results show that at this time Kerry nevertheless functioned at levels that were significantly delayed below their chronological age. Both developmental and language function findings indicated an approximate 11- to 12-year gap between expected developmental function and documented abilities at this midway point. Notably, though Kerry grew chronologically older, the gap between their expected capacity and actual abilities shrank. The significance of this finding is probed further during the conclusion section of this chapter.

Table 4 displays a summary of mid-intervention findings through the developmental framework.

Table 4

Summary of Mid-Intervention Developmental Findings

Development Framework			
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-Many correct conventions of language, grammar -More parts of speech utilized -Longer, more complex written sentences	-Drawings increased in representational complexity -Evidence of finer orthographic control -Greater attention to artistic detail	-Preliminary capacity to interact with others -Displays other agents on the page -Human figures proportional and symbolically representational
Evidence from samples	-Fewer run-on sentences -Adds prepositional phrases, adverbs, and possessive nouns -Punctuation, syntax complement conveyed ideas	-Acts of higher-order thinking, listening, speaking displayed -Few errors in alphabetic script, straight lines across full page -Speech and thinking bubbles developmentally appropriate for setting	-Spoken to practitioner: “What are you writing?” -Drawn student and teacher sharing joint conversation re: schoolwork -Main figure facing to the right with outstretched hands towards other
Practitioner impressions	Kerry held “lots of pictures in [their] head,” but “lacked vocabulary to describe certain objects or ideas.”	A “gap” existed between Kerry’s level of thinking and level of language	-Kerry exhibited “calmer, more appropriate” behavior and “made fewer excuses” over time
Developmental/ Functional stages	-Preoperational development -Early schemata artistic stage	-Preoperational development -Early schemata artistic stage	-Preoperational development -Early schemata artistic stage
Estimate of developmental age	4-5 years old	4-5 years old	5 years old

Table 5 displays a summary of mid-intervention findings through the learning framework.

Table 5

Summary of Mid-Intervention Learning Findings.

	Learning Framework		
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-More advanced referential function exhibited -Engages in psychological processes of literacy -Borrowed language still evident	-Complexified productivity and flexibility functions -Alignment between multiple communication modalities -Logical sequencing of ideas, yet lack of temporal chronology	-Increased agency in social thinking -Ownership of role as student and learner -Greater capacity identifying emotions of others
Evidence from samples	-Answers specific questions instead of fixating on topics of interest -Drawing process of visual literacy acquisition (pictures in head) -Purposeless language: "In a jiffy," "and everything."	-Multiple action words recount beginning, middle, end of story -Drawings and writings show synchronous ideas -Time beginning to be depicted as quantities of space; concept of "typical day" still challenging	-Dialogue shows speech act of "requesting" -Kerry states, "I work, I did really good [in school]." -Crying boy in story matches depicted events
Practitioner impressions	"[Kerry] has more patterns than concepts," and some "borrowed phrases."	"[Kerry] becoming more present in sessions."	"[Kerry] developing sense of agency… leading to more questioning of activities."
Developmental/ Functional stages	-Preoperational -Preoperational language -Restricted language function	-Preoperational -Preoperational language -Restricted language function	-Preoperational -Preoperational language -Restricted language function
Estimate of functional age	4 years old	4 years old	5 years old

Endpoint Intervention Findings

To investigate how Kerry's learning and development had changed since the pre-intervention and mid-intervention phases, three additional artifacts were analyzed from Kerry's case file that represented an end point in the total duration of time investigated for this study. By this time, Kerry had aged to 18.2 years old. Kerry had completed 183 sessions between mid and end points, with each session ranging between one and three hours. During the duration of this study, Kerry completed a total of 366 hours of Neuro-Education based interventions.

The artifacts collected to represent this end point in the intervention included: (a) an oral language sample describing the story contained within a picture, (b) a drawing sample, and (c) a writing sample. These artifacts are depicted in Figures 13 and 14 below, with typed transcriptions provided. The subsequent sections analyze these end-point intervention artifacts through the developmental and learning cognitive frameworks. Efforts were made to investigate these language samples both on their own attributes at the end point in time, as well as in relation to the characteristics found during the pre-intervention and mid-intervention phases.

Figure 12 displays the event-based picture that was provided to Kerry during this phase. Kerry was asked to tell a story describing the depicted events that had occurred in this picture.

Figure 12

End-Point Intervention Event-Based Picture

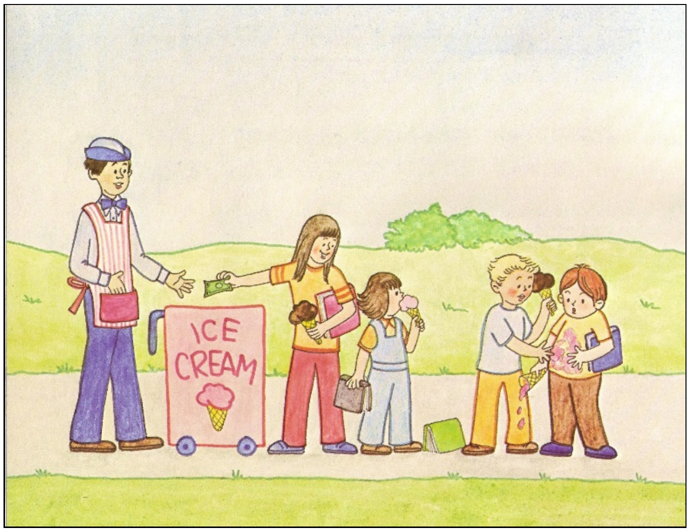


Figure 13 displays a transcript of Kerry's oral language sample that described the events that had occurred in the event-based picture presented in Figure 9. This transcript was originally scribed by the practitioner and then typed for inclusion here.

Figure 13

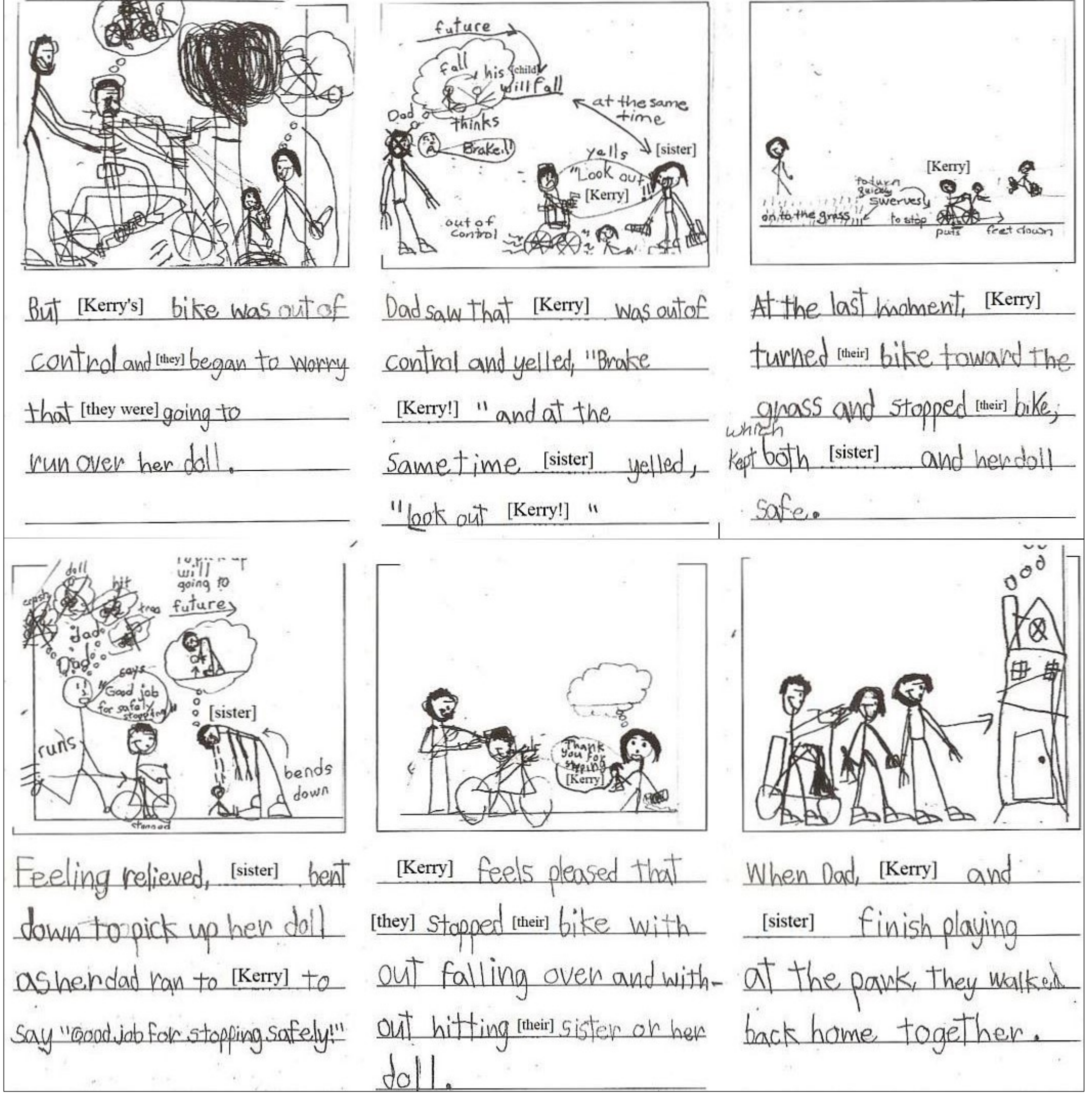
End-Point Intervention Oral Language Sample

"That guy is the ice cream man. The other girl, I think her name was probably Elizabeth. And the young girl is Emily. They are eating chocolate and strawberry ice cream. I think that [other] ice cream flavor is probably vanilla flavored. Well, the two boys named Charlie and [Kerry] were fighting over ice cream, and [Kerry] got ice cream all over his new clean shirt. Well, [Kerry]… ('I made a mistake' said in aside to practitioner)… Well, Charlie didn't drop his chocolate flavored ice cream. The two girls are eating ice cream and the two boys are fighting to get ice cream."

Figure 14 displays a lengthy drawing and writing sample completed by Kerry during the end-point phase. Figure 14 visually presents the events that had occurred in a story from Kerry's perspective.

Figure 14

End-Point Drawing and Writing Sample



Transcription of written language sample: “One day, Dad took his [child], [Kerry], and his daughter, [sister], to the park to play. As [sister] played with her doll, the dad helped his [child] learn how to ride [their] bicycle. [Kerry] put [their] feet on the bike pedals and then [their] dad gave [them] a good push by putting one hand on the bike seat and his other hand on [Kerry’s] back. After his push, [Kerry] began to pedal but [their] front wheel started to wobble. With [their] front tire wobbling, [Kerry] struggled to control [their] bike and then saw that [their] sister [name] was playing with her doll on the same bike path [they were] riding on. [Kerry] tried to turn [their] bike away from [sister] and her doll so [they] would not hit them. But [Kerry’s] bike was out of control and [they] began to worry that [they were] going to run over her doll. Dad saw that [Kerry] was out of control and yelled, “Brake [Kerry!]” and at the same time [sister] yelled, “Look out [Kerry!]” At the last moment, [Kerry] turned [their] bike toward the grass and stopped [their] bike, which kept both [sister] and her doll safe. Feeling relieved, [sister] bent down to pick up her doll as her dad ran to [Kerry] to say, “Good job for stopping safely!” [Kerry] feels pleased that [they] stopped [their] bike with out falling over and with out hitting [their] sister or her doll. When Dad, [Kerry] and [sister] finish playing at the park, they walked back home together.”

Description of Developmental Functioning

Artifacts presented in Figures 13 and 14 were first coded and analyzed using the developmental cognitive framework. Results from these analyses were categorized into findings related to linguistic, cognitive, and social-emotional domains.

Language Development. An analysis of end-point intervention artifacts revealed that during this phase Kerry made identifiable progress in using complex grammar, syntax, mechanics, and conventions of language to communicate their ideas. In the oral language sample, Kerry incorporated additional parts of speech into their summary of the story, such as adverbs ("all over", "fighting over") and precise pronouns to refer to specific people. Similarly, Kerry included additional parts of speech in their writing, such as appositives, phrasal verbs ("look out!"), and additional conjunctions. In addition, the writing sample provided evidence of more complex verb tense consistency, such as using the gerund phrase "…with [their] front tire wobbling" to depict multiple moments in time simultaneously. By incorporating additional prepositions and noun phrases that functioned as adjuncts of time ("one day," "at the last moment"), Kerry demonstrated their capacity for using a single sentence to depict multiple chronologies – an indicator of greater verb tense alignment and stronger fluency with time-based language (Fludernik, 2003).

In both the oral and written language samples, Kerry exhibited additional conventions of language to more clearly convey their imagined take on the stories in each artifact. For example, in the oral sample Kerry used coordinate adjectives ("new clean shirt," "chocolate flavored ice cream") to convey more precise descriptions. In the written sample, Kerry demonstrated more control over language mechanics by enjoining the grammar, syntax, punctuation, and functor words to complement each other in pursuit of a singular idea. Scholars observe that in order for writing to begin to sound more natural, children must learn to make a series of subtle adjustments to the mechanics of their language, which only occurs when feedback is provided by others and these refinements are able to be mentally processed by the individual (Underwood & Tregidgo, 2006). Composite evidence from end-point artifacts established that Kerry had made noteworthy growth in using more diverse and precise language to communicate their ideas (Saxton, 2017).

Cognitive Development. Evidence compiled from the end-point artifacts displayed advancements in Kerry's ability to sequence events into a logical order, portray more multi-faceted drawings and descriptions of environmental settings, and utilize more fine motor cognitive connections to more precisely display the sensory details comprising depicted visual symbols. Investigating the oral summary of the event-based picture portrayed in Figure 12 uncovered new cognitive strengths in Kerry being able to name identify five separate agents, assign distinct actions to each person, and mentally group these individuals together based upon their gender characteristics ("two girls", "two boys"). A different mixture of strengths and challenges was observed between the logical ordering of events in the oral versus written samples. The oral sample provided only rudimentary sequencing of ideas, resulting in separate events told sequentially without obvious connection between them. However, in the written sample Kerry demonstrated greater competence for displaying a progression of connected events, perhaps in part because they had the opportunity to work on this piece over multiple sessions and incorporate semantic refinement provided by the practitioner.

An analysis of the drawings in Figure 14 revealed a story with a clearly defined park setting that was accurately labeled with a signpost. These drawings showed more than just one representative sample of the setting, such as a single tree repeated over and over. Instead, as the family progressed through the frames, the drawings depicted new vantage points of this setting, indicating a more complex spatial awareness of how environments can be represented through multiple connected symbols (Cronin-Jones, 2005). Children demonstrating this capacity are thought to have entered the *landscape* stage of artistic development, where students use a set of symbols to carefully compose a balanced representation of a real place (Edwards, 2016).

Relatedly, this greater attention to detail was also seen in how Kerry consistently portrayed the agents in the written story, such as ensuring that the sister held a doll in the same hand during multiple frames, the dad figure was consistently recognizable due to the inclusion of a beard, and the characters were engaged in identifiable actions notated by the addition of arrows and swooshing lines. Evidence of these cognitive advancements in mark making showed developmental progress according to the orthogenetic principle. That is, Kerry portrayed increasingly complex concepts through the use of visual symbolization strategies that paralleled their cognitive development over time (Boyatzis, 2000; Werner, 1957).

Social-Emotional Development. Viewing the end-point artifact samples through the lens of social-emotional development revealed a mixture of new intellectual strengths and continued psychological challenges. In one instance of social-emotional evolvement, the figures presented in the drawing sample were portrayed in coordinated movements, thus suggesting a meaningful relational connection between these agents (Vygotsky, 1978). According to interpretive literature, as children develop they typically move away from random placement of humans in drawings and instead position them on the page to reflect a greater understanding of each figure's role in the whole depiction (Golomb, 2004). Evidence for this evolution was found in Kerry's drawing, where family members were grouped together with the father consistently taller than their children. These findings suggested an augmented understanding of symmetrical ordering and size relations and an overall advancement in Kerry's social-emotional development (Cherney et al., 2006).

Though the drawing artifact demonstrated social-emotional progress in organizing figures by meaningful criteria, evidence from Kerry's oral language sample presented in Figure 13 displayed psychosocial irregularity in interpreting the facial expressions of the characters in the event-based picture from Figure 12. Upon viewing the figures in the picture, Kerry described the two boys as "fighting to get ice cream," though a more conventional interpretation of the facial context clues might characterize this scene as one boy spilling ice cream on his own shirt and the other boy attempting to help him clean it up. This finding echoed previous characteristics from mid-intervention artifacts, where Kerry struggled to identify and portray facial expressions in a semantically accurate manner. In a potential interpretation of this finding, developmental literature has demonstrated that children who have experienced differences or interruptions in social-emotional development, especially those with autism, may struggle to correctly configure facial features together into a recognizable mental representation (Rump et al., 2009). This phenomenon speaks to the inherently intricate and complex trajectory of social-emotional development in that children may more quickly advance in some areas while continuing to struggle in others (Rubin et al., 1998).

Summary of End-Point Developmental Findings. A composite analysis of end-point artifacts through the developmental cognitive framework provided evidence that Kerry had advanced in numerous age-based milestones by this point in the timeline of the study. Aggregate developmental findings found multiple examples of Kerry utilizing grammar, vocabulary, sentence construction, and elements of descriptive writing more closely associated with children five- to six-years of age. For example, by age five or six many children begin to incorporate more complex verb tenses, such as past participles, and exhibit fewer errors in agreement between adjectives, nouns, and pronouns (Petty, 2016). At this stage adverbial conjuncts frequently appear (“if,” “so”), suggesting preliminary understanding of cause and effect (Saxton, 2017). Milestones during this stage also involve increasing the specificity of acquired vocabulary and using descriptive writing to convey a story with clearer sensory details (Ventura, Scheuer, & Pozo, 2020).

Cognitively, completing a 12-panel story required sustained, goal-directed attention (Akshoomoff, 2002). Creating such a lengthy and intricate artifact suggested an increased capacity to use the prefrontal cortex for functional behavior that could be associated with children five-years of age or more (Gallese & Lakoff, 2005). This finding coincided with greater evidence of imagination being used by Kerry to create increasingly elaborate drawings. Relatedly, by age five to six, children typically begin to categorize objects by similarities and differences, name or identify up to five people, and sequence four to six events in a story (Travers et al., 2009). This is accomplished through greater organization of thinking, which is in turn reflected in more complex language and drawings.

By age five to six, children begin to make leaps in their social-emotional development, typically resulting in the ability to draw a fully-formed person with eight or more body parts (Johnson et al., 1979). Similarly, children at this stage begin to become more aware of their own emotions and the emotions of others (Shaffer & Kipp, 2013). Both of these social-emotional traits were found in the drawings, though the bodies depicted in some frames were contorted in slightly unnatural positions and the faces of some characters exhibited simplistic representations of the complex feeling labels used to describe them.

Lastly, the manner in which Kerry portrayed and labeled themselves in the story evinced the complexities associated with the maturity of growing independent while still remaining connected to a family unit. For example, the main character asked for their father to let go of their bike and ride unassisted, but soon after this occurred they felt out of control and made efforts to avoid destroying the doll of their little sister. These dualistic qualities between the push and pull of independence are frequently associated with children who are entering the middle childhood stage of social development, often experienced around five or six years of age (Meleis, 2010). In all, much evidence was accumulated of a social-emotional advancement to a five to six level of development more closely associated with the emergence into a high preoperational/low concrete stage of social-emotional development (Olson, 2011).

Much composite evidence was found of developmental advancements in Kerry's development from the mid-intervention to end-point intervention sessions. As presented from the developmental cognitive framework, Kerry during this time had even brushed with moments of exhibiting emerging concrete levels of language, cognitive, and behavior (Halliday, 1976; Meilinger & Vosgerau, 2010). However, despite these augmented moments of intellectual progress, overarching findings from the end-point phase suggested that Kerry still functioned within the preoperational stage of development. Comparing Kerry's progress at the time of intake against a priori expectations culled from the developmental cognitive framework suggested that Kerry functioned at a level that most closely matched developmental milestones associated with the six-year-old level of language development, five-year-old level of cognitive development, and six-year-old level of social-emotional development, respectively (Halliday, 1976; Johnson et al., 1979; Meilinger & Vosgerau, 2010; Olson, 2011; Shaffer & Kipp, 2013).

Description of Language Function

Artifacts presented in Figures 13 and 14 were also coded and analyzed using the learning function cognitive framework. Results from these analyses were categorized into findings related to linguistic, cognitive, and social-emotional domains.

Language Function. In comparison to the pre-intervention and mid-intervention artifacts, evidence contained within Kerry's end-point oral language sample exhibited a notable increase in the quality and quantity of spontaneous language used by Kerry to describe events. In particular, the oral language sample included greater functional use of linguistic qualifiers, or words added to another word to modify its meaning, in the examples of “other girl” and “young girl” (Meunier & Granger, 2008). In addition, this sample contained linguistic quantifiers, or words used to denote something belonging to a set, in the phrases “the two girls” and “the two boys” (Meunier & Granger, 2008). Despite this progress, Kerry’s oral language also remained overly redundant at times in using more words than needed to describe the event, as well as by repeating the interjection “well…” multiple times to fill gaps in their oral language (Hockett, 1960). This excess of redundancy in Kerry’s oral language functioning suggested that Kerry continued to struggle with the efficiency of their language, which was also reflected in the lack of semanticity used to reply to basic constituent questions (Arwood, 2011). As described during previous intervention phases, Kerry appeared to continue to exhibit a gap between their oral language function and that of their drawing and writing. Literature indicates that this finding is common for individuals like Kerry who form ideas using a visual symbolizing system, as these latter modalities may better allow for clearer and more succinct expression of ideas (Green-Mitchell, 2016).

Additional evidence contained within Kerry’s end-point drawing and writing sample portrayed examples of stronger language function in that the dialogue between the main characters sounded natural and appropriate for the context. These samples also featured an increased proficiency in modulation, as seen in the use of morphemes such as “the,” “at,” and “to” to complement more foundational concepts in the story

(Humphries et al., 2006). End-point artifacts also displayed an increase in relational language, also referred to as "because" language, or language that is used to describe the reasoning behind one's actions (Gentner et al., 2009). One example of this could be seen in the phrase "…so he would not hit [them]," a subordinating clause depicting cause and reason. Over time, children demonstrate greater capacity for relational language by using visuals in context to explain an idea or event, and by meaningfully connecting the actions of people to the words used to describe them (Arwood, 2011; Bruner, 1975). Evidence for advancement in this type of relational thinking and language could also be seen in the end-point drawings, which contained logical explanations for the actions of each character (Farokhi & Hashemi, 2011). Relatedly, an increase in the use relational language has also been described as a hallmark of increased cognitive functioning, in that these two processes form a positive feedback system in the brain where one operation influences the other through neurobiological learning over time (Gentner & Christie, 2010). In all, end-point artifacts suggested that Kerry experienced a multitude of advancements in their language functioning during this phase.

Cognitive Function. Findings from analyzing Kerry's depiction of both real and imagined events in the end-point artifacts uncovered a higher level of cognitive flexibility, in that Kerry's language was used to problem-solve challenging life events and propose potential solutions (Arwood, 2011; Halliday, 1976). Evidence for this could be seen in the methodically drawn depiction of the family's bike ride through the park, which can be assumed was a troubling event for each of the characters involved. Cognitive problem solving through drawing is thought to arise from the need to create a visual context to help individuals process what to do when not enough meaningful information was initially provided during the event (Arwood & Brown, 2001). Specifically, the use of Viconic Language Methods, such as drawing concepts in real time, has been shown as a high-context modality that can help visual thinkers translate auditory properties of English that were not acquired through the act of listening alone (Arwood et al., 2015). Scholars observe that this capacity for visual thinking often emerges during middle childhood when children are eager to share their visual stories with the adults in their lives to receive alternative perspectives (Olson, 2011).

Similarly, the drawing and writing artifacts showed marked progress towards passing the hallmark of functional dependency in included semantic relationships, meaning that these modalities carried enough semanticity for Kerry to use them to functionally learn and think (Athey, 2007). Children are thought to develop the capacity to use drawing and writing as viable methods for communicating their thinking when the ideas depicted in either modality can stand on their own, as well as in conjunction with each other (Arwood, 2011). Evidence for progress towards this cognitive hallmark could be seen in how each frame of the drawn sample contained enough details so that the reader could intuit what would happen next. Similarly, the written ideas semantically matched these drawings. By including enough visual contextual clues, the drawings at this time began to function like storyboards from a movie – also referred to as representations of visual thinking (van der Lelie, 2006). These end-point artifacts displayed evidence of drawing being a semiotic activity for Kerry, in that it contained a conceptual representation of events and held meaning for both the artist and observer (Kress, 2003). Drawings and writings become semiotic for the learner when meaning is assigned in a modality that matches their visual neurobiological learning system (Jaskowiak, 2018).

Though the oral language sample displayed some inconsistencies in aligning verb tenses to correctly portray the passage of time, the drawing samples provided greater evidence of Kerry projecting their temporal thinking into the future to consider multiple possibilities of what might happen (Humphries et al., 2006). For example, when the main character sees the doll lying on the ground, they utilize thought bubbles to anticipate the unfortunate event of running this over with their bike. This action was labeled "the future," and was connected via arrows to the potential future where Kerry "will fall" off their bike. Similarly, the sister character also thought about these future scenarios. These findings showed Kerry beginning to recognize that the future is not yet set in stone, and that through one's actions they may alter the course of events to come (Erikson, 1968). This finding also demonstrated Kerry's stronger capacity for positioning themselves spatially within sequences of time, in that the functional relationships between the temporal landmarks in each drawing frame were presented more clearly to the reader or observer (Núñez et al., 2006). Composite end-point artifacts displayed notable growth in Kerry in using more complex cognition to function in the world around them.

Social-Emotional Function. An analysis of end-point artifacts revealed a mixture of social-emotional progress and challenges on behalf of Kerry in identifying the roles that agents play in relation to a shared event. For example, processing the scenario that occurred in Figure 12 required a higher flexibility function in thinking literacy, as the scene portrayed five separate agents all engaging in different actions (Bruner, 1975). Kerry was able to name each of these individuals and label their actions as well as identify which agents were involved with the main tension in the story. The fact that Kerry spent greater amounts of time discussing these main agents suggested that they had begun to more strongly perceive the sensory features inherent in the figure rather than the background – a capacity for internalizing the figure-to-ground in representational art (Lambert, 2009). Acquiring the capacity for the brain to discriminate between what is foreground and background within an image has been described as a critical step for one's mind to begin assigning meaning to the shapes of objects and people (Rubin, 2001).

On a similar note, during this phase Kerry appeared to be attuning more proficiently to the visual shapes that were provided to them as word-patterns. As discussed, this increased proficiency in visual literacy could reasonably be attributed to the efforts of the practitioner working with Kerry to help them attune to these word shapes and assign conceptual meaning to these patterns (Arwood, 2011). From the perspective of the brain, acquiring visual literacy through these kinds of visual modalities requires the visual cortex to be able to discriminate which aspects of visual stimuli are 'marked' and therefore hold meaning versus which elements are non-essential background (Potter, 2012). Kerry's increased proficiencies in these socio-cognitive processes indicated that their brain was now efficiently processing the shapes and movements of drawn concepts, as well as beginning to observe more complex semantic relationships among individuals within a drawn reference (Arwood, 2011).

Despite these gains in visual thinking, some challenges in social-emotional functioning were still discerned, such as the fact that Kerry did not specify how the characters depicted in Figure 12 were semantically related. This omission potentially indicated Kerry's continued struggle to conjoin provided figures based upon a set of relationships that might be more obviously discerned by typically developed children (Farokhi & Hashemi, 2011). In another example of Kerry's struggles to discern the intentions behind drawn characters' actions, the main boys in the oral sample were described as "fighting over ice cream," though the provided facial context clues indicated otherwise. This facial misinterpretation also indicated further lagging social-emotional difficulties for Kerry. According to developmental scholars, the concept of fighting is less socially advanced than the concept of sharing, as it suggests competition for limited resources and an egocentric perspective (Hartrup, 1996).

On the other hand, additional evidence from end-point artifacts documented some of Kerry's progress in adapting facial features to represent a higher level of social thinking (Dosman et al., 2012). For instance, in the drawing sample all three figures changed their facial expressions to appropriately match the context of the scenario happening in each panel. Moreover, a wider variety of drawn facial expressions were used. This finding showed some evolvement in Kerry's scaffolding towards increased social-emotional literacy (Cohen, 2001). In addition, the depiction of multiple mental pictures of the father character suggested the emergent literacy function of viewing others' thinking, also referred to as perspective taking (Arwood, 2011; Cooper, 2006). Despite this, some of the thinking bubbles in the drawings were left empty, reflecting either an unfinished drawing or latent struggles in frame of reference relativity (Levinson, 2003).

Lastly, evidence from Kerry's oral language also displayed a more advanced understanding of referent functioning in social contexts. For example, by orally stating, "I made a mistake" in an aside to the practitioner, Kerry engaged in a conversational milestone associated with the semantic refinement of their own thinking. More specifically, in amending their language to reflect greater clarity, Kerry utilized the speech act of self-repair, or altering one's oral language so that it is more understood by the listener (Schegloff et al., 1977). Such an act demonstrated an increase in social pragmatics, or the unspoken rules that guide oral conversations (Arwood, 2011; Prutting, 1982). This finding also suggested an increase in the event-based-picture becoming a shared referent between Kerry and practitioner, indicating a greater functional understanding of the social purpose of drawing (Arwood, 2011; Todisco et al., 2020). Overall, evidence contained within end-point artifacts showed a mixture of social-emotional progress and challenges, yet nevertheless demonstrated clear gains in shared-referent function, facial emotion recognition, social-emotional literacy, and understandings of social pragmatics (Arwood, 2011; Cohen, 2001; Prutting, 1982).

Summary of End-Point Language Function Findings. A composite analysis of end-point artifacts through the learning cognitive framework demonstrated that at this point in time in the study Kerry had begun to develop their capacity for using the deep structures of language to think and problem solve (Dore & McDermot, 1982; Vygotsky, 1962). Evidence for this was found in Kerry's use of "because" language within the samples, a turning point in cognition where children begin to understand that actions have consequences (Taylor, 1985). Notably, children age five to six still require adult assistance to deepen their conceptual understanding of cause and effect, which if nurtured often serves as a precursor to further self-refinement and eventually thinking on one's own (Berko, 1958; Vygotsky, 1962). End-point artifacts indicated that Kerry had initiated this quality of thinking during this phase.

Through the language lens, Kerry's advancement in their social and pragmatic problem-solving capacities was also observed in the shift that occurred within their use of language from merely using borrowed language structures to an overall increase in visually-based thinking modalities to represent a stronger composite of language functioning (Arwood, 2011; Xiang-Lam, 2016). Overarchingly, Kerry's progress in using the visual modalities of drawing and writing continued to outstrip their proficiency for using oral language to represent their cognition. This phenomenon resulted in a gap between Kerry's oral and visual communication that was most clearly evident in how Kerry continued to struggle to use oral language to sufficiently interpret and summarize the story contained within Figure 12. In all, a much stronger global profile of language functioning was discovered in Kerry's written and drawn samples rather than in their oral language.

Viewing the end-point artifacts through the lens of social thinking uncovered additional insights into how Kerry had evolved to use drawing as a meaningful communication medium to understand complex social situations (Cohen, 2001). For example, by age five or six many typically developed children have internalized sufficient understanding of social pragmatics to use language as a tool for describing stories and events from their lives with greater detail (Fernández, 2013). For Kerry, evidence for meeting these age-based expectations was found as drawing and writing became a tool to represent cognition slowly over time. Indeed, the drawn and written narrative contained within Figure 14 portrayed evidence of Kerry using their drawings to show rudimentary understandings of cause and effect. For example, the drawn narrative contained a primitive chain of events and some plot and organization of time. Despite this, the story did lack a high point or resolution, thus suggesting that Kerry's understanding of cause and effect was attenuated in some aspects (Sax & Weston, 2007).

The use of drawing and writing as a tool for Kerry to understand social pragmatics further extended to the manner in which Kerry included multiple types of semantic relationships within their language usage. For instance, Kerry's use of relational concepts frequently provided enough necessary context for the reader to understand the majority of their intentions (Golomb, 2004). Examples of these new types of semantic relationships within Kerry's language included the use of additive ("…and his daughter"), temporal ("…then his dad gave him a good push…"), causal ("so he would not hit them…"), and contrastive ("but his front wheel began to wobble…") semantic functions (Sax & Weston, 2007).

Socially, Kerry exhibited certain actions associated with five-to six-year-old behavior such as typified in their acknowledging the need to make a conversational repair with the practitioner during their conversation ("I made a mistake"). Similarly, Kerry demonstrated certain advanced social pragmatics associated with children of this age range including using some deictic terms, or terms used to denote the perspective of the speaker such as “this,” “that,” and “here” (Sax & Weston, 2007). Though these actions still fell within the parameters of preoperational socialization, such behavior frequently precedes the start of perspective taking associated with allocentric or concrete social thinking (Meilinger & Vosgerau, 2010).

Although Kerry did exhibit progress in understanding social pragmatics during this phase, certain social-emotional limitations were still observed. For example, by age seven many children’s ideas are able to be understood by the listener or observer without requiring a great deal of interpretation (Fernandez, 2011). Composite evidence within Kerry’s oral, drawn, and written language samples during this period showed that many ambiguities still existed in their language that necessitated guesswork on behalf of the reader; thus, it appeared that Kerry’s progress in this social-emotional capacity fell short of the aforementioned age-based hallmark.

Moreover, though some characteristics from the artifacts showed social progress, other aspects such as misinterpreting facial clues revealed extant evidence of restricted social thinking. Because emotions are formal concepts, correctly understanding how humans display feelings through facial contortions is a highly scaffolded process thought to begin at birth (Arwood, 2011; Elliot & Jacobs, 2013). It appeared that Kerry still required a substantial amount of meaning to be assigned to their actions for them to acquire higher-order levels of pro-social thinking (Arwood & Young, 2000).

Composite evidence from end-point artifacts demonstrated that by this point in the study Kerry had begun to acquire the capacity to use language to function in increasingly complex ways. As previously described, this finding indicated that Kerry had begun to learn at a level that surpassed the mere input-output processes that characterized pre-intervention samples. End-point artifacts demonstrated a stronger mixture of conceptual understanding of a wider range of semantic, pragmatic, temporal, and relational concepts. Research from neuroscience, language, and psychology has established that such increases in life functionality only occur when the brain can acquire new meaning in an efficient and long-lasting manner (Doidge, 2007). Put another way, evidence from the end-point of the study exhibited that Kerry began learning in a way that they could 'take with them' into next contexts, meaning that semantic knowledge was not situation-specific (Harel & Koichu, 2010). This kind of learning is represented in the brain's neuronal networks, in which one's natural language function is strengthened over time by successfully conducting oneself in multiple environments (Pulvermüller, 2013). Learning that engages all parts of the brain, including the prefrontal cortex, becomes integrated into existing circuits and networks in ways that have been shown to lead to longer-term retention and language functionality (Arwood, 2011; Pulvermüller, 2013).

In sum, the mixture of progress in linguistic, cognitive, and social-emotional functioning appeared to align with the principle that the process of learning is socio-cognitive, and that advancement in thinking does not follow a linear progression, especially in individuals who have been impacted with developmental disabilities (Arwood, 2011; Lucas, 1981; Pulvermüller, 1999). Though Kerry made much notable progress in their learning over time, overarching findings demonstrated that at the end-point of the study Kerry still exhibited restricted language and thinking. Age-based estimates of functioning in each domain suggest a six-year-old level of language function, a five-year-old level of cognitive function, and a six-year-old level of social-emotional function (Arwood, 2011; Berko, 1958; Fernandez, 2011; Sax & Weston, 2007; Taylor, 1985).

Findings from Practitioner's Clinical Impressions

Coding the clinical notes taken by the practitioner during the mid-to-end point sessions revealed additional insights into how they specifically worked with Kerry to cultivate many of the cognitive and linguistic advancements seen in the end-point artifacts. For example, the practitioner memoed that they frequently wrote verbatim on paper the words and phrasing that Kerry orally shared in conversation so that Kerry could "see" how those phrases sounded when read back aloud. This was done purportedly to provide Kerry with the kind of visual input that their learning system could process; namely, the visual shapes that the words meant conceptually when attached to drawn representations (Green-Mitchell, 2016; Rapp et al., 2016). This Viconic Language Method 'pictographing' has been described as a way to attach visual semantic meaning to the auditory modality of oral language, which Kerry had not used successfully throughout their life in order to learn conceptually (Robb, 2016). Additional examinations of multiple Viconic Language Methods are provided in Chapter 5.

After providing multiple types of visual semantic refinements during their sessions, the practitioner observed that Kerry began to orally express and write out their ideas in a "different, more developmentally appropriate" manner. Part of this process involved the practitioner identifying what language was "borrowed" versus what was "authentic," with the borrowed phrases requiring significant clarification to arrive at Kerry's original intent. At this stage, Kerry was described as "learning very well," but "require[d] many layers of drawings before [they] would write on [their] own." Some of these layers included adding additional visual elements to Kerry's drawings in order to show transitions between ideas as well as the passage of time. According to the Neuro-Semantic Language Learning Theory (Arwood, 2011), learners require multiple layers of meaningful perceptual patterns to overlap in the brain to scaffold to a semantic understanding of a concept. The structure of the brain itself neurobiologically matches this layering, where higher-order thinking and language is represented by the uppermost layers of the cerebral cortex and spread downwards to other regions of the cerebrum (Baars & Gage, 2010). Functionally, increasing the efficiency and complexity of these pathways through learned experiences has been shown to lead to longer-term retention of semantic memory (Duffau et al., 2014). These neurobiological facets of the brain's functionality would appear to align with the practitioner's observation that Kerry required multiple types and layers of sensory input before they could write their own semantic ideas.

In the end-point phase notes the practitioner observed that Kerry began to considerably increase their attention span, resulting in them remaining "engaged" during many of the drawing and writing sessions for "up to three hours at a time." The concept of student engagement is frequently associated with cognitive psychology where adults use theory of mind to describe the behavior that children exhibit and attribute this behavior to individualized choices (Siegler, 2002). Through the language function lens, however, engagement only occurs when the brain can attune to sensory input that is meaningful – namely in this case the providing of visual-based input modalities during intervention (Xiang-Lam, 2016).

Similar to their observation of Kerry's increased academic engagement, the practitioner also memoed that Kerry "[began] to think more about advanced concepts," and "moved faster" to classify and understand the relationships between agents and actions in the provided event-based pictures. Halfway through the end-point time period these innovations in Kerry's cognition culminated in a description of Kerry being able to "write a story from memory" after only seeing a provided picture for a short period of time. As Kerry thought with a visually symbolizing system, this finding suggested that Kerry's mental pictures began to complexify in increasingly precise and intricate ways (Arwood, 2011; Ismael, 2015).

At least once a week during this time period, the practitioner worked extensively with Kerry to help them understand the concepts of numbers and time, and how these two constructs were meaningfully interrelated. At first, Kerry did not understand that numbers could be added together, so Kerry drew out simple calculations visually. When time was reconceptualized as taking up various quantities of space, referred to as "the space of numbers," Kerry began to understand that "every number on the clock equals something counted." As the sessions progressed, Kerry became able to add one, and then two-digit numbers together, leading to rudimentary comprehension of the concepts "less," "more," a "day," a "month," and "today." These newfound skills helped Kerry realize what a "bedtime" was, as well as how they could be "late" for going to sleep or arriving at school. These cognitive progressions matched the learning trajectory described earlier of reconceptualizing time as events connected spatially and sequentially (Grondin, 2010). As previously stated, the auditory learning system is set up in the brain to process acoustic features of time temporally, which Kerry did not appear to attune to; but, the visual system is arranged spatially to form visual images through visual-movement sensory input, thus allowing for these concepts to be displaced and expanded (Núñez et al., 2006).

Socially, the practitioner's memos echoed the aforementioned finding of Kerry interpreting the facial expressions of the agents in the event-based pictures in atypical ways. According to the practitioner, Kerry "kept drawing [*their*] developmental level, and not the developmental level of the characters in the story," resulting in the practitioner needing to provide many layers of drawings in order to refine these concepts. Put another way, the practitioner realized that for Kerry to see the emotions of others, a plethora of social concepts would need to be communicated via visual modalities. To help with Kerry's overall social-emotional functioning, the practitioner described needing to draw out extensive visual representations of many formal social-emotional concepts including: stages of social development, how to show affection and appreciation, being at fault, social norms/niceties, why to be nice to others, how to be a friend, asking for permission, taking responsibility for one's own actions, hygiene, stealing, and many more.

As presented, each one of these social concepts listed by the practitioner are vastly complex and intricate, and thus by nature cannot be easily understood without a sufficient scaffolding of content from basic to more advanced understandings (Arwood, 2011; Elliot & Jacobs, 2013). Indeed, research from neuroscience has confirmed that emotions are formal concepts that can only be acquired neurobiologically over time through the scaffolded socio-cognitive processes of learning (Vigliocco et al., 2014). Specifically, individuals acquire deeper capacity for social-emotional understanding by using their own functional language to meaningfully interact with others in their lives, where previously acquired concepts overlap to create new schemas in the mind (Pulvermüller, 2013; Rostamizadeh, 2009).

The outcomes of working to refine these social-emotional concepts resulted in a mixture of progress and challenges for Kerry. On one hand, Kerry was described as "doing better with social agency" in that they "acknowledged" the rationale for some social behaviors such as not biting others, apologizing to peers after hurting their feelings, and making efforts to "fit in" among social groups at school. On the other hand, Kerry was noted as continuing to "drop" developmental levels from time-to-time, resulting in them acting "like a three-year-old" on occasion. Examples of these behaviors included: spitting during sessions, pushing peers at school, blaming others for their actions, saying inappropriate or hurtful things to others at school, describing themselves as "lazy," engaging in disturbing behavior with toys at home, and other events.

Much literature has provided context for better understanding these social findings. Because scaffolding towards an understanding of social concepts takes much time, children continuously vacillate between progress and regression as they develop their social agency (Meilinger & Vosgerau, 2010). Thul (2019) further explains that individuals perpetually rise and drop between levels of language functioning as they acquire the capacity for pro-social thinking over time. Jaksowiak (2018) adds that raising expectations for social thinking to too advanced a level, such as by referencing unfamiliar or displaced concepts in discussions, can also lead to drops in social-emotional functioning as the learner cannot process what is expected of them in the moment. The social-emotional findings of Kerry written by the practitioner illustrate the axiom that the act of learning in the brain follows a spiral, where new information connects to older acquired information and continuously challenges the learner to redefine their apperception of the world around them (Arwood, 2011; Ismael, 2015). Acquiring social-emotional concepts in particular has been described as a lengthy process that often poses a challenge for individuals like Kerry who enter into young adulthood already having displayed evidence of restricted social thinking (Arwood et al., 2018; Jaskowiak, 2018).

In sum, the finding that the practitioner spent significant amounts of time in sessions working with Kerry on many of the happenings found in the end-point artifacts suggested that developmental progress on these concepts appeared to be directly linked to these particular Neuro-Education based interventions. Moreover, the linguistic, cognitive, and social-emotional progress outlined by the practitioner in their clinical impressions mirrored in many respects the developmental trajectories that young children frequently experience once they have begun to assert more of their independence (Meleis, 2010). For example, developmental scholars observe that children frequently resolve during middle childhood many of the social-emotional complexities that Kerry drew about with the practitioner (Olson, 2011). Children at this stage frequently test the boundaries of the adults in their lives, requiring increasing amounts of social feedback to understand why rules and norms exist (Shaffer & Kipp, 2013). During this process, children may revert back to less mature behaviors in an attempt to regain control over their realities and react against changes in life they do not yet comprehend (Cook-Greuter, 1985). In all, overall findings from the practitioner's case notes during the end-point period complemented earlier mentioned results and added additional awareness to Kerry's progression through growth and struggles. Though Kerry remained predominantly situated within the preoperational level of development at the terminus of the end-point phase, some glimpses were also found of Kerry beginning to push further into a concrete understanding of the world around them (Meilinger & Vosgerau, 2010).

Summary of End-Point Intervention Findings

Coding and analyzing the artifacts selected in this chapter that Kerry created during the duration of this study yielded a multitude of insights about how their learning and development changed over time. Though substantial progress was observed on behalf of Kerry between the mid and end-points of the study, overall results showed that at this time Kerry still functioned at levels that were significantly delayed below their chronological age. Tables 6 and 7 display the levels of development and language function that Kerry was exhibiting when the end-point artifacts were created. Both developmental and language function findings indicated an approximate 12- to 13-year gap between expected developmental function and documented abilities at the end-point of the study. More analyses regarding the significance of these findings are presented during the conclusion section of this chapter.

Table 6 displays a summary of end-point findings through the developmental framework.

Table 6

Summary of End-Point Developmental Findings

Development Framework			
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-Mechanics of written language convey ideas with natural precision -Single sentence presents multiple temporalities -Oral language exhibits more thorough summary of picture	-Mental groupings of people by classified categories -Drawings convey clear environmental setting with multiple contexts -Orthogenetic advancement reflected in attention to detail	-Meaningful semantic connections shown between drawn agents -Family members “fitting in” to explicit roles -Psychosocial irregularity of understanding facial expressions
Evidence from samples	-Additional adverbs, conjunctions, appositives, phrasal verbs used -Gerund phrase depicts time: “…with [their] front tire wobbling.” -Recounts complex story with actions of four separate individuals	-Gender characteristics observed: “two boys,” “two girls.” -Park settings shows more than one representative sample -Sister and dad figures identifiably presented from frame to frame; clear actions portrayed	-Family depicted in coordinated, cooperative movements -Symmetrical ordering in size relations among agents -Mistakenly interprets accidental spilling of ice cream as purposeful “fighting” between brothers
Practitioner impressions	With feedback, began to phrase ideas in a “different, more developmentally appropriate” manner	Increased attention span; drawing and writing “up to three hours at a time.”	Kerry “kept drawing [their] developmental level, and not the developmental level of the characters in the story.”
Developmental/ Functional stages	-Preoperational development -Landscape artistic stage	-Preoperational development -Landscape artistic stage	-Preoperational development -Landscape artistic stage
Estimate of developmental age	6 years old	5 years old	6 years old

Table 7 displays a summary of end-point findings through the learning framework.

Table 7

Summary of End-Point Learning Findings

	Learning Framework		
Domain	Language	Cognition	Social-Emotional
Defining characteristics	-Increase in quantity and quality of spontaneous oral language -Depicts dialogue natural sounding and appropriate for context -Expansion and extension of relational language	-Cognitive flexibility to problem solve and propose solutions -Drawing and writing functionally independent -Visual thinking displaced forwards/backwards in time	-Greater figure-to-ground capacity in identifying characters and actions -Mixture of progress on understanding complex emotions -Amended language for sake of interpersonal clarity
Evidence from samples	-Linguistic qualifiers (“young girl”) and quantifiers (“the two boys”) -Morphemes and functor words work to help flow of expression -Clause “… so he would not hit [them]” depicts cause and effect	-Methodical depiction of avoiding running over sister’s doll -Multiple communication modalities function both separately and in tandem -Sufficient context between drawing panels to facilitate understanding and predict what happens next	-More time spent speaking on actions of main (versus auxiliary) characters -Drawings convey understanding of repertoire of emotions; oral language does not -“I made a mistake” shows speech act of self-repair
Practitioner impressions	“I had to write what [Kerry] orally shared so [they] could ‘see’ the ideas.	“[Kerry] required many layers of drawings before [they] would write on [their] own.”	“[Kerry] is doing better with social agency…” and acknowledged the rationale for some social norms.
Developmental/ Functional stages	-Preoperational language -Preoperational development -Restricted language function	-Preoperational language -Preoperational development -Restricted language function	-Preoperational language -Preoperational development -Restricted language function
Estimate of functional age	6 years old	5 years old	6 years old

This concludes the retrospective document analysis portion of this study. The results from coding and analyzing the semi-structured interview that was completed with the practitioner are displayed next.

Results from Practitioner Interview

Engaging in the document analysis methodology uncovered numerous salient findings contained within Kerry's case file that helped identify the impact that Neuro-Education intervention methods had upon their learning and development over time. Though these results contained much valuable information, they were notably constrained in their epistemological significance to findings only situated in the past. To provide for an additional perspective upon the data, one semi-structured interview was conducted with the practitioner who had provided intervention services to Kerry over the two-year time period measured for this study. Data from this interview were coded using a two-cycle inquiry process, beginning with open coding leading to theming the data (Saldaña, 2015). These two rounds of coding were then compared for consistency.

Results from this interview illuminated new findings upon the practitioner's clinical impressions of Kerry before, during, and after the two-year intervention began. In addition, the practitioner provided multifaceted rationale for why they utilized the intervention methods that they did. These impressions provided for a greater triangulation of findings from the data than using the document analysis methodology alone. The following section summarizes the results from this interview.

Initial Impressions

When describing their initial impressions of first meeting the participant during the intake process, the practitioner described Kerry as an individual who did not socialize with others but instead “zoned out” in their “own little world.” During these mental lapses, Kerry “self-stimmed” repeatedly with multiple objects, such as a ball of string that they carried around everywhere. Of note, individuals who have impacted learning systems have been described in the literature to engage in the act of self-stimulation when their brains cannot meaningfully process the stimuli occurring in the environment around them (Smith, 2009). This behavior occurs frequently in individuals who have autism and has been hypothesized to reflect the low level of processing that they are experiencing in the moment (Boyd et al., 2012).

According to the practitioner, Kerry did not hear others when they spoke and never demonstrated awareness that others were speaking about them. Kerry was described as a childlike individual in an adolescent’s body who simply “existed,” as if they were floating through life. The only way to get Kerry’s attention during these early sessions was to physically rouse them, such as by tapping their shoulders. Relevant literature describes that the use of touch alone does not provide a meaningful pathway for long-term learning; nevertheless, it can still excite arousal of the lower-level sensory cortices thus priming an individual to devote attention to the stimulus (Bauer et al., 2012). The practitioner described that Kerry did not sleep well most nights and in turn relied on this tapping strategy to rouse Kerry’s attention when they had gotten fatigued during sessions.

The participant observed that Kerry could “word call,” or orally say words out loud; yet, these words appeared to hold no meaning for Kerry. The practice of word calling stems from a psycholinguistic approach to teaching literacy (Kelley-Hortsch, 2018), where children learn to sound out words using phonics-based methods. This practice is thought to impart the meaning of the word into long-term memory (Ensar, 2014). Though this practice is commonly used in schools (Betts et al., 2009), research has demonstrated that such auditory stimuli alone frequently does not lead to long-term learning among visual thinkers (Diaz et al., 2009). The practitioner concluded that reading out loud did not appear to lead to much meaningful processing of provided sensory input.

On a related note, the practitioner noticed additional “red flags” regarding Kerry’s language acquisition, such as the fact that they could not process oral language or hold even a rudimentary oral conversation. These observations coincided with the determination that Kerry appeared to have “very low” levels of thinking during their first few months at the clinic. During these early sessions, the practitioner shared, it was “very, very difficult to get [Kerry] to engage with learning.” Up until this point, Kerry had only experienced conventional forms of teaching interventions that utilized auditory-based modalities for instruction. The practitioner hypothesized that these types of conventional education approaches had not led to Kerry acquiring sufficient academic content during their childhood. Thus, the practitioner felt tasked with re-framing Kerry’s relationship with learning, which itself took time.

The practitioner volunteered additional insights regarding Kerry’s education prior to beginning Neuro-Education intervention sessions, as well as hypothesized about how Kerry’s past may have contributed over time to the developmental differences witnessed during intake. Before enrolling at the clinic setting of this study, Kerry's family had enlisted them in numerous treatment programs that, according to the practitioner, all shared the common focus of "working exclusively on patterns" in order to help children develop. Examples of such patterns included "input-output" type activities, such as imitation-repetition exercises or filling in worksheets. These treatment programs stemmed from the "behaviorist or 2-tier model of learning." According to the practitioner, these types of treatments only engaged "low levels of [Kerry's] brain," and did not "intellectually stimulate" Kerry sufficiently enough for long-term growth or intellectual changes to occur. Because these programs did not empower Kerry as a learner, the practitioner recounted, Kerry's brain had not been engaged and may have "lost pieces" of structural biology over time. It was hypothesized that this lack of neurobiological activity throughout Kerry's childhood may have resulted in the kind of atrophy seen in older individuals who are later found to possess brain abnormalities.

Rationale for Provided Interventions

As discussed, the practitioner deciphered that Kerry's neurobiological system did not process auditory input in a manner that allowed them to learn beyond a pattern-based level. In addition to this observation, the practitioner also quickly realized during early sessions that Kerry's learning system did not process visual input streams when they were provided in isolation, such as attempting to view a pre-made drawing or a static photograph. Though Kerry did think with a visual symbolizing system, they nevertheless struggled to make meaning from static images alone. In fact, Kerry's visual processing during this time was described by the practitioner as "so low, that it was as if [they] didn't see pictures at all." One notable exception to this finding was that Kerry could indeed see and speak about visual objects if they had directly experienced them, such as by conversing about a character from a movie if they had already watched the film in the past.

In explaining these phenomena, the practitioner referenced that not all visual thinkers will be able to look at a provided picture and take ample meaning off the page. Diving deeper into this finding through the lens of academic theory provides further perspective on the issue. Literature explains that images exist on a spectrum of accessibility for the brains of visual symbolizers depending on how much semantic context they provide and how much of a cognitive load they require the mind to process (Lu et al., 2010; Xiang-Lam, 2016). The brain 'sees' in two-dimensions, meaning that the eyes only take in rudimentary 2-D information which is later reconstructed in the visual cortex as consisting of additional dimensions such as depth, contour, or color shading (Livingstone & Hubel, 1988). For this reason, simple ink images drawn on a white paper require less cognitive translation in the brain between the raw data of the original source material and what this data conceptually represents (Arwood, 2011). More complex images, such as detailed drawings or photographs, contain an embedded amount of complex visual stimuli thus requiring the learner to have acquired the background knowledge to understand the content. Put another way, the brain can only 'see' what it has acquired language for. This may explain the practitioner's observation that Kerry did not 'see' images unless they were created at a level to match their current development and they were semantically unpacked by assigning layers of meaning to the content in real-time (Xiang-Lam, 2016).

At this point in the intervention, the practitioner understood that in order for Kerry to learn and develop they would need to "move beyond pattern-based academics." This would "require [Kerry] to begin thinking on [their] own." The first step on this path involved creating a visual context, such as an event-based picture, that could be shared so that both individuals could reference the same source material. In some children, providing an event-based picture is sufficient for them to begin engaging in intervention. However, because Kerry's brain could not process such visual input on its own, the practitioner understood that they would need to add in additional "meaningful layers" of neurobiological input so Kerry could begin learning again.

According to the practitioner, Kerry required "motor-motor" neurobiological input in order to learn. In Neuro-Education theory, motor-motor input refers to multiple movement-based learning actions occurring simultaneously, such as when an educator holds a child's hand and concurrently draws a picture (Arwood, 2011; Arwood & Merideth, 2017; Kiefer & Pulvermüller, 2012). In this example, two movement-based modalities occur simultaneously: (a) the movement of the hand and (b) the movement of the pencil on the page making dynamic shapes. The phenomenon of movement translating into meaningful connections within the brain was described by the practitioner who stated, "I needed to do some movement [like writing] and do something else motor on top of it," such as the movement of Kerry's hand. "The only way [Kerry] could process anything was if [they] moved [their] hand."

The practitioner continued that at first "all communication [between the practitioner and Kerry] was written hand-over-hand" during their sessions. During this time, Kerry required all input to be provided through the hands. Over time as Kerry began to demonstrate more cognitive awareness during sessions, the practitioner began to add in additional “visual-motor” instructional modalities, such as sitting at such an angle that Kerry could see the practitioner’s mouth move. The difference between “motor-motor” and “visual-motor” is that the eyes can also perceive movement-based input when it is provided in an intentional manner (Mostofsky & Ewen, 2011). The practitioner further explained that when the human mouth moves to speak it creates a series of visual shapes. As humans mouth each word, these shapes move dynamically from one position to another, thus creating visual-motor movement (Woodhouse, Hickson, & Dodd, 2009). This process allows for two sensory inputs to be used simultaneously, which research shows results in cross-modal integration in the brain (Koelewijn et al., 2010). Therefore, instead of motor movements being recorded by Kerry’s hand, as had been the case during motor-motor methods, they were visually processed by Kerry’s eyes. The practitioner summarized the rationale for this method by stating, “Unless [Kerry] saw my face, [they] did not know I was talking.”

As time went on, the practitioner began to see evidence of increased academic comprehension in Kerry, such as being able to identify more complex semantic relationships contained within provided event-based pictures. This finding led the practitioner to include an additional visual-motor strategy into the sessions in which they drew and wrote out ideas and asked Kerry to copy these marks onto Kerry’s own paper. The practitioner recounted that they let the process of deixis guide these ongoing interventions to continuously “meet [Kerry] at [their] level.” In practice, this meant that each moment with Kerry was a perpetual assessment, described as a "mental dance" between the two. The practitioner constantly needed "to understand what [Kerry] was processing and what [they were] not" from the provided visual and motor input streams. This required "presenting content in multiple ways" and requiring Kerry to "run this content back through [their] learning system." For Kerry to learn, they needed to "do something" with the content on their own, such as draw out their understanding of a story or an event that occurred at school.

In practice, this meant that the practitioner never followed any prescribed lesson plan or agenda. "What I did with [Kerry] was dependent upon what [they] provided me in the moment," the practitioner shared. In the final step of the deixis, the practitioner took measures to increase the quantity and quality of their provided intervention if they deemed that Kerry was not grasping a concept that they were working on. "If [Kerry] was not understanding the information," the practitioner stated, "it was up to me to layer the content one more time," such as by re-writing and re-drawing ideas through Kerry's visual learning system. "[Kerry] needed to do the thinking." These deictic processes were followed by the practitioner over the course of the two-year time period during which they observed many notable changes in Kerry's learning and development. These changes are further explored next. (Of note: additional theoretical rationale for utilizing the Neuro-Education based interventions presented in this section can be found in Chapter 5.)

Observed Changes in Learning and Development

As previously mentioned, Kerry's language, cognitive, and social-emotional functioning were described as significantly restricted by the practitioner at the beginning of the intervention period. During this time, Kerry's global intellectual progress was described as “slow,” in that changes in learning and development were often difficult to perceive from week-to-week. Despite these intellectual challenges, the practitioner did note certain characteristics that they perceived as potential learning strengths. “Once you got into [Kerry’s] system and stayed at [their] level,” the practitioner explained, “you began to notice some permanent cognitive changes” that occurred in some areas of functioning.

One example that was cited of these changes was Kerry’s rapid transformation in handwriting. During the first few weeks, Kerry wrote with a random mix of upper- and lower-case letters. However, after the practitioner drew out the design and purpose of the English alphabetic script, Kerry’s writing quickly became orderly and their lines became straighter and more uniform. This rapid change made a noteworthy impression upon the practitioner.

Accordingly, research has demonstrated that the neurobiological regions responsible for both recognizing the shapes of words and representing these shapes via handwriting overlap in the brain; and, more importantly, acquiring the shapes of new words through novel learning experiences has been shown to functionally alter certain brain structures responsible for visual processing (Xue et al., 2006). This may explain the rapid change in Kerry’s handwriting, even though the practitioner stated that they did not specifically work to develop Kerry’s skills in orthography.

In a different example of Kerry’s changes in cognition over time, the practitioner found that when provided a prompt about a specialized topic of interest, such as a comic book character, Kerry could speak at length regarding trivial knowledge concerning this topic. These findings suggested to the practitioner that

Kerry held the potential to learn in depth about certain types of information. More importantly, Kerry's potential rate of learning could be efficient when provided sufficient meaningful input to scaffold to a new conceptual understanding.

In spite of these intermittent strengths, the practitioner acknowledged that Kerry experienced many linguistic, cognitive, and social-emotional barriers that interfered with their propensity to learn. Because Kerry had experienced childhood and adolescence with a severely impacted learning system, this meant that they had not acquired much academic content in school; and, therefore were "significantly lacking in world experience." These losses translated most impactfully into severe delays in Kerry's social-emotional functioning. As a result, Kerry had acquired a large array of "antisocial behaviors" that "got in the way of [their] learning."

In early sessions, the practitioner described that Kerry acted "like a toddler," in that they did not acknowledge that their actions impacted others. Spitting, burping, passing gas, and wreaking long yawns in the practitioner's face were common behaviors experienced during early sessions. Though this plan went counter to their intended treatment goals of working solely on academics, the practitioner felt it necessary to assign meaning to these antisocial behaviors when they occurred. These behaviors continuously "disrupted [Kerry's] potential to learn," and resulted in overall academic progress going "much more slowly" than might be expected based upon Kerry's cognitive potential. On the whole, the practitioner summarized these findings as a "significant gap" between Kerry's social-emotional functioning and their potential to continue learning and developing over time.

Changes in Quality of Life

One particularly insightful finding occurred when the practitioner recounted how Kerry had changed as an agent in multiple environments during the first 2 years of intervention. When Kerry first arrived at the clinic their high school teacher shared that Kerry had primarily sat in the back of the classroom, turned their back on everyone, and spent the duration of class drooling silently. Within the first few months of working with the practitioner, Kerry experienced notable social-emotional changes in that they began "sitting with their peers at group tables" and began "working with others on team projects." The practitioner explained that during this time Kerry became "groupable," or able to be socially included with others. "[Kerry] learned how to cooperate and collaborate" during this time, and even expressed a desire to be sociably involved amongst peers. This led to Kerry learning how to do "research" on topics of interest and create "small booklets" containing information of interest. Kerry also learned how to successfully participate in school-based outings, such as taking the bus to go to a restaurant.

According to the practitioner, Kerry also made social progress in connecting with their family and participating in group events. In the beginning, for example, family outings were described as challenging affairs fraught with arguments. Over time this shifted so that Kerry could engage in small family trips without constantly questioning "why" they had to attend. Kerry also learned to participate in family-based holidays, such as birthdays, Fourth of July, or Halloween. During early months of the intervention, Kerry did not convey an understanding of what holidays were or why they were celebrated. Within a two-year period, however, Kerry began looking forward to holidays, and even dressed up in costume for different events.

Literature related to the process of socialization may shed additional light on the types of life changes that Kerry experienced while undergoing Neuro-Education based interventions. For example, research has shown that older individuals such as adolescents can develop pro-social language functioning over time even though they had acquired numerous antisocial behaviors during their childhoods (Arwood et al., 2015; Martin-Raugh et al., 2016). This is because social-emotional development is thought to hold the potential to scaffold in both pro- or anti-social directions in learners (Ellis, 1980), depending upon how meaning is assigned to them by the adults in their lives (Green-Mitchell, 2016). More simply, children can in fact begin to learn how to be pro-social at any point in their lives. Acquiring greater levels of language functionality in multiple areas of Kerry's life may explain some of the social-emotional shifts that were observed in Kerry by the practitioner.

Making up for Lost Time

When offered the opportunity to reflect on Kerry's journey as a learner during the first 2 years of working together, the practitioner pondered on whether they had started working with Kerry at too advanced of an age for the Neuro-Education intervention methods to impact Kerry's brain to its full potential. "[Kerry] made a lot of progress," the practitioner recounted, "but lost a lot of time [during their childhood] for learning and development to happen." Globally, Kerry was described as exhibiting a great deal of intellectual advancement during this time but still experienced significant barriers to learning – some neurobiological, and some environmental. Thus, while Kerry "gained significantly in perspective taking," Kerry nevertheless "did not make it to the concrete level" of social-emotional development, according to the practitioner. In effect, this meant that Kerry did not develop the capacity to become self-sufficient in their learning and life functionality.

In reference to these ideas, some research from neuroscience and psychology has demonstrated that certain ‘sensitive periods’ exist within the course of a young child’s development (Shaffer & Kipp, 2013). It is crucially important for children to learn and acquire knowledge during these periods because doing so leads to the formation of healthy brain structures that in turn result in an increased neurobiological capacity to function (Bjorklund & Pelligrini, 2002). Missing out on learning during these sensitive periods has been shown to lead to observable intellectual challenges over time in some children (National Research Council, 2000; Siegel, 2001).

At the same time, different research has demonstrated that the brain can continue to change again later on in a child’s life even if they had experienced extended lapses of time without meaningful learning occurring (Howard-Jones, 2014; Squire et al., 2014). This is because the inherent neuroplasticity of the brain means that it can continue to adapt and reform neuronal connections again once neurobiological learning has become reengaged (Li et al., 2014). Scientists have yet to fully discover just how much the human brain can evolve and change after it has missed out on years and years of learning time, as would appear to have been the case for Kerry.

The practitioner acknowledged this paradox by questioning what kind of child Kerry might have become had they experienced Neuro-Education based intervention from an earlier age. “What I do know,” they stated, “is that the brain is like a muscle – if you don’t use it, you lose it.” The practitioner shared that though Kerry made much progress over time, lamentably they may never know what could have come had Kerry's brain been maximized to its full potential over the course of their childhood.

Summary

This chapter presented findings related to the impact that Neuro-Education based intervention methods had upon the learning and development of one individual with developmental disabilities who had experienced this therapy over the course of 2 years. Participant-created artifacts were collected from three different phases of the intervention corresponding to samples created before intervention started, samples created in the middle of the intervention, and samples created at the end-point of the study. Viewing the overarching changes that occurred in these artifacts over time in turn allowed for this investigation to identify how Kerry themselves changed as a result of receiving the Neuro-Education based interventions. More specifically, coding and analyzing changes within the artifacts that Kerry created through the cognitive framework of learning, as represented by language functioning, and the cognitive framework of development revealed numerous insights into how Kerry evolved as an individual in multiple aspects of their life. In addition, coding the clinical notes taken by the practitioner and coding the semi-structured interview conducted with the practitioner for this study revealed additional insights into how Kerry transformed as a person.

Comparing Kerry's progress through the cognitive framework of learning, including the theoretical guidance provided by Arwood's Neuro-Semantic Language Learning Pre-Language Assessment Protocol (ANSPA) (Arwood, 2011), the Neuro-Semantic Language Learning Theory (Arwood, 2011) and the Temporal Analysis of

Propositions Behavioral Checklist (TemPro - Arwood & Beggs, 1992), definitively demonstrated that Kerry exhibited progress in their capacity to use language to function in the world at the conclusion of the study. Composite progressions inherent in Kerry's language samples included that Kerry acquired more advanced proficiency in all measured language functions including semanticity function, referential function, productivity function, and flexibility function. Additional evidence from drawn, written, and oral language samples established that Kerry generated more sophisticated cognitive displacement of their thinking such as by referencing a variety of communicated ideas outside of the immediate here and now. Kerry also showed substantial increases in expanding, extending, and modulating their language to reflect the increasingly complexified nature of their thinking. This diversification of Kerry's language was captured through advancements in multiple literacy processes including thinking, speaking, listening, reading, writing, drawing, observing, and calculating. Similarly, Kerry made progress in beginning to understand how they learned from a neurobiological perspective. Kerry also showed marked improvements in social-emotional functioning over time, resulting in a global shift from low preoperational to high preoperational functioning that occasionally evinced moments of concrete pro-social thinking.

When comparing these synergistic learning advancements against a priori expectations from relevant literature it was hypothesized that Kerry experienced approximately 3 years of growth in language functioning, 2 years of growth in cognitive functioning, and 3 years of growth in social-emotional functioning during the duration of the study (Arwood, 2011; Berko, 1958; Fernandez, 2011; Sax &

Weston, 2007; Taylor, 1985). The findings presented in this chapter provide convincing evidence that Kerry experienced these changes in learning precisely because they received the Neuro-Education interventions that the practitioner had provided in sessions. More precisely, parental and practitioner report indicated that Kerry made extant progress in learning before arriving at the clinic setting; however, once they began receiving the Neuro-Education interventions the qualifiable progressions in Kerry's learning became incontrovertible by multiple measures. By all accounts, Kerry experienced changes in their learning that could be directly tied to the theoretical aims provided by the Neuro-Education based interventions.

Table 8 displays a summary of results that Kerry experienced from the beginning to the end of the study from the learning framework perspective.

Table 8

Summary of Changes in Learning

Characteristics of learning	Pre-intervention	Post-intervention
Language function	-Absence of shared-referent, relational, flexibility, efficiency, and productivity functions -Lack of expansion, extension, modulation of language -Semanticity function not sufficient for shared understanding of ideas	-Proliferation of semanticity, referential, productivity, and flexibility functions -Additional expansion, extension, modulation of relational language -Increase in quantity and quality of shared spontaneous oral language
Cognitive function	-Lack of cognitive displacement of ideas -Artifacts devoid of basic agent-action-object relationships -Absence of literacy processes for acquiring new information -Inability to orient themselves to concepts of time	-Increasingly complex cognitive displacement of ideas -Engaged in all forms of literacy: thinking, speaking, listening, reading, writing, drawing, observing, and calculating -Enhancement of problem-solving abilities -Increased capacity to understand function of own learning system
Social-emotional function	-Absence of perspective taking and deciphering the needs of others -Inability to engaged in shared, mutual conversation -Did not address who, what, where, when, why, or how of social situations	-Drawings showed beginnings of including others in mental pictures -Amended language for sake of interpersonal clarity -Mixture of progress on understanding complex emotions -Greater environmental understanding of social contexts
Composite levels of language functioning	-Restricted language functioning -Pre-language level	-Restricted language functioning -Preoperational language level -Glimpses of concrete language, cognition, and social thinking

Viewing Kerry's progress in their development through the changes that transpired in their artifacts over time revealed additional noteworthy insights into how they evolved as an individual. Linguistically, Kerry exhibited a substantial complexification of the grammar, syntax, mechanics, and conventions of their language usage. Cognitively, Kerry demonstrated more advanced proficiencies in abstract thinking, sustained attention for goal-directed tasks, and mental grouping of objects by schema. In addition, intellectual progressions were clearly observed through Kerry's augmentations in art-based cognitive representationalism and their orthogenetic advancement through greater attention to artistic detail. Kerry also experienced discernible gains in perspective taking as evidenced by their greater propensity for understanding the needs of others both in drawing and in conversation. Composite evidence from artifact analysis demonstrated that Kerry experienced transformative changes in the linguistic, cognitive, and social-emotional developmental domains during the course of this study.

When comparing Kerry's progress in development against age-based developmental milestones, results demonstrated that between the onset and the terminus of the study Kerry experienced approximately 3 years of growth in language development, 2 years of growth in cognitive development, and 3 years of growth in social-emotional development. Table 9 displays a summary of results that Kerry experienced in their development from this cognitive framework.

Table 9

Summary of Changes in Development

Characteristics of development	Pre-intervention	Post-intervention
Language domain	-Irregular oral and written language usage -Profuse grammatical errors -Incompletely expressed ideas -Talked only about topics of interest	-Mechanics of written language conveyed ideas with natural precision -Fewer grammatical mistakes -Oral language exhibited more thorough summary of surroundings
Cognitive domain	-Inability to read and comprehend a 4th grade passage -Atypical artistic representation of people and places -Attenuated mark-making capacity -Absence of orthographic control	-Mental groupings of people by classified categories -Drawings conveyed clear environmental setting with multiple contexts -Increased capacity for sustained, goal-directed attention -Orthogenetic advancement reflected in attention to detail
Social-emotional domain	-Inability to engage in shared oral conversation -Ill-defined relationships between drawn characters -Lack of understanding social norms and conventions	-Meaningful semantic connections shown between drawn agents -Coordinated, symmetrical ordering in size relations and details among drawn agents -Still exhibited psychosocial irregularity of understanding facial expressions
Composite levels of developmental functioning	-Preoperational development -Preconceptual artistic development	-Preoperational development -Sporadic instances of cognitive functioning -Landscape artistic stage

Lastly, coding and analyzing the practitioner's clinical notes and the results from the semi-structured interview with the practitioner uncovered additional discoveries regarding how Kerry changed as a young individual. Findings from these analyses indicated that during the time period investigated for this study Kerry experienced numerous transformational changes to the quality of their life. For example, Kerry shifted how they engaged with school, changing from a child who sat detached from their surroundings to an agent who socially interacted with others and participated in school-based events. Similarly, Kerry acquired the capacity to understand the purpose of holidays, resulting in their family taking multiple short trips together. Kerry also notably progressed from a student who initially did not hold a functional relationship with learning to a pupil who could engage in learning during sessions for up to 3 hours at a time.

Table 10 displays exemplary findings depicting noteworthy life changes that Kerry experienced during the course of the study.

Table 10

Summary of Changes in Quality of Life

Defining characteristics	Pre-intervention	Post-intervention
Summary of actions and behavior	-Frequently complained and protested work completion during clinic sessions -Sat mostly silent in back of school classroom with back turned to teacher -Lack of meaningful social inclusion with peers -Lack of acknowledgment of family holidays and vacations	-Engaged in learning with practitioner for up to 3 hours at a time -Researched and created own written booklet reports on topics of interest -Became groupable in school by sitting with peers and interacting in small groups -Participated in school-based field trips -Participated in family outings and dressed up in costume for holidays -Some antisocial behavior still exhibited -Dropped developmental levels during some intervention sessions

The findings presented in this chapter documented a substantial amount of progress that Kerry experienced in their learning and development during the time period investigated for this study. Despite these advancements, zooming out to a macro viewpoint of the results showcased a series of remaining global limitations that Kerry continued to experience at the end of the investigation. At the onset of the study Kerry was determined to function at a low preoperational level of development and language function. Though Kerry experienced glimpses of functioning at the concrete level of development and language in certain instances, composite measures suggested that Kerry still predominantly functioned at the preoperational level of development at the conclusion of the study. One possible explanation for this finding was that making the developmental and functional shift to the concrete level would have necessitated at least a four-year comprehensive gain in proficiencies for each functional domain. As reported, Kerry made at most 3 years progress during the two-year time period. Thus, despite their overall progress Kerry's composite profile of learning and development most closely matched the preoperational stage at the conclusion of the study. In addition, though Kerry shifted from pre-language to preoperational levels of language function, their language at the conclusion of the study still exhibited overall characteristics of restricted linguistic, cognitive, and social-emotional thinking.

Both of these findings indicated that Kerry experienced a 12- to 13-year gap between their chronological age and developmental and language functioning at the conclusion of the study. Of note, however, was that this gap did not widen after Kerry initiated intervention services and subsequently matured in age. As stated by the practitioner, this finding suggested that Kerry began making up for 'lost time' in learning and development once the Neuro-Education intervention began.

Comparing the developmental trajectory that Kerry was engaged in before intervention began to their new trajectory charted once they started receiving these services generated compelling conclusions. After engaging in these analytical comparisons it can reasonably be surmised that Kerry would not have experienced the innovative changes documented in this chapter had they not received the Neuro-Education based interventions in their life. This is because development only occurs in children when learning can happen, and when the brain can change over time (Piaget, 1964; Salkind, 2004; Walker et al., 2011). Reengaging with learning again unlocked Kerry's development to reemerge in the profound ways documented in this chapter.

As Kerry's brain began to experience new growth and meaningful interconnectivity, this in turn began to change who they were as a unique agent in the world (Doidge, 2007; Li et al., 2014).

The purpose of Chapter 4 was to answer the research question for this investigation; namely, to document the *what* changes Kerry made in both learning and development throughout the course of the study. This section concludes these analyses. The exploration of Kerry's progress is continued in Chapter 5. By returning to the literature that established the Neuro-Education Model used for this study – namely neuroscience, cognitive psychology, and language, Chapter 5 reanalyzes the findings from this study to further hypothesize *why* Kerry may have exhibited these changes. This chapter is presented next.

Chapter 5: Discussion

Chapter 4 displayed the results of analyzing the research question for this study: What impact do intervention methods derived from Arwood's Neuro-Education Model have upon a young individual with developmental disabilities' cognitive, linguistic, and social-emotional functioning over time? These results were presented through the lenses of two cognitive frameworks: (a) development, as culled from literature pertaining to developmental psychology, and (b) learning, taken from analyzing changes in language function (Arwood, 2011). In addition, one semi-structured interview with the practitioner who had provided the intervention to the participant was conducted to provide for an alternative vantage point to findings gleaned from the data. Thus, Chapter 4 aspired to account for *what* changes the participant exhibited upon experiencing the intervention under investigation. This chapter seeks to re-examine these findings through the three disciplines that comprise Arwood's Neuro-Education Model: neuroscience, cognitive psychology, and language. Though this study was not experimental in design, and thus causation could not be confirmed, the goal of this re-examination is to establish a working hypothesis as to *why* the participant changed in the way they did. More specifically, the intention of this chapter is to better understand how theory fuses into practice, for without understanding why as educators we use particular methods to help children learn, we are often unwittingly operating without a guiding theoretical compass (Sloat et al., 2012).

This chapter begins with a recapitulation of literature from Chapter 2 that showcases how individuals with developmental disabilities still function today within a special education system that poorly understands their needs. Next, Arwood's Neuro-Education Model (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016) is re-introduced as a potential new way of understanding the learning needs of this population with greater definitude. A summary of results from this study follows, which includes an additional bevy of analyses beyond the scope of findings presented in Chapter 4. These findings are also re-examined within the context of current, relevant literature. In the last section of analyses, the methods utilized by the practitioner from this study are re-appraised through scientific literature to establish a rationale for their continued usage with learners. This chapter then concludes with potential practical applications, limitations inherent within this study, and areas of future research.

A Special Population

Literature in Chapter 2 established that society continues to struggle to understand the learning needs of individuals with developmental disabilities (Gallagher, 2004; Hastings, 2005). Part of this struggle stems from the fact that each academic field holds a different viewpoint upon how to define and characterize the concepts of development and disability (Cosier & Pearson, 2016; Society for Disability Studies, 2019). The field of special education predominantly utilizes a deficit-based viewpoint of disability, where children are tested against normed data and ultimately qualify for special services if these deficits are deemed significant enough to interfere with academic and/or life functioning (Buntinx, 2013; Stalker, 2012). American schools hold a long history of social exclusion of students with disabilities, which is most overtly noticeable for those children who spend the majority of their days in life skills classrooms or separate school placements (Katz & Mirenda, 2002). Scholars observe that students who stay for long periods of time in these settings hold little promise of gaining functional independence later in life (Boutot & Bryant, 2005; National Council on Disability, 2018). Educators who train to teach this population predominantly take coursework that is geared towards providing remediation on a narrow set of skills (Harry & Klingner, 2007). According to some scholars, educators primarily receive training on how to utilize auditory-based methods of instruction for their pupils, such as oral-based pedagogies and input-output demonstration of knowledge (Jaskowiak, 2018; Kelley-Hortsch, 2018; Robb, 2016). Research has also established that pre-service teachers feel wholly unknowledgeable of how the brains of their students with developmental disabilities may be different, as well as how their students' developmental life trajectories each tell a story that is fundamentally unique to who they are as individuals (Howard-Jones, 2014; Owens & Tanner, 2017).

Over the past few decades, scholars from a variety of academic fields including disability studies, neuroscience, and cognitive psychology have begun to advocate for educators to reconceptualize what it means to have a developmental disability by making efforts to find each student's inherent strengths for learning (Ayres et al., 2011; Levine & Barringer, 2008; Moore & Slee, 2012). Similarly, many prominent authors have called upon academic institutions to begin infusing knowledge about the brain into teacher preparation programs (Battro, 2010). In a review of literature regarding the translation from research about the brain into educational practice, Arwood's Neuro-Education Model was the only model found that incorporated knowledge pulled from three different lenses (neuroscience, cognitive psychology, and language) in order to establish strength-based, brain-based methods for working with children who exhibit learning differences. For these reasons, this model was used to establish the conceptual framework and research questions for this study.

In order to determine whether novel interventions derived from this model may meet the learning needs of students with developmental disabilities, this study measured the impact that such methods upon one participant's learning and development over time. First, a summary of results from this study is reviewed. Then, these results are reexamined using the three lenses of Neuro-Education in order to more fully hypothesize *why* the participant changed in the way they did. Findings from these inquiries may further illuminate practical implications for educators as well as new directions of research in the future.

Summary of the Study

This retrospective case study utilized the methodological process of document analysis to analyze artifacts created by one participant who had experienced Neuro-Education based therapy in a private setting over the course of 2 years. Artifacts were coded using two cognitive frameworks: (a) development, culled from literature in the field of developmental psychology, and (b) learning, represented by language functioning informed by Arwood's (2011) Neuro-Semantic Language Learning Theory. Results from these investigations were grouped into themes and analyzed to provide insights into how the participant changed over time. In addition, one semi-structured interview was conducted with the practitioner who had provided intervention to the participant, from which data were coded and themed to provide for an alternative vantage point upon the findings presented in Chapter 4.

Pre-Intervention Findings

Before the Neuro-Education based intervention began, Kerry was a 16-year-old young adult who was moderately to severely impacted by the developmental condition of having autism spectrum disorder. An analysis of pre-intervention artifacts determined that Kerry remained highly restricted in their linguistic, cognitive, and social-emotional functioning. Kerry exhibited a markedly curtailed capacity for comprehending what they read. Moreover, the content of their oral language and drawings was not able to stand alone for interpersonal communication, thus requiring the listener or observer to continuously guess at their intended meaning. Kerry was described by the practitioner who provided intervention methods for this study as someone who merely "existed" in time and space and did not appear capable of taking care of themselves in any functional capacity.

Carefully investigating the pre-intervention artifacts that Kerry produced provided numerous insights into the strengths and challenges of Kerry's learning system. A multitude of signs contained within Kerry's language samples established that Kerry had struggled to learn meaningful concepts throughout their childhood when provided instruction through auditory modalities such as speaking, listening, phonics, or other psycholinguistic methods. For instance, when Kerry was asked by the practitioner to orally read a passage written at a fourth-grade level, Kerry did not generate sufficient mental pictures to be able to answer basic constituent questions about the text. In addition, Kerry appeared unable to answer elemental questions about their life that required them to displace their thinking outside of the here-and-now. Instead, Kerry talked only about topics of interest and used borrowed oral language resulting in a string of communicated ideas that did not meaningfully connect together. Kerry's challenges in using language to successfully function in the world extended into the social-emotional realm, where ample evidence suggested that Kerry did think pro-socially about others in their life.

Examining the pre-intervention findings through the framework of Arwood's (2011) Neuro-Semantic Language Learning Theory yielded more specificity to the kinds of processes that had been purported to occur in Kerry's brain throughout their childhood. For instance, the fact that Kerry could see, walk, produce coordinated movements, and utilize some oral language indicated that their neurobiological system was capable of processing certain amounts of raw sensory input and overlapping this input to form perceptual patterns in their brain. This established that Kerry could in fact learn; but, this learning was severely restricted to produce changes only in lower, subcortical regions of their brain thus resulting in a two-tiered pattern integration, commonly referred to as input-output learning (Arwood, 2011; Robb, 2016). When such learning ceases at the pattern level (tier 2), individuals are precluded from gaining a conceptual or linguistic level of understanding the world and do not demonstrate the capacity to use their own language to function (Arwood, 2011). According to Arwood and colleagues (2018), many children on the autism spectrum experience this phenomenon, where sensory input provided through auditory modalities is not sufficiently inhibited and integrated with existing neurobiological information to provide for long-term conceptual meaning. Functionally, when these children's brains do not recognize previously provided sensory input, they may internalize only a small fraction of their life experiences and operate akin to an individual who is continuously taking in the world around them for the first time, over and over again (Arwood et al., 2018).

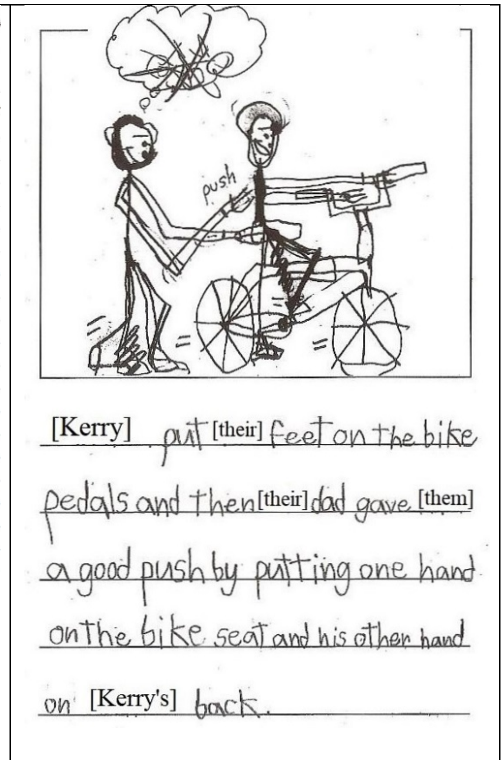
The assertion that Kerry's learning system remained functionally impacted – and therefore operating solely at the pattern-based level – was also supported by a multitude of pre-intervention developmental findings. Kerry's pre-intervention language samples contained profuse grammatical errors and embedded ideas were incompletely expressed. Kerry also exhibited atypical artistic renderings of people and places resulting in overly large drawings that lacked defined semantic relationships between characters. Kerry displayed a lack of orthographic control culminating in irregular lettering and spacing between words. As a whole, pre-intervention findings markedly differed from a priori developmental milestones associated with typically developed 16-year-old adolescents. By the age of 16 children whose learning systems can process feedback from adults and meaningfully internalize life experiences would be expected to have acquired a full grammar, initiate and maintain pro-social relationships with others, and demonstrate a readiness to begin leaving the nurturance of their parents and begin fully caring for themselves (Fernández, 2013; Nelson, 1981). Though Kerry had the qualities of being severely developmentally delayed at the onset of the time period for this study, Kerry began experiencing pronounced and observable shifts in their capacity for learning once intervention began. These findings are explored in the next section.

Post-Intervention Findings

After Kerry began participating in the Neuro-Education interventions, many noteworthy changes became evidence in their midpoint artifacts. Because the observance of each of these midpoint changes also carried over into the end-point phase artifacts as well, the decision was made to merge findings from these two phases into a ‘post-intervention’ section curated specifically for this summary. Figure 15 displays a side-by-side comparison of Kerry’s pre- and post-intervention language samples to provide visual cues and retrospective reference points for the reader. These samples allow for a pre/post comparison of composite learning and developmental changes, which are further examined next.

Figure 15

Pre- and Post-Intervention Drawing and Writing Samples



Pre-Intervention Drawing and Writing Sample	Post-Intervention Drawing and Writing Sample

A multitude of evidence contained within mid- and end-point artifacts, such as depicted in the right side panel of Figure 15, demonstrated that Kerry began experiencing profound shifts in their capacity to learn after initiating Neuro-Education interventions. According to their case notes, the practitioner quickly ascertained that Kerry possessed a movement-access learning system, which meant that Kerry’s brain continuously required overlapped layers of meaningful movement-based sensory input in order to accumulate sufficient neurobiological entry points in their perceptual system (Arwood, 2011). Because Kerry had not received this kind of input throughout their childhood, they had not been assigned meaning in a modality conducive for them to help create conceptualizations of the world, thus resulting in their thinking and language being restricted to the immediate here-and-now. This began to change once the practitioner found previously untapped entry points into Kerry's brain such as by using the Viconic Language Methods of hand-over-hand writing and drawing, tracing the edges of shapes to form visual patterns, using the movement of the mouth to produce dynamic shape-based sequences corresponding to oral ideas, pointing and gesturing, and finally requiring Kerry to draw and write each idea that they wished to communicate. In a later section of this chapter, the neurobiological rationale for providing each of these methods is explored in greater detail in relation to contributing academic and scientific literature.

Once Kerry began learning through an overlap of motor-motor and motor-visual based sensory input, their mid- and end-point artifacts illustrated that they began engaging in numerous psychological processes associated with the acquisition of literacy. For example, Kerry's oral and written language began displaying more advanced referential functioning in that they engaged in multiple speech acts and began answering explicit questions rather than talking about eccentricities. Kerry's drawing and writing exhibited complexified productivity and flexibility functions in that these two mediums displayed greater synchronous cognitive alignment. Kerry also demonstrated an increase in cognitive displacement in being able to talk about past and future events, as well as reference certain abstract concepts such as emotions. Though fully grasping how to position themselves in relation to time remained elusive for Kerry, they nevertheless made substantial progress in logically sequencing ideas together and demonstrating chronology between drawn events.

On the whole, evidence from mid- and end-point artifacts established that soon after intervention started Kerry began using their learning system to acquire language and translate this into increased functionality. Drawing and writing became a viable form of communication and a semiotic activity for Kerry, meaning that these modalities now held purpose in Kerry's life (Kress, 2003). This purpose was also pragmatic in that Kerry began to see a reason for communicating with others; namely, that they may get their needs met in their life through the use of drawn and written language (Jaskowiak, 2018; Prutting, 1982). Perhaps more importantly, Kerry began using increased relational language to refine their own ideas. This only occurred because meaning was assigned to Kerry in a way that matched their neurobiological learning system, such as by providing accessible visuals in context to explain an idea or event, as well as meaningfully connecting the actions of people together (Arwood, 2011; Bruner, 1975). Kerry's language, therefore, began forming a reciprocal relationship with their cognition, where each component helped to refine the other through meaningful synergism (Tomasello, 2009).

Despite making progress in many aspects of language functioning, some evidence of restricted thinking was still observed in Kerry's post-intervention artifacts and the practitioner's case notes at the terminus of the study. Kerry demonstrated sustained difficulty in perspective taking, as recounted by the practitioner who noted many examples of Kerry struggling to understand why caring about others and their needs was important. This finding was unsurprising, especially when presented in the context of how much time the process of socialization takes to unfold for every human. Arwood (2011) explains that learning is socio-cognitive in nature, meaning that from birth children require a continuous assignment of meaning to their actions by multiple adults in their lives and in multiple environments. Social-emotional learning in children is by nature inherently complex and non-linear, meaning that it is characterized by a constant push-pull between striving for independence and requiring perpetual nurturance (Meleis, 2010). This lengthy process of social-emotional learning is also reflected in the growth of structures and functionality of the brain, where research has shown there is not one ‘region’ for social-emotional growth; but, rather social thinking depends upon vastly enriched and interconnected neuronal fiber tracts that represent a myriad of multi-faceted and intangible concepts about interacting with others (Duffau et al., 2014; Pulvermüller, 2013). Because it can be inferred that Kerry’s brain missed out on years and years of opportunities to make such neuronal connections in reference to social-emotional happenings, Kerry will undoubtedly require many more years’ worth of life experiences that can in fact be registered by their brain so that enough neurobiological patterns can be integrated into circuits (concepts) and eventually networks (language) (Tomasello, 2009). Put more simply, Kerry continued to struggle with social-emotional functioning post-intervention because they needed substantially more time to successfully internalize a wide variety of life experiences.

As a result of engaging with meaningful learning Kerry experienced many noticeable shifts in their developmental and linguistic functioning. This resulted in a global shift from a pre-language function to a high preoperational language function in many areas. Some elements contained within the post-intervention artifacts and practitioner notes also suggested that Kerry exhibited glimpses of functioning within the concrete level of development, such as when they made efforts to fit in to multiple social environments and repair social relationships at school that had undergone a rift. Towards the end of intervention Kerry was described by the practitioner as more "present" and someone who was "developing a stronger sense of agency."

Many examples of these global shifts in developmental functioning were also reflected in mid- and end-point artifacts. Kerry demonstrated a stronger grasp of the grammar, mechanics, and conventions of both oral and written language. Kerry artistically rendered agents and environments in their drawings with more granular attention to detail, resulting in more accurate semantic descriptions of the relationships between agents and a greater capacity for identifying the emotions of drawn characters. Moreover, because the practitioner helped Kerry depict drawings as more anatomically correct, this translated into Kerry being able to form the actions that humans engage in with greater clarity. As a result of these changes, the drawings that Kerry produced began to symbolically represent events that had occurred in their life and thus the modality of drawing became a conducive medium for engaging in therapy with the practitioner.

The shift from pre-language functioning to high preoperational functioning also translated into changes in Kerry's quality of life. Before intervention began, Kerry did not engage in meaningful, reciprocal social interactions with peers or adults. By the end of the time period investigated for this study, Kerry had successfully re-integrated in their special education classroom by participating in field trips and other events. At home, Kerry began celebrating holidays with their family and going on small vacations as a cohesive family unit. By all measures used for this investigation, Kerry made notable progress in their development and capacity to learn as a result of participating in the Neuro-Education based interventions. These results are explored in greater detail in the Findings Related to Relevant Literature section presented later in this chapter.

This section presented a review of results depicting how Kerry changed in relation to learning and development during the course of this study. The next section investigates why these changes may have occurred by closely examining the Neuro-Education intervention strategies that the practitioner used during their clinical sessions with Kerry.

Interpretation of Results Through the Neuro-Education Paradigm

The document analysis methodology utilized in Chapter 4 was designed to measure the changes that Kerry experienced in their learning and development as reflected through the products that they created. As discussed, learning and development cannot be measured directly, but some products that students create can serve as literal abstractions of their thinking and can therefore serve as proxy for the changes that their brains and minds might be experiencing (Papandreou, 2014; Van Sommers, 1984). How one interprets these student-created artifacts, however, depends upon which cognitive framework they utilize in their analyses. Using the cognitive frameworks of both learning and development simultaneously was essential for this study because each lens illuminated what the other could not.

Importantly, even using both of these comprehensive frameworks as interpretive guides of the data left many intriguing questions unanswered. For instance, from an ontological perspective Kerry appeared to experience profound changes in their identity and consciousness that fundamentally altered who they were as an agent in the world. The field of pragmaticism, which heavily influenced the creation of Arwood's Neuro-Education Model, might argue that Kerry experienced changes in the whole of their being that were greater than the sum of changes in each component part (Arwood, 1983; Peirce, 1905; Searle, 1969). Scholars have wrestled for years regarding the most coherent way to demarcate such changes. The following sections draws from relevant Neuro-Education literature in order to revisit results found in Chapter 4 to hypothesize why Kerry might have experienced such foundational shifts in their being. In order to understand why Kerry changed in the way they did, however, one must understand what the practitioner did and why they did it. Following these lines of inquiry necessitates a re-exploration of Neuro-Education theory from the perspective of an adult assigning meaning to a pupil. As such, these additional analyses aim to conceive of new interpretations in order to provide a complementary point of observation on this case study.

Rationale for Provided Interventions

Learning is neuro-semantic in nature, meaning that it requires the individual to create complex systems of feedback in their own brain; however, learning is also socio-cognitive in that learning cannot occur without adults continuously assigning external meaning for that person in the manner that their brains can process (Arwood, 2011). Reviewing the case notes kept by the practitioner revealed that they understood this axiom; and fortunately for this study, kept detailed recorded logs of all that they did with Kerry in order to help them learn.

This memoing process was initiated by the practitioner during the baseline functional language assessment which was designed to illuminate: (a) how Kerry learns best, (b) how Kerry processes information best, (c) Kerry's rate of learning, and (d) Kerry's learning strengths. Here, one might notice how closely these aims of this evaluation align with the types of strength-based, brain-based student assessments advocated for by disability scholars and neuro-educators alike (Battro, 2010; Gallagher, 2004).

After engaging in this functional language assessment, the practitioner promptly surmised that Kerry learned using an overlap of visual and motor-based input and would benefit from receiving a wide variety of Viconic Language Methods derived from Neuro-Education theory. This standpoint was captured in their clinical notes when the practitioner wrote, "Through the assessment process the evaluator found that: (1) [Kerry] learns best when [they] use drawing and writing to see the meaning of words/ideas, (2) [they] process best when talking is reduced and drawing is increased, (3) [their] rate of learning is very good when provided with the opportunity to learn in a way that matches [their] thinking, and (4) [their] learning access is motor/motor; that is, using drawing and writing to create meaning/understanding." When providing recommended next actions to Kerry's parents, the practitioner continued, "[Kerry] will benefit from using visual language methods such as cartooning, picture dictionaries, letter shape bubbling, pictographing, etc., as a way to understand material, retain material, and thereby increase conceptualization which will result in higher cognitive and social development."

In applying the socio-cognitive theoretical underpinnings of learning into practice, the practitioner immediately began incorporating these recommendations by drawing and writing with Kerry in sessions, often incorporating hand-over-hand methods into their therapy. The following sections examine the various rationale that supports the Viconic Language Methods used by the practitioner during this study. The methods are explored through the lenses of relative literature pertinent to the fields of neuroscience, cognitive psychology, and language.

The Hand-Eye-Brain Connection. Our society functions primarily as an auditory culture, which means that children are expected to make their way in the world by attuning to provided sensory input through their distance receptors; namely, their eyes and ears (Arwood, 2011). Thus far this study has established that, like many other visual thinkers, Kerry did not learn best by using their eyes and ears alone. This section highlights research that supports certain Viconic Language Methods that the practitioner utilized to help Kerry learn through alternative learning access points within their brain. Specifically, theory and research are introduced to support: (a) the meaningful movement of the eyes, (b) the use of cartooning to provide an overlap of visual-motor movement, (c) hand-over-hand learning, and (d) the meaningful movement of the mouth to make dynamic shapes. Each of these learning strategies harness the connections between the hands, the eyes, and the brain to serve as strength points for individuals like Kerry who have previously struggled to learn using auditory modalities.

Movement of the Eyes. Sensory input overlaps in ways that ultimately form either auditory or visual patterns and concepts (Dekker et al., 2014). While many typically developed students acquire the capacity to translate auditory stimuli into visual input that can be functionally processed by their brains, research paints a starker picture for individuals like Kerry who have severely impacted learning systems (Kelley-Hortsch, 2018; Robb, 2016; Xiang-Lam, 2016). These individuals who think with a visual symbolizing system require an overlap of different kinds of sensory input in order to learn (Gallese & Lakoff, 2005; Pulvermüller, 2013). In practice, this means that the brains of these visual thinkers need to process multiple sensory modalities simultaneously, such as light and movement, in order to inhibit this input and strengthen existing cell assemblies into useable visual patterns and concepts (Gainotti et al., 2009).

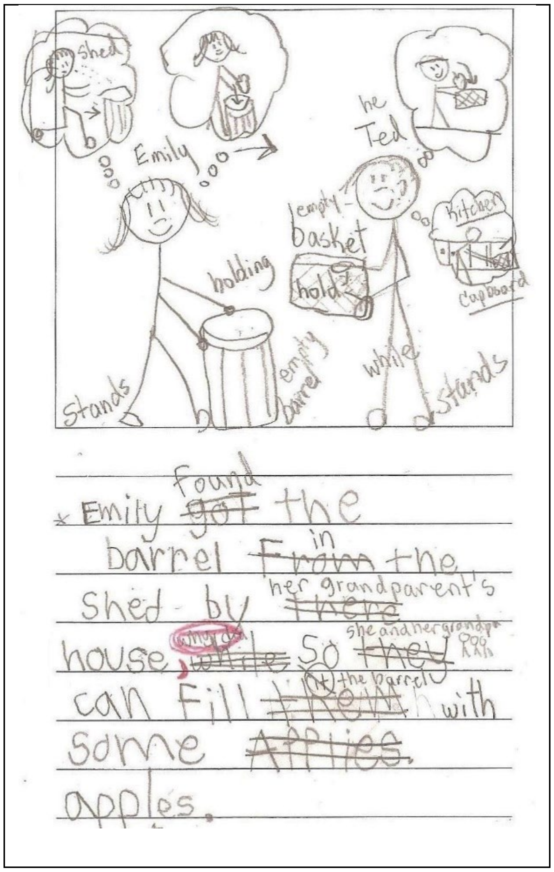
The eyes are designed to move as they scan the environment in front of them. For many visual thinkers, their learning systems function to combine this movement-based sensory input that comes from the movement of the eyes with the visual-based sensory input that occurs from light entering into the eyes' photoreceptors (Arwood, 2011; Bear et al., 2001; Lu & Sperling, 1995). If learners can make sufficient meaning from this overlap of visual and movement-based sensory input, then this visual information is sent to the visual cortex. If the visual cortex can inhibit this electrochemical information, it is then integrated and spread to many other brain regions through diverse fiber connections including the parietal and temporal lobes and eventually the prefrontal cortex (Baars & Gage, 2010).

Though Kerry did not appear to learn past a pattern-based level using auditory methods alone, the practitioner surmised that Kerry could in fact utilize the visual pathways originating with their eyes to begin to learn conceptually through the aforementioned overlap of visual and motor input. In practice, this meant that the practitioner knew that the act of drawing with Kerry would in fact provide for the necessary overlap of these modalities. For example, the light waves reflecting off of the paper provided the visual sensory input for Kerry while the movement of the practitioner's hands on the paper was also perceived as movement by Kerry's eyes scanning the page (Kooiker et al., 2016). In sum, the realization that Kerry's brain could attune to the overlap of visual and motor movement paved the way for the practitioner to utilize the Viconic Language Method of cartooning with Kerry. This method is further analyzed next.

Cartooning. Because Kerry thought in mental pictures, the practitioner understood that the most cognitively expedient manner to share content back and forth with Kerry was to translate these mental pictures onto the page in the form of drawings (Kraemer et al., 2009). Cartooning allowed the practitioner to assign visual meaning to Kerry's ideas through drawings as well as help Kerry expand their own thinking through semantic refinements. Figure 16 shows one example of a cartoon that the practitioner drew with Kerry for the purposes of visually assigning meaning to the events that transpired within the context of an event-based picture.

Figure 16

Example of Cartooning



As mentioned, the practitioner engaged in hundreds of such drawings with Kerry over the course of the two-year period. In most of these artifacts the practitioner's drawings and writing accounted for upwards of 90% of the mark-making depicted on the page, easily demarcated by their more refined penmanship. This meant that the practitioner provided an overabundance of drawn semantic feedback on the page for each small drawing that Kerry volunteered.

The decision to provide a plethora of visual feedback for Kerry is substantiated by what is now known about the brain's feedback system. In the brain, sensory information that flows ‘upstream’ from the senses into the prefrontal cortex initiates a causative chain reaction, where substantially more information flows back ‘downstream’ through these channels and spreads to additional brain regions in the process (Squire et al., 2014). It is hypothesized that this cascade of electrochemical feedback is the result of the brain forging connections between a relatively small amount of input and the vast amounts of existing knowledge it has already acquired (Baars & Gage, 2010). Put more simply, for each quantity of input it receives, the brain multiplies the amount of feedback many times.

Although the brain may be designed to provide itself with a plethora of feedback for each piece of meaningful input it receives, children nevertheless need help in developing and nurturing the neurobiological pathways that guide this feedback loop (Baars & Gage, 2010; Squire et al., 2014). While children are young they require adults to externally assign a multitude of feedback to their actions in order to help forge novel associations between concepts (Anderson, 2015). This axiom explains why adults are expected to provide continuous feedback to children as they develop; or, in the case of assigning meaning through cartooning, why a practitioner would need to draw nearly ten times as much as their pupils, especially for students with severely impacted learning systems (Arwood & Merideth, 2017).

The use of cartooning has been described as truly strength-based in that it often allows visual thinkers like Kerry to communicate ideas or concepts without succumbing to the learning challenges they had experienced when using oral language alone (Green-Mitchell, 2016; Van Sommers, 1984). Green-Mitchell (2016) adds that cartooning has been shown as a way to raise cognition for visual thinkers like Kerry by providing additional context to an event, such as by expanding, extending, and modulating the visual languages used to depict agents, actions, and objects in a shared setting.

Cartooning with Kerry allowed the practitioner to establish a shared referent so that the ideas of each person could be seen on the page. According to Arwood (2011), cartooning uses the basic agent, action, and object relationship functions that underlie all languages, thus speaking to their universality in intervention situations. However, the practitioner acknowledged that it was important to draw out these cartoons in real time with Kerry, meaning constructed in the moment. Providing Kerry with a pre-made drawing did not allow for sufficient processing within their brain because the overlap of real-time visual and motor movements were lacking. Instead, the practitioner understood that each drawing would need to be constructed from scratch with Kerry. This was needed to provide for a sufficient overlap of movement in the form of the pencil making dynamic shapes on the page and the movement of the hands being recorded by the eyes and motor cortex (Arwood, 2011; Gallese & Lakoff, 2005).

Even with this movement of the hand in real time, the practitioner observed that Kerry still struggled at times to attune to topics that were more cognitively demanding. This led the practitioner to surmise that Kerry may need even *more* movement in order for their brain to fire and neuronal connections to wire together. Children who meet this description are said to have the ‘motor-motor’ learning system previously mentioned by the practitioner in their report. Put simply, the practitioner knew that emphasizing a substantial amount of overlap of motor-based movements would be necessary in order for Kerry to learn at their best. Thus, to provide Kerry with additional overlapped motor movements, the practitioner took Kerry's hand in theirs and continued cartooning and writing during sessions. The strategy of hand-over-hand learning soon became an essential cornerstone of the practitioner's approach to facilitating learning in Kerry. This strategy is further covered next.

Hand-Over-Hand Learning. Understanding the neurobiological underpinnings that comprise the brains of visual thinkers informed the practitioner that Kerry required additional overlaps of motor-based movement in order to tap into their movement-access system. In the initial evaluation report, the practitioner summarized this insight by writing, "[Kerry] moves to think. However, random movements from the eyes scanning a room, or the hands picking up objects, or the feet wandering about are not thinking movements. They are certainly movements; but, they do not create language/meaning and therefore do not create higher cortical function or thinking. Since [Kerry] moves to think then [they] can use the movements of [their] hand while drawing and writing to increase thinking in a more productive and efficient manner."

Much neuroscientific research has demonstrated strong functional connections between the movement of the hand and how this sensory information becomes distributed to multiple regions of the brain during learning. When pupils move their hands in meaningful ways, such as tracing the edges of the shape of a word or picture, this information is first processed by the motor cortex and then spread into other access points of the brain, such as the visual cortex and the prefrontal cortex (Baars & Gage, 2010; Gallese & Lakoff, 2005). In addition, overlapping neuronal networks have been found between brain areas associated with the visual perception of words and motor areas associated with producing handwriting (Nakamura et al., 2012).

These two brain regions have also been shown to activate during both reading and writing processes for typical learners (Nakamura et al., 2012), and even for blind individuals who use their fingers to read braille (Sadato et al., 1996).

In a related study on the topic of the hand-brain connection, Macedonia and colleagues (2011) found that individuals learned new words more efficiently when they were taught accompanied by meaningful gestures presented within a semantic context, rather than random meaningless gestures detached from a learning task. On the whole, much research has demonstrated that many of the processes involved with learning can be strengthened when the brain constructs connections between areas responsible for motor functions and the areas more commonly associated with linguistic tasks (Ghazanfar & Schroeder, 2006).

From the perspective of Neuro-Education theory, the movements of the hands in space is cross-modal in function, meaning that these movements overlap to form edge patterns of shape-based concepts (Arwood, 2011; Gallese & Lakoff, 2005; Robb, 2016). This means that hand-over-hand input allows the learner to feel the shapes of words and concepts by touching and tracing them on the page (Arwood et al., 2015). Engaging in hand-over-hand tracing of ideas is also referred to as increasing the figure of the input in the figure-to-ground ratio found in pictorial-based graphics. In these graphics, the figure represents the forefront message that is intended to be conveyed, while the ground is the less important peripheral information that the brain is designed to tune out (Lambert, 2009). This figure-ground perception overlaps to create the motion neuro-semantic circuits of the visual system. Visual thinkers like Kerry sometimes require additional overlap of movement-based input so that their brains know what to focus on versus what to discard in visual stimuli (Arwood, 2011). Robb (2016) elaborates that when individuals who have visual symbolizing systems watch and/or feel the movement of a practitioner's hand in intervention, their brains process the dynamic shapes that are made during the writing of words or the drawing of ideas. Specifically, tracing the edges of words or drawn ideas provides for cross-modal sensory input that is recorded in the visual cortex; and, activates language networks associated with thinking and learning (Robb, 2016).

Dewey (1909) further connects the processing of meaningful movement to the processing of language by declaring that gestures, finger movements, and other such hand movements can logically be declared as 'signs' that represent underlying linguistic concepts. In an argument connecting neuroscientific research to the rationale for movement-based Neuro-Education methods Xiang-Lam (2016) states, "A target learning strategy that would consider the underlying meaning of language would be to integrate the visual-motor writing with semantic representations and to set a writing goal based on the functional use of language" (p. 73). The research thus far presented provides a clear case for the rationale for utilizing hand-over-hand based intervention methods with individuals like Kerry. The use of this strategy stems from interpreting neuroscientific literature through the strength-based learning lens of Neuro-Education.

Movement of the Mouth. As previously reported, Kerry's brain did not attune well to the auditory properties of the language that had been provided to them during their childhood. This was conveyed by the practitioner during the semi-structured interview when they stated that, unless Kerry watched the movement of the practitioner's mouth, Kerry did not know that the practitioner was in fact speaking.

The mouth is another human organ that can be harnessed to add additional overlapping layers of visual-motor movement when working with a visually thinking student like Kerry. This is because when humans speak, their mouths move to make dynamic shapes that can be visually perceived by others (Koelewijn et al., 2010). More specifically, as individuals mouth words these shapes move dynamically from one position to another, thus creating visual-motor movement in the process (Woodhouse et al., 2009). Instead of motor movements being recorded by Kerry's hand, as had been the case during hand-over-hand methods, the motor movements of the practitioner's mouth were visually processed by Kerry's eyes. To allow for maximum opportunities for this visual-motor overlap to occur, the practitioner always made sure that Kerry was positioned in such a manner that they could see the practitioner's face.

The rationale for the use of this visual language strategy stems from understanding the differences between the way that the brain processes auditory versus visual-motor input. The neurobiological mechanisms involved in the processing of auditory-based information in the brain are incredibly complex. Arwood (2011) explains that in order for humans to acquire auditory patterns, raw sensory input must change from acoustic modalities (sound waves) to mechanical modalities (ear drum vibrations), and finally to electrochemical modalities (neuronal firings) before this input can be processed by the brain. Due to the inherent intricacies built into this biological architecture, these auditory pathways can become functionally disrupted at any of these stages, thus severely diminishing the quality of signal that is ultimately perceived by the auditory cortex (Foxe & Simpson, 2002). By and large, children like Kerry who have moderate to severe disabilities are much more likely to experience impairments in these auditory pathways thus preventing them from making meaning by the act of listening alone (Bailey, 2010).

Knowing that much functional overlay exists in the brain between visual processing systems and overlapping hand and eye movement circuitry (Debreczeny, 2019), the practitioner sought to never use oral language by itself with Kerry and instead always ensure that Kerry could see their mouth move while they spoke. Colloquially, one only needs to observe how individuals who are deaf can nevertheless functionally 'hear' people speak by only reading their lips (Woodhouse et al., 2009). Research also demonstrates that lip reading, also called speech reading, is used by most adults in face-to-face communication whether they are hearing impaired or not (Woodhouse et al., 2009).

Additional research by Nip and colleagues (2011) has found that children as young as infants tend to fixate on the facial, mouth, and jaw movements that their adult caregivers utilize when speaking. As children grow older and begin their schooling careers, many students intuitively watch the movement of their teachers' mouths to supplement or even bypass provided auditory-based input (Robb, 2016). Recommendations for learning that incorporate this knowledge about the brain state that children should be seated in classrooms in a position to see their teachers' faces at all times (Woodhouse et al., 2009).

The Viconic Language Methods utilized in this section might be overarchingly categorized as procedures that the practitioner did to best prime Kerry for learning to commence; and, thus maximize their potential for academic success during sessions. Put another way, understanding the research and the theories presented thus far allowed the practitioner to set the stage for more specific interactive learning strategies to commence. The use of some of these strategies are covered in the following section.

Translating from Auditory to Visual Properties of Language. Chapter 2 established that psycholinguistic methods for teaching language to children are commonplace in both general education and special education classrooms alike (Betts et al., 2009; Kelley-Hortsch, 2018). These phonics-based methods break apart words into smaller sound-based components and then require children to reconstruct these sound units into a meaningful whole to learn a new word (Ensar, 2014). Numerous potential problems for visually thinking students exist within this approach. As stated, the brains of visual thinkers do not attune to sound sufficiently in order to automatically make auditory patterns and concepts in their brains (Arwood, 2011). Thus, requiring visual thinkers to learn new words primarily through these auditory strategies would appear to be an antithetical approach to how their brains best process information (Diaz et al., 2009). Moreover, breaking apart words into smaller components, such as sound-letter combinations, would also appear to make it more challenging for visual thinkers to 'see' what these words look like as a unique whole unit. For further reference, additional mismatches between the ways that visual thinkers symbolize the world around them and the psycholinguistic approaches to language learning they are regularly exposed to in schools has been documented by Kelley-Hortsch (2018).

The following sections identify additional Viconic Language Methods that the practitioner used with Kerry in order to help them acquire language through alternative non-auditory strategies. The creation of these strategies was derived from

Neuro-Education theory that specifically made efforts to provide leaning opportunities that would most intuitively match the mental workings of visual thinkers (Arwood, 2011; Robb, 2016). In particular, the following strategies are presented: (a) acquiring the shapes, not the sounds, of words, (b) matching the shapes of words to visual depictions, and (c) understanding one's own visual learning system. The use of these strategies by the practitioner led to Kerry being exposed to a way of learning language that radically differed from anything that they had been exposed to prior to beginning intervention.

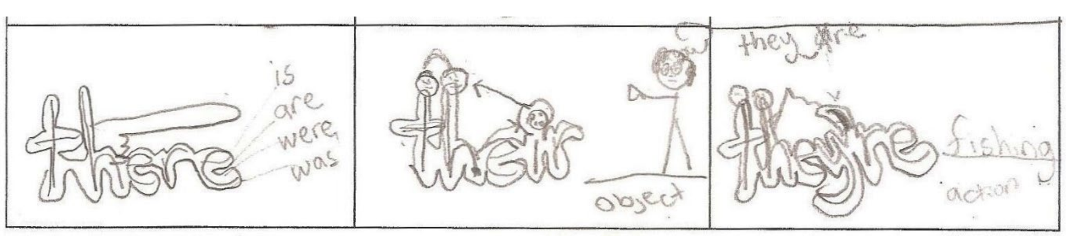
Acquiring the Shapes of Words. Literature presented in Chapter 2 determined that the spaces and edges that comprise each written word in English make a unique shape that can be perceived through visual-motor forms of sensory input (Gumbrecht, 2017; Rapp et al., 2016). Research has shown that some proficient readers of English can activate prior knowledge in their minds just by looking at the shapes that words make in conjunction with other words/shapes on the page (Nakamura et al., 2012). Other individuals like Kerry require the addition of movement in tracing these edges so that they are indeed perceived (Arwood, 2011). From a semantic standpoint, the shape that a word makes holds the potential to signify a variety of concepts based upon how it is used to portray meaning within the context of a sentence (Rapp et al., 2016). Understanding this principle opens up a wide variety of potential ways that words can be semantically attached to other visual information, such as drawings.

In their evaluation report, the practitioner outlined one strategy they used to help Kerry acquire the shapes of words, not their sound-based components. In order for Kerry to best acquire the meaning of words, they explained, Kerry would need to draw a ‘bubble’ around the shape of these words to accentuate the edges of the letters in a shape of a concept or word. The practitioner further clarified this process by writing, “[I] showed [Kerry] a way to SEE the shape of the lower-case letters using bubbling around words and then developing the meaning of unfamiliar vocabulary words by drawing the meaning of these words on a picture dictionary page.” To best provide additional layers of movement-based sensory input during this process, these bubbles were drawn hand-over-hand with the practitioner.

Figure 17 provides an example of the practitioner bubbling around a word to accentuate its shape and then pasting this meaningful shape into a picture dictionary, or a visual catalog of concepts needed to understand a current topic. This specific example of bubbling around words illustrates that even though “there” “their” and they’re” are homonyms, each word makes a different shape that can be visually discriminated by others. Importantly, learners must be able to visually discriminate between different words before these can later be identified, memorized, and conceptually acquired (Rubin, 2001).

Figure 17

Bubbling the Shape of a Word



The rationale for bubbling the shapes of words fits within aforementioned research from neuroscience and language. For example, this process effectively translates English words, which are typically broken apart into sounds and letters, into ideograms that incorporate many of the visual aspects associated with Chinese logograms (Hansen, 1993; Xiang-Lam, 2016). It has been hypothesized that helping children acquire the shape of a word – in either English or Chinese – engages dynamic circuits and networks of the brain known to process handwriting (Xiang-Lam, 2016; Yu et al., 2011). Indeed, cognitive scientists have long known that the act of tracing an object records a unique imprint with one's motor memory, where recalling this movement has been shown to help later with visual discrimination (Hulme, 1979).

Xiang-Lam (2016) further postulates that handwriting to acquire the shapes of words might also pay longer-term dividends in activating more advanced brain operations simultaneously. The author writes, "Word form recognition and handwriting gestures involve other brain regions in the frontal premotor and motor areas, suggesting that both streams may be engaged in higher order thinking; or, processes of semantic integration of images with perceptual forms" (p. 68). More generally, these processes describe what the brain does during motor-based movement as it takes raw motor sensory input and meaningfully connects this to existing knowledge-based patterns and concepts.

The process of bubbling around a word has been described as a strategy that is essential for visual thinkers like Kerry to be able to 'see' words on the page. Visual learners are also encouraged to write out their own bubbled shapes of words, when applicable (Rostamizadeh, 2009). This is because looking at the shape of a word has been shown to generate similar types of neural activity as has been found by using handwriting to re-create this shape (Nakamura et al., 2012). As visual thinkers become more skilled at discriminating between word shapes, they can begin to assign meaning to each word (Hulme, 1979). Eventually, visual thinkers like Kerry can learn to generate mental pictures merely by visually perceiving a word in context (Hillesund, 2010). This in turn can lead to strong learning gains later in writing this word. For example, research has demonstrated that when one reads and writes proficiently, their brains simultaneously activate motor regions associated with the production of handwriting that would be used to reconstruct this word on the page (Katanoda et al., 2001). Acquiring the capacity to visually take information off of the page by intuitively understanding what each visual shape (word) means in context takes time, especially for visual learners like Kerry who had not been exposed to this strategy during their childhood.

Though acquiring the capacity to visually discriminate between words was essential on Kerry's journey towards acquiring literacy, this process was merely the first step of many. The next section showcases how the practitioner assigned visual meaning to each word, thus allowing Kerry to understand what each of the shapes meant conceptually.

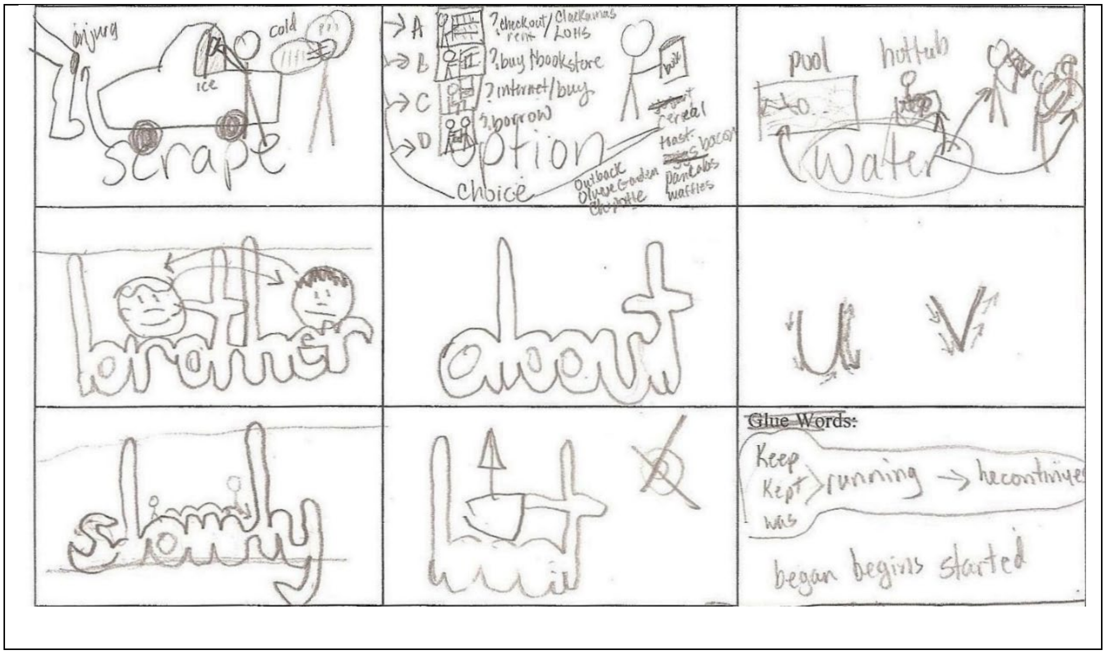
Matching the Shapes of Words to Visual Depictions. According to the practitioner in their notes, acquiring the shapes of words was just the first step in helping Kerry acquire literacy through visual language strategies. From a strictly theoretical perspective, the shape that a word makes only represent a word-pattern that has not yet developed into a concept (Arwood, 2011). As an analogy, memorizing the shape of a word alone would be akin to learning how to discriminate between a square and a triangle without knowing how many sides each shape was comprised of, nor how one might use each of these shapes to build different kinds of structures. This analogy shows that memorizing the shapes of words is a pointless endeavor unless meaning is also attached. In fact, from a neuroscientific perspective, word-patterns can only be discriminated, memorized, and then used for later functionality through the process of attaching meaning to them (Rubin, 2001; Xiang-Lam, 2016). Put another way, the brain cannot see what it does not have language and context for (Arwood, 2011).

To help an individual scaffold a visual word-pattern into a concept, one must show the pupil how this word-pattern is used in multiple contexts. And, as previously specified, each of these contexts must be visually rich so as to provide visual thinkers with enough overlap of conceptual information (Arwood et al., 2015).

According to the practitioner, pictographing is one Viconic Language Method that can be used to attach multiple drawn depictions of a word-pattern in visual different contexts, thus providing for such overlapping of visual patterns. The use of pictographing dates back to ancient cave drawings, but in more modern contexts English words themselves have been described as indivisible pictographic patterns (Lenneberg, 1969). Figure 18 provides an example of how the practitioner utilized pictographing to visually expand and extend the word-patterns of multiple ideas into numerous contexts. Learners who can draw and write on their own are encouraged to draw their own pictographs to accompany word-shapes (Rostamizadeh, 2009).

Figure 18

Example of Visual Pictographing



It is important to note that analyzing the practitioner's case notes established that Kerry acquired more functional language despite the fact that the practitioner did not break down words into sounds and letters nor teach correct parts of speech. Instead, Kerry acquired more functional language because the practitioner made thousands and thousands of visual-contextual semantic refinements when needed during clinical sessions. The practitioner memoed that following this process of attaching visual contextual meaning to the shape of word-patterns helped Kerry redefine their fundamental relationship with words. For example, Kerry had only been instructed how to use words auditorily, which resulted in many examples of borrowed patterns seen in pre-intervention samples. However, over time the practitioner recounted that pictographing allowed Kerry to "see how ideas become words, words become sentences, and books contain ideas that are formed by sentences.” As Kerry began attaching conceptual meaning to more and more clusters of word patterns, this resulted in Kerry reading school textbooks more thoroughly and even hand-constructing their own miniature booklet reports of topics of interest.

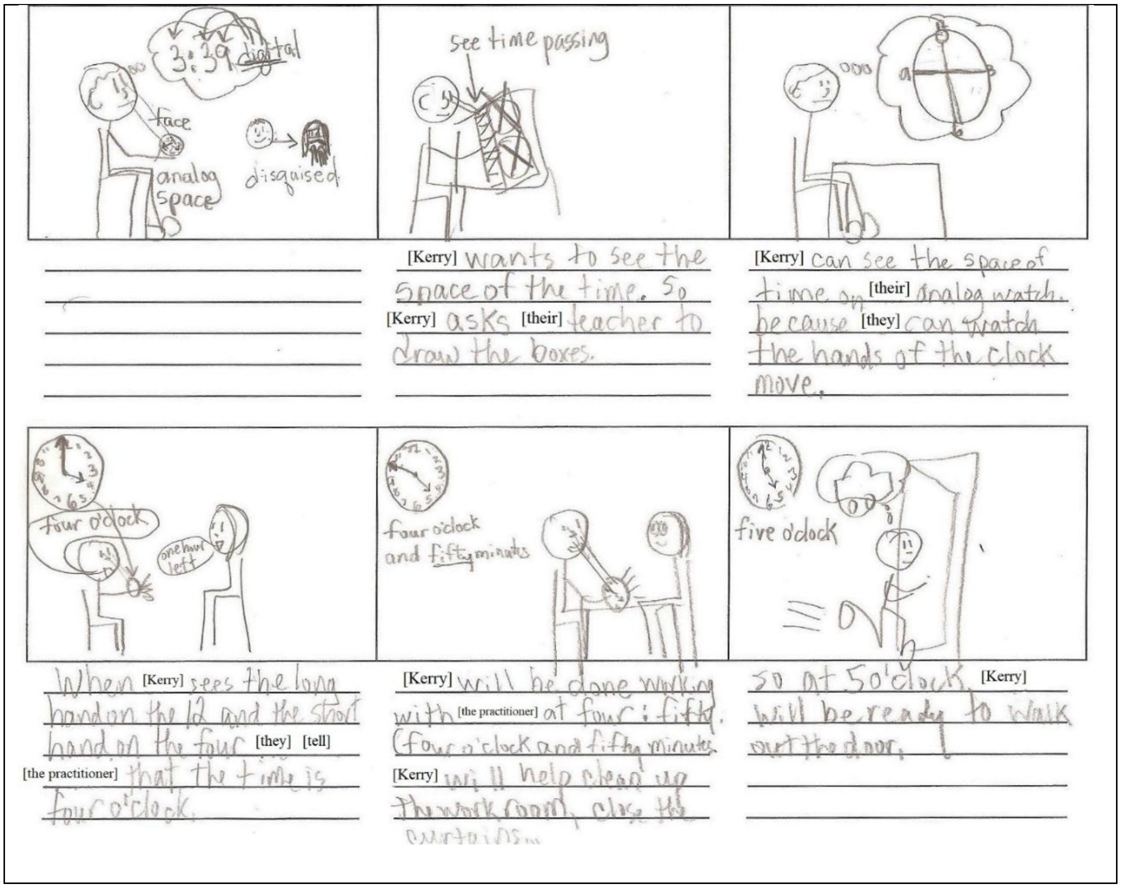
Understanding One’s Own Learning System. Acquiring a greater capacity for literacy and more complex language functioning was an important step in Kerry’s journey towards being able to learn on their own beyond a pattern-based level. In fact, becoming ‘self-literate’ has been described as an indispensable step towards a child cognitively maturing on their path towards self-determination (Hart & Edelstein, 1992). In their memos, the practitioner expressed their recognition that Kerry would acquire the capacity to become self-determined over time only if they were to understand how to help themselves learn on their own. As previously expressed, the overarching philosophy of the clinic setting from this study was not to provide tutoring for clients, but instead to help equip individuals and their family members with strategies that could be used to tap in to the act of learning in the brain through alternative access points. Research from cognitive psychology literature is clear that for a child to meet life’s demands as they age and mature, they must become capable of continuously problem-solving and adapting to unforeseen obstacles (Anderson, 2015). Pre-intervention findings established that Kerry struggled with nearly every aspect of self-sufficiency, including the ability to navigate the schedules of each day – a prerequisite for successfully participating in organized activities such as school. As such, the practitioner recounted that they used the topic of understanding *time* as one entry point for engaging with Kerry in helping them understand the neuro-semantic processes that effectuate learning with a visual brain (Arwood et al., 2015).

As presented in Chapter 2, society primarily operates within an auditory-based culture, which also extends to its intellectual construction of time (McAnally et al., 1994; Grondin, 2010). Recognizing that this prior exposure to concepts of time did not intuitively match the visual strengths of Kerry's learning system, the practitioner specifically spent a large amount of time in sessions helping Kerry better orient themselves in time and space by drawing out multiple overlapping schedules representing aspects of their life. By drawing out how to mark time visuo-spatially rather than relying on auditory conceptualizations of time, the practitioner helped Kerry cross-reference the passage of time through multiple overlapping visual-motor modalities.

Figure 19 showcases an example of the practitioner cross-referencing multiple visual schedules for Kerry to provide sufficient overlapping visual-motor input for their learning system. Debreczeny (2019) explains that helping students 'see' the passage of time as taking up different quantities of space on the page can help some visual thinkers understand that scheduling their day requires drawing out each task and crossing them off as they are completed. When an individual becomes capable of successfully orienting themselves to the passage of time, they can begin the process of self-determination because they can now arrive at events when others expect them, among other considerations.

Figure 19

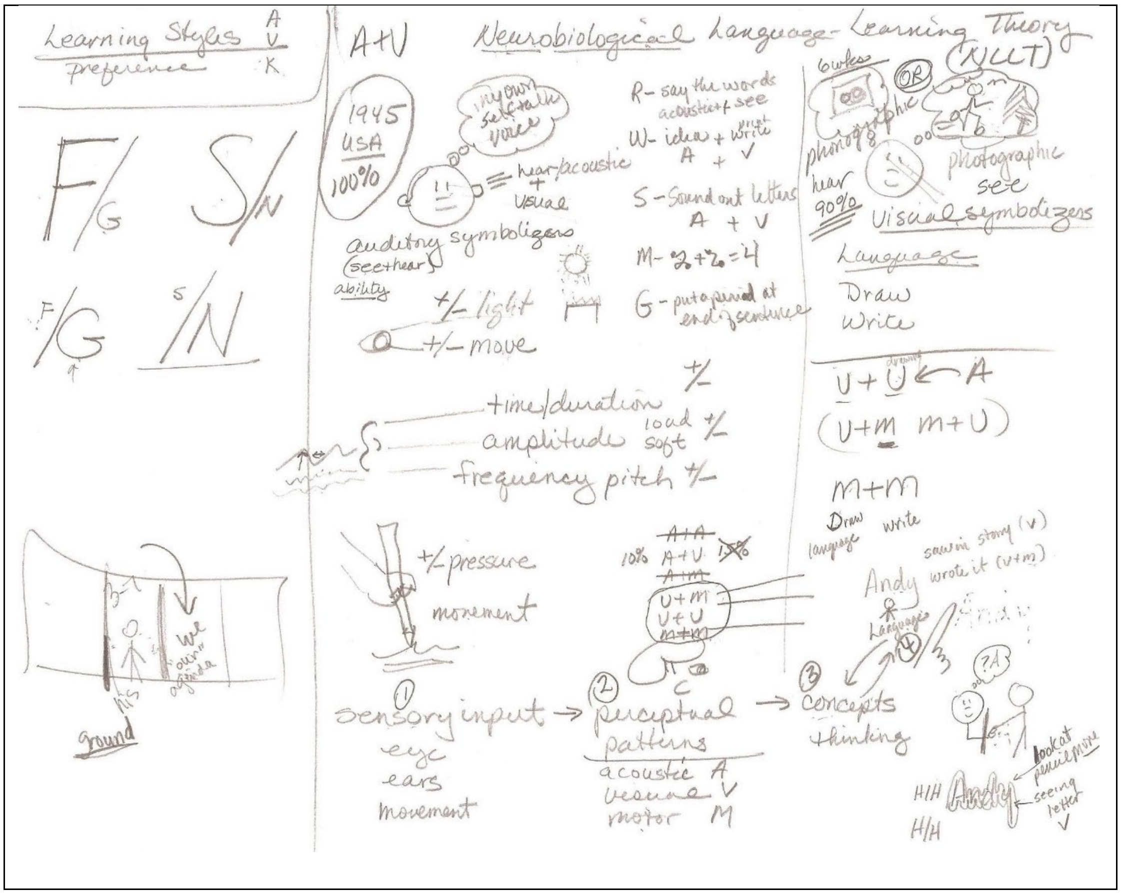
Cross-Referencing Time as Quantities of Space



Helping Kerry better access concepts of time also helped them realize that successfully engaging in life requires one to participate in different societal expectations occurring at different points in time within one's life. Evidence for this was found in the Chapter 4 artifact in which Kerry first drew and wrote about their goals for obtaining enough credits to graduate school. To best help Kerry plan for these expectations and engage in problem-solving when complications arise, the practitioner continued helping Kerry become self-determined by drawing out what it means to function with a visual neurobiological learning system. While viewing this finished product may appear to be visually overwhelming to the reader, it should be noted that each aspect of this image was drawn out slowly and methodically with Kerry. Thus, the narrative would have unfolded in real time and potentially over multiple sessions. Figure 20 shows an example of the practitioner drawing out the Neuro-Semantic Language Learning Theory (Arwood, 2011) for Kerry during their sessions.

Figure 20

Drawing Out the Neuro-Semantic Language Learning Theory



The strategies depicted in this section helped Kerry on their journey from translating the auditory properties inherent within the English language into content that could more easily be acquired by their visual learning system. These Viconic Language Methods added to the theoretical groundwork previously explored during the hand-eye-brain connections. Next, additional strategies are depicted that were used with Kerry to help apply their newfound capacity for learning in novel settings, environments, and social contexts.

Strategies for Developing Pro-Social Thinking. Individuals at the preoperational stage of development engage in egocentric thinking, where they regularly do not consider the needs of others (Piaget, 1959; Vygotsky, 1962). Chapter 4 established that at the beginning of the study Kerry operated at a very low preoperational level of linguistic, cognitive, and social-emotional functioning that could not be considered pro-social because they did not initiate and maintain healthy relationships with others (Hockett, 1960; Smith, 1985). In recent years, many schools have invested heavily in progressive intervention efforts that are designed to help individuals like Kerry learn how to successfully integrate into multiple environments and become pro-social with peers over time (Friend, 2018). These programs have honorable intentions of helping students with developmental disabilities learn how to socialize in a positive manner. Despite this, these efforts require participants to function in at least a concrete level of development to take part in the proceedings, which much literature has established does not represent the reality of these populations (McCroskery, 2000; Walker et al., 2011).

Arwood's Neuro-Education Model was the only therapy-based intervention system found in the review of literature that directly accounted for students' level of language functioning and provided a series of intervention strategies that were designed to help educators raise their students' thinking from a preoperational to a concrete level over time. This section explores how the practitioner utilized Viconic Language Methods to help Kerry acquire greater pro-social functioning in their life. In particular, the following strategies are presented: (a) drawing social rules, and (b) engaging in semantic refinements through writing.

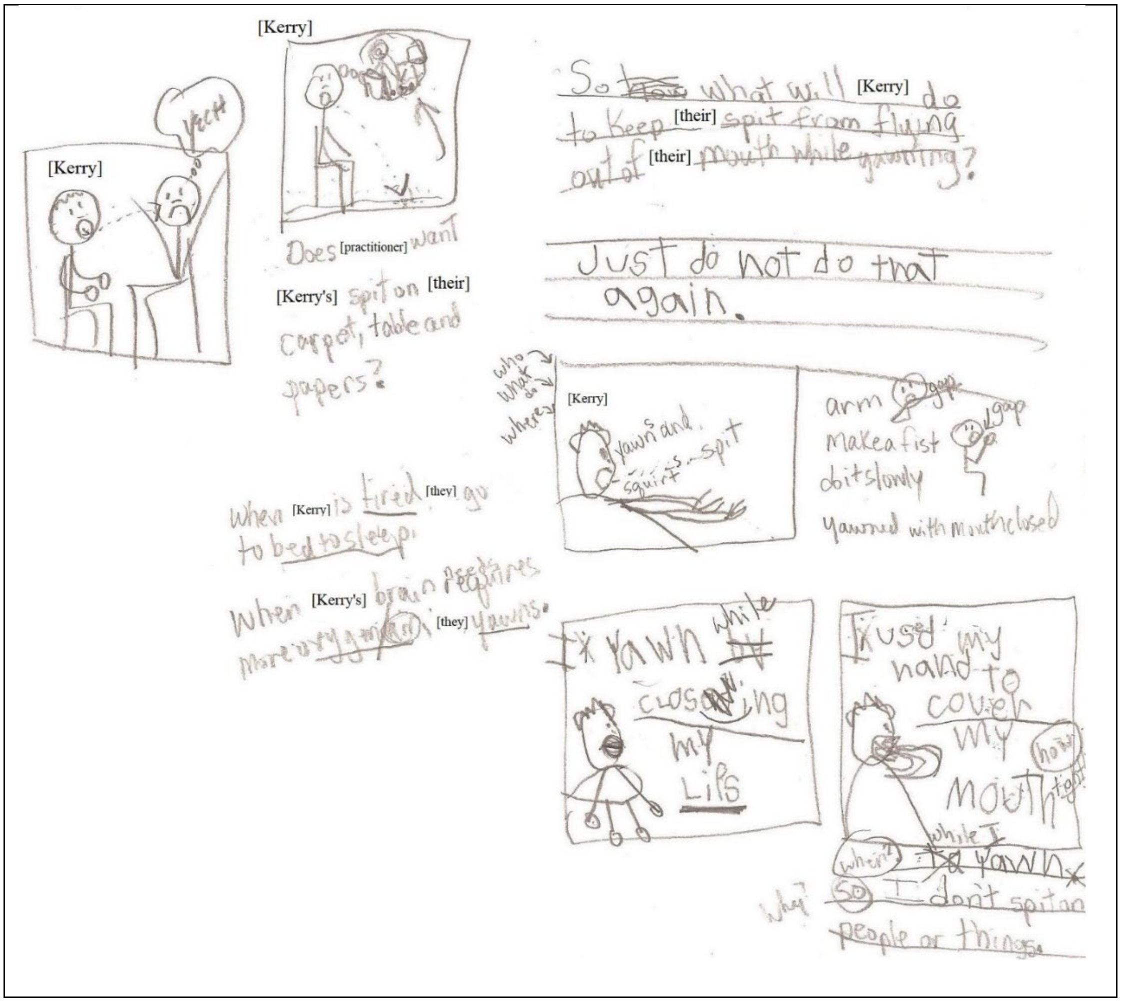
Drawing Social Rules. The successful understanding of social rules takes a tremendous amount of time and is not expected to occur in most typically developed children until they reach the age of seven (Epley et al., 2004; Kopp, 2011). Understandably, individuals like Kerry, who struggle to make meaning from auditory-based instruction, find it ever more challenging to understand social rules and engage in perspective taking when the world around them is inherently confusing to them (Shaffer & Kipp, 2013). An analysis of Kerry's behavior established that Kerry struggled in life with the pragmatics of language, or the system for conducting social communication while functioning within societal norms (Graves, 1986). Understanding the pragmatics of language is essential for competent language functioning, as these processes are involved in the sharing meaning with others (Searle, 1969). In addition, pragmatics are grounded in semantic rules and functions (Arwood, 2011).

During their sessions, the practitioner helped Kerry acquire a more functional relationship with the pragmatics of social norms and communication by borrowing from real-life events that occurred in Kerry's life in order to draw out social rules and expectations for pro-social behavior in multiple settings. The practitioner explained that the goal of these efforts was to help Kerry acquire anticipated rules and conventions for acting as an agent amongst other agents in the world. In their evaluation report, the practitioner explained why it was important for them to draw out each social rule that needed to be addressed. "[Kerry] will benefit from having rules for perspective taking and social interactions developed in a different way," they wrote. "For example, we draw out where [they] stand, where [they] sit, what [they] can touch, when [they] can speak at the various offices/homes/places that [they] visit, and so forth… AND we draw these in the context of how [Kerry's] words and actions affect other people." Later, the practitioner clarified that when drawing out these ideas, "Be sure to draw other people in all cartoons and include their feelings, wants, and needs. Make sure to use thought bubbles [to visually depict what others are thinking about]."

Figure 21 provides a visual example of the practitioner drawing out a series of social conventions to help Kerry learn how to act like an agent in the world. In their case notes, the practitioner described how Kerry would occasionally allow saliva to leak from their mouth onto the table or floor – an act commonly referred to as spitting when the individual engages in this action with intentionality. To help Kerry understand that the practitioner would need to clean up any saliva that came out of Kerry's mouth, the practitioner drew out how Kerry's actions affected them and what potential solutions might be agreed upon so that the needs of both parties were met. This drawing was one of many in which the practitioner assigned social meaning to Kerry's actions through visual modalities. In fact, the practitioner shared that they often drew with Kerry about one social event for multiple therapy sessions in order to account for multiple cognitive perspectives on what had transpired.

Figure 21

Drawing Out Social Conventions



It is important to notice that during the processes depicted in Figure 21, the practitioner provided Kerry with a series of pro-social choices for how they could remedy the unpleasant situation. Scholars have also long argued that for children to make progress in social-emotional development, they must be provided the opportunity to choose different paths of action from a series of valid options (Taylor, 1985). The capacity to choose is also an essential part of shifting one's locus of control from external to internal constructions (Rotter, 1966). Importantly, Green-Mitchell (2016) adds that the choices that are provided to children are not valid if they are not fully comprehended; these will not lead to pro-social outcomes. It is equally important to understand that visual thinkers such as Kerry require their choices to be drawn out for them in order for them to understand which option will lead to pro-social harmony between agents (Jaskowiak, 2018).

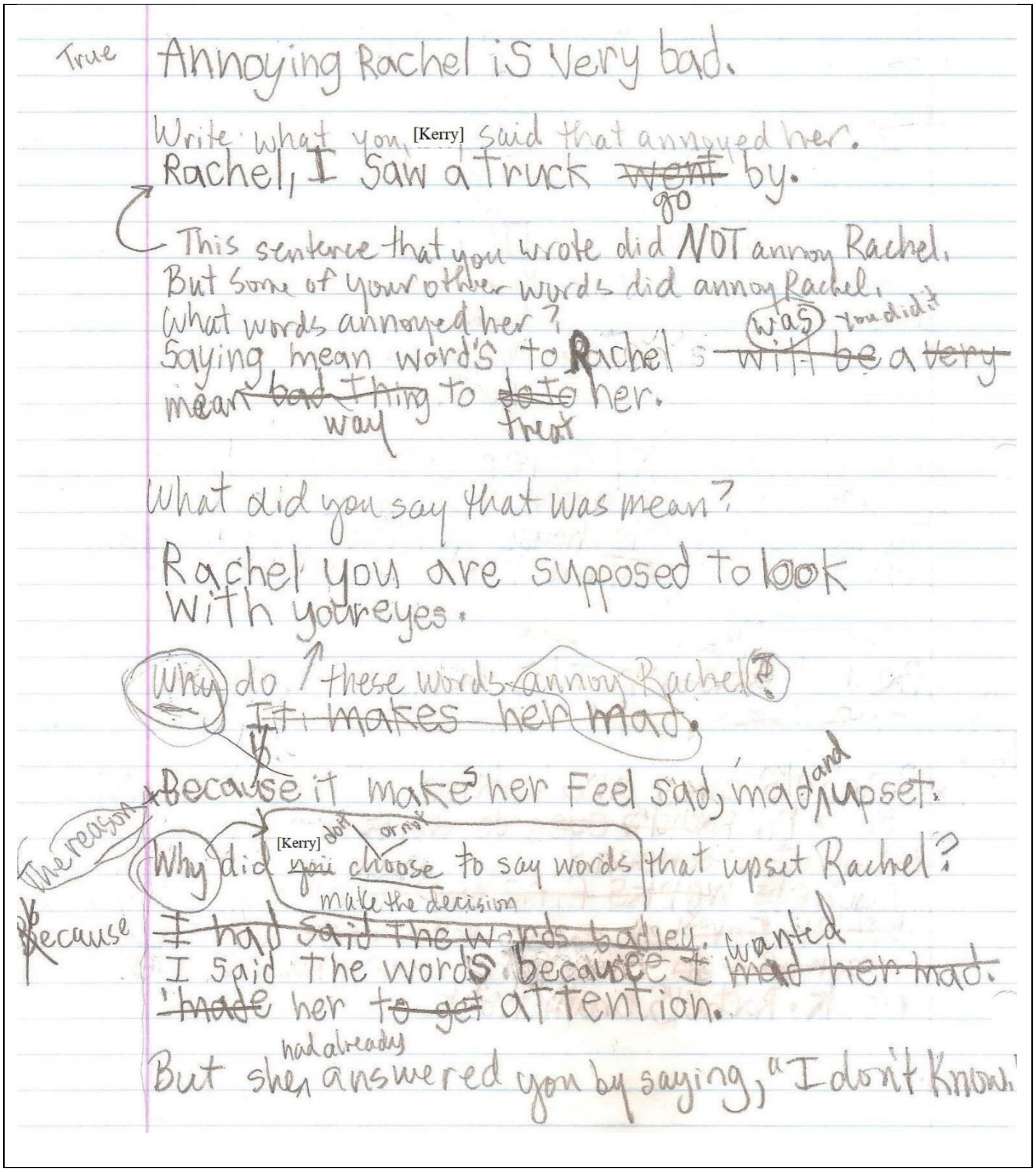
The practitioner summarized their approach to helping Kerry acquire the capacity to make pro-social choices through Neuro-Education methods by memoing, "[Kerry] will benefit from understanding that [they] have a CHOICE on how [they] react or respond to [their] problems. [They] also will benefit from seeing on paper how [their] CHOICES affect others (both positively and negatively)." Over time, the practitioner explained how this process would yield greater social intelligence in perspective taking by writing, "[Kerry] can refer to the information shown in cartoon sequences so [they] can visually match [their] behavior to the drawn behavioral expectations. Through the drawn examples [they] will be able to see (visual pattern) what [they] are to do (motor pattern) and then do (motor pattern) what [they] see (visual pattern). By drawing [Kerry] from another person's perspective (e.g., what other people see [them] do) as well as showing [them] what others think (thought bubbles) and say (speech bubbles) about [their] behavior, [they] will begin to understand the perspective of other people."

Ultimately, artifacts that Kerry created at the end of the study demonstrated a significant leap in progress in pro-social thinking and understanding that the needs of others are important. These results speak to the potential for social-emotional therapy to impact change upon students with developmental disabilities when varying levels of development and language functioning are taken into account during the therapeutic process.

Semantic Refinements Through Writing. Just as drawing out social rules was a powerful cognitive force that initiated pro-social change for Kerry, the act of writing also served many functional purposes in therapy. Primarily, asking Kerry to draw and write their ideas, rather than speak them out loud, provided for a more semantically accurate assessment of Kerry's current understanding on a topic. After Kerry had written out their version of their ideas, the practitioner would use this opportunity to engage in a multitude of semantic refinements. Figure 22 displays an example of the practitioner providing therapeutic clarity to Kerry's actions that had occurred during a disagreement while at school.

Figure 22

Example of Writing out Social Norms


True
Annoying Rachel is very bad.
Write what you [Kerry] said that annoyed her.
Rachel, I saw a truck ~~went~~ go by.
This sentence that you wrote did NOT annoy Rachel.
But some of your other words did annoy Rachel.
What words annoyed her?
Saying mean word's to Rachel ~~will be~~ was a ~~very~~ mean ~~bad thing~~ way to ~~do to~~ treat her. You did it
What did you say that was mean?
Rachel you are supposed to look with your eyes.
Why do these words annoy Rachel?
~~It makes her mad.~~
Because it makes her feel sad, mad and upset.
The reason
Why did [Kerry] ~~you~~ don't or not choose make the decision to say words that upset Rachel?
Because
~~I had said the words badley.~~
I said the words because I wanted ~~mad her mad.~~
~~made~~ her ~~to get~~ attention.
But she had already answered you by saying, "I don't know."

The example presented in Figure 22 provides a plethora of ways that the practitioner used the mark making associated with visual language and symbols to help Kerry understand how their actions affected one of their classmates. Notably, this page represents only 1 of 3 total pages documenting this visual conversation. Linguistically, the practitioner utilized much relational language to establish clear social guidelines and boundaries for Kerry. Acquiring a thorough understanding of such boundaries and conventions has been described as essential for children to know what is socially accepted at which times and in which places (Meleis, 2010).

In their memos, the practitioner realized that they needed to rewind back through Kerry's life all the way to their early childhood and re-write many of the processes of socialization that a typically developed child might process automatically through the oral language of their parents. As explained, Kerry's parents had tried to teach Kerry these concepts, and Kerry had participated in many types of therapies and remediations, but these efforts had not helped Kerry to acquire pro-social conceptual understandings. The practitioner understood that it was their responsibility to help Kerry develop greater pro-social thinking through a modality that their brain could definitively process.

Although utilizing oral language with Kerry did not lead to fruitful gains in pro-social thinking, writing down conversations on the page proved to be much more successful. This is because writing bypassed Kerry's auditory channels and instead overlapped visual and movement modalities that were more meaningful to Kerry's brain (Arwood, 2011; Hillesund, 2010). The practitioner shared that during these back-and-forth written conversations, the use of any oral language was supplementary to the written content, not in place of this writing. The use of this process led to the overall increase of complexity in Kerry's written ideas over time such as was previously depicted in the pre/post artifacts.

From the perspective of acquiring literacy in the brain, helping a child to semantically refine their writing provides for more conceptual meaning to be assigned to a topic (Arwood, 1991). Moreover, asking a child to write their ideas frequently unveils a more authentic record of their understanding than just using speech alone (Hockett, 1960). The practitioner understood that with enough time, Kerry's brain could process their external semantic refinements and eventually scaffold towards higher internal language functioning (Gallucci et al., 2010). According to relevant literature, however, this internal semantic refinement would not have happened without hundreds and hundreds of drawing and writing opportunities provided by the practitioner to help Kerry see how their actions affected other people and decipher what choices would lead to greater pro-social outcomes (Green-Mitchell, 2016; Jaskowiak, 2018; Vallacher & Wegner, 1989).

Summary of Neuro-Education Rationale for Provided Strategies

The preceding sections identified multiple Neuro-Education based Viconic Language Methods utilized by the practitioner to help Kerry learn. Reviewing relevant literature for this study revealed that the use of these specific methods is highly uncommon in traditional school or private intervention-based settings. Moreover, scholars have observed that many special educators continue to use remediation methods that are devoid of, and unsupported by academic theories of learning (Klaver et al., 2016). A failure to ground educational practices in theory does not benefit the educator or the learner (Vaughn et al., 2002).

The use of these Viconic Language Methods can truly be described as a translation from educational theory into educational practice (Arwood & Merideth, 2017). This is because the use of each of these strategies can be directly substantiated by the research that informed the grounded theories of the Neuro-Semantic Language Learning Theory (Arwood, 2011), and Arwood's Neuro-Education Model (Arwood, 2011; Arwood & Merideth, 2017; Robb, 2016). Contributing literature presented in this section chronicled that the use of these methods has been shown to provide for alternative access points into the brain, thus harnessing the brain's inherent neuroplastic capacity to adapt and evolve once sensory input becomes meaningful again (Li et al., 2014; Doidge, 2007).

As previously stated, this study was not experimental by design, and therefore any hypothesized ideas of causation could not be methodologically confirmed. Nevertheless, because it can be concluded that Kerry did not receive these Viconic Language Methods at all outside of the clinic setting, the changes that they exhibited in this study may be conceptually attributed to their exposure to these Neuro-Education based interventions. To be more precise, receiving the Neuro-Education based interventions appeared to re-start the processes associated with Kerry's learning, as reflected through their language and hypothesized by changes in their brain and mind. These changes in learning are proposed to have served as the catalyst for additional changes in development and quality of life to have continued occurring. Without receiving this intervention, it would appear as though Kerry's learning and development would have continued to remain stagnant, as had previously been reflected in their childhood prior to age 16 and the onset of this study.

Thus, combining the findings presented in Chapter 4 with the theory and brain-based applications presented in this chapter definitively yields the working hypothesis that Kerry changed in the ways they did in the largest part due to the Neuro-Education interventions they received. Though alternative explanations for these changes are hypothetically possible, the arguments made thus far in this study demonstrate that such alternative explanations would be highly improbable.

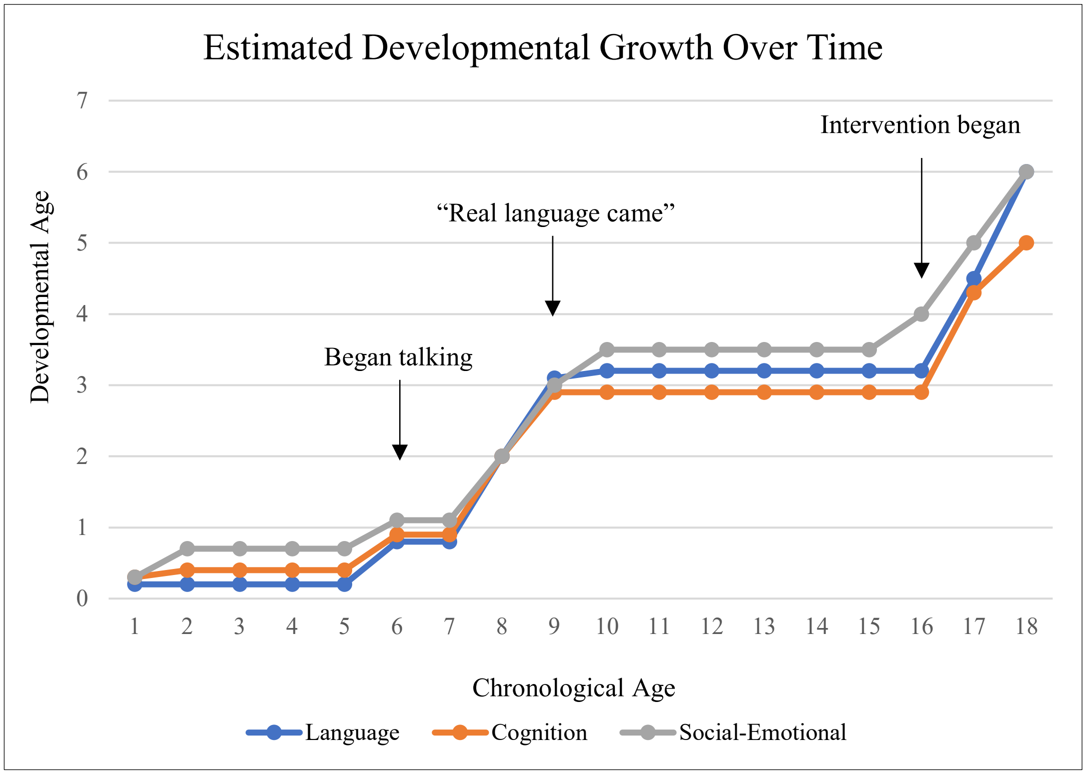
Closely analyzing the changes that Kerry exhibited while in the clinic setting and comparing this progress to findings from relevant literature generated a few select aphorisms that can be used to describe the broad stroke processes that exemplify human learning. These new understandings regarding the nature of human learning are presented in the next two sections.

Findings Related to Relevant Literature

By all measures used for this study, Kerry made substantial progressions in their learning and development that were clearly identifiable and definitively demarcated. When comparing Kerry’s progress in learning and development against age-based developmental milestones, results demonstrated that over the course of 2 years between the onset and the terminus of the study Kerry experienced approximately 3 years of growth in language development, 2 years of growth in cognitive development, and 3 years of growth in social-emotional development. Figure 23 shows the estimated changes in developmental functioning that Kerry experienced throughout their lifetime, beginning at birth, and ending with the end-point of the study. (Notably, any age-based estimates presented in Figure 23 before the start of the study were generated only through educated inferences taken from parental self report and from the results of the practitioner interview. Therefore, these inferences could not be independently verified).

Figure 23

Summary of Developmental Growth by Age



Note. This figure presents an estimated developmental trajectory based solely upon reported information that could not be independently verified.

Figure 23 graphically purports that between the ages of 9 and 16 Kerry made extant progress in language, cognitive, and social-emotional domains. Once Neuro-Education intervention began at age 16, however, multiple years of developmental growth began to materialize in the ways previously cataloged in this chapter. The fact that Kerry experienced multiple years of developmental growth and learning after remaining stagnant in their learning for numerous years might be considered as unexpected to scholars who study the growth trajectories of students with developmental disabilities (Ayres et al., 2011; Morningstar et al., 2017). This phenomenon is covered in further detail in a later section of this chapter.

Despite the noticeable changes in learning and development presented in Chapter 4, end-point artifacts and practitioner report established that Kerry remained fully situated within the preoperational stage of development at the terminus of the study (Kohlberg, 1983; Meilinger & Vosgerau, 2010). Final analysis indicated that Kerry remained approximately 12- to 13- years delayed below chronological a priori expectations in each developmental domain.

Simultaneously, Kerry made larger jumps in their progression of learning-based functions, shifting from pre-language function to high preoperational function that occasionally bordered on concrete thinking (Meilinger & Vosgerau, 2010). The fact that Kerry exhibited concrete levels of thinking, even only for certain glimpses and facets of their life, suggested that Kerry made approximately 4-5 years of progress in some aspects of their language functioning. Comprehending why these changes might have occurred requires an understanding of how both learning and development are currently measured within society. This topic is further explored next.

Learning Versus Developmental Progress

To best understand the phenomenon of why an individual such as Kerry made more growth in learning functionality rather than developmental progress, one must consider the nature of how these two foundational processes are understood in the canon of relevant literature. For example, using age-based developmental milestones serves many valuable purposes, such as providing reference points for the kinds of skills and aptitudes that typically developed children tend to acquire at different stages of their lives. By age eight, however, children who can use their learning systems to function are expected to have acquired a full grammar, meaning that the products that they produce typically demonstrate hallmarks associated with semantically accurate oral language, writing, and drawings (Nelson, 1981). From this vantage point, measuring changes in children's development past the concrete stage of development becomes a less granular and less task-specific operation. Instead of identifying many of the building blocks that scaffold towards the acquisition of accurate grammar and artistic representations, measurements of development in older adolescents observe how these individuals begin refining their own ideas as they develop functional autonomy (Ahearn, 2001). In short, the developmental changes that children exhibit become more challenging to demarcate as they grow older.

The process of learning, on the other hand, begins at the moment of birth and continues throughout one's entire lifetime (Burbules, 2013). Arwood (2011) describes learning as a spiral that is never finished because individuals can acquire new ideas at any time and continue to mentally complexify conceptual understandings of existing ideas in the mind long into adulthood (Ismael, 2015). This is one reason why the act of learning has been described as a latent variable that is inherently difficult to measure in others (Muijs, 2011). Though learning cannot be measured directly (Didau, 2016), the act of learning nevertheless can be indirectly 'seen' in individuals such as Kerry who change over time in fundamental ways and in functional capacities (Norman, 1991).

Comparing the progress that Kerry made in learning and development beyond the level of specificity provided by developmental milestones may be an impracticable endeavor. This is because every student is by nature born with a unique learning system, and each child accumulates different life experiences as a result of being raised in heterogenous environments (Squire et al., 2014). Moreover, the developmental trajectory of each student is inherently different due to the complex synergy between their genetic composition and their environmental influences (Baars & Gage, 2010). What this means in the broadest sense is that accounting for the forces of both nature and nurture on the developmental progress that a student has made can be prohibitively challenging (Sameroff, 2010).

The paradoxical relationship between learning and development has been described as a conundrum that each academic discipline has grappled with by using different viewpoints and strategies (Dosman et al., 2012). On a macro level, this paradox strikes at the heart of why translational disciplines such as Neuro-Education continue to call for greater interprofessional collaboration between scientists, academics, educators, and other professionals (Arwood & Merideth, 2017; Feiler & Stabio, 2018). The purpose of collaboration may provide additional vantage points upon a topic, metaphorically represented as a three-dimensional box. When using only one academic lens, one vantage point for example, individuals may clearly see two-thirds of the box; but, the capacity to see the rest of the box requires one to step into a different academic world and view the box from the other direction. This metaphor succinctly describes both the complexity and the potential benefits of viewing the interconnectedness of learning and development from multiple disciplines simultaneously.

Though comparing Kerry's progress to findings from related literature remained to be a challenging endeavor, engaging in these philosophical inquiries nevertheless uncovered additional insights about the nature of human learning and development. These realizations in turn yielded numerous practical implications that could be gleaned from the results of this study. These potential implications are further covered next.

Practical Implications of the Study

The phenomenological quintessence of what it means to have a developmental disability is not well understood, nor it is agreed upon in our society (Cosier & Pearson, 2016). As a result, professionals who work with this population continue to pull in opposite directions from each other, each thinking they are making progress. On the one hand, individuals who follow a medical model of cataloging deficits claim that these students need skill-based remediation, while on the other hand disability scholars argue that this population needs more advocacy over their own lives through self-determination (Society for Disability Studies, 2019). Moreover, academic literature has yet to find consensus definitions on what constitutes human learning and development (Degener, 2006; Illeris, 2018; Masadeh, 2012). Though research from neuroscience and psychology is beginning to affirm that the brain may possess additional strengths for learning that have yet to be fully harnessed (Battro, 2010), special educators in schools still utilize status quo methods based upon dated theories such as behaviorism, psycholinguistics, and direct instruction (Klaver et al., 2016; Wood & Shears, 2018).

Closely analyzing the changes that Kerry exhibited in their learning and development over time uncovered numerous insights into how these two processes might be better understood by researchers, scientists, and academics. This section documents new understandings regarding human learning and development that were realized throughout this study. These insights may provide inspiration for future educators to use an entirely different, holistic path in order to better help students with developmental disabilities learn; and, therefore become more fully integrated into comprehensive classrooms at much higher rates.

Learning is Neuro-Semantic

Research is clear that children do not develop automatically (Piaget, 1964; Walker et al., 2011). Although this axiom is claimed to be understood by academics and educators in society, leaders from both of these populations still continue to compare *all* students' developmental progress to neurotypical children (Overton, 2016; Walker, 2014). In practice, this means that children who are not learning are simply thought to need 'more' quantities of instruction, even though these previous methods had not been successful (Buntinx, 2013; Harry & Klingner, 2007). According to the Neuro-Semantic Language Learning Theory (NsLLT - Arwood, 2011), however, development can only occur when neurobiological learning is meaningful to the child. This means that the developmental products a child creates, such as drawings and writing, can only change as a result of changes to their processes of learning. Expecting a child like Kerry to change simply by providing them 'more' of the same kinds of instruction is a grave misuse of educational resources and a waste of precious time for learning to occur.

From the perspective of the NsLLT, before intervention began Kerry could only learn utilizing sub-cortical regions of their brain. This equated only to rudimentary, pattern-based, two-tiered levels of learning that left Kerry with highly restricted levels of language function and thinking (Arwood, 2011). Unfortunately, our current educational system continues to produce many, many kinds of children who are just like Kerry. Academic literature is filled with numerous examples of young individuals who progress through school with the capacity to memorize large quantities of information but cannot operationalize this knowledge into successful life functionality (Arwood et al., 2015; Treffert, 2009). Memorizing information, but not being able to apply it into practice, does not equip children for long-term academic or social successes in their lives (Treffert, 2009).

Instead, for individuals to learn conceptually, Arwood (2011) explains that humans must be able to process neurobiological information at the third and fourth tiers of learning if they wish for this knowledge to stick with them indefinitely. This is because language is acquired in the brain through a series of neuro-semantic steps at four interconnected levels (Arwood, 2011). In this view, to truly learn something beyond a pattern-based level, individuals must find a way to attach new incoming information to existing semantic information in a way that is uniquely meaningful to each person. This is the type of conceptual learning that Kerry began engaging in during their clinical sessions after their brain had remained functionally dormant for the majority of their childhood.

Results from the end of the study demonstrated that Kerry experienced this kind of conceptual learning as a result of acquiring increased amounts of meaningful language. Arwood (2011) explains that the more developed our concepts become, the more our language abilities will evolve. In addition, the richer and more complex our language becomes, the more advanced our thinking can become. In the brain, neuronal circuits can continue to connect to other neuronal circuits in an infinite number of biological configurations (Baars & Gage, 2010). Therefore, learning at the third tier – called *conceptual learning* – is by definition never finished (Burbules, 2013). This principle explains why Kerry experienced certain setbacks, such as dropping developmental levels from time-to-time, while they nevertheless made global intellectual progress that steadily continued to complexify over time. Put another way, though learning consists of a set of neuro-semantic steps, these steps are not linear by nature (Ismael, 2015; Meleis, 2010).

At some point during the middle of the study, Kerry appeared to make the transformational shift from relying on adults to bestow them all of the information in their life to fostering the capacity to begin slowly learning on their own. Accordingly, in order for someone to continue to refine their own thinking over time, their brain must be able to provide its own semantic feedback through reflection and metacognition (Arwood, 2011). How proficiently someone uses the feedback system of their own mind can be reflected in the semantic and pragmatic language functions they exhibit (Robb, 2016). In the case of this study, these semantic and pragmatic language functions were measured through the changes in the artifacts that Kerry created.

Towards the end of the intervention phases, Kerry experienced substantial progress in each area of language functioning. This was purportedly achieved in

Kerry's brain when third-tier circuits overlapped to form meaningful fourth-tier networks, or endlessly complex pathways of circuits for electrochemicals to flow through (Pulvermüller, 2013). Such changes in the brain resulted in new observable conceptual understandings of Kerry's world. Kerry experienced continuously new semantic feedback in the brain in a constant back-and-forth exchange of language between the third and fourth tiers of learning. This can be hypothesized because without such feedback, humans cannot deepen their understanding of how they connect to the reality around them (Arwood, 2011).

From a zoomed-out perspective, one can make the convincing argument that Kerry began to learn beyond a pattern-based level because their brain had rewired and reconnected itself in innovative ways. This reconnection with learning is precisely what educators strive to achieve with *all* of their students, but especially for those students who have greatly struggled to learn in the past. As such, the phenomenon of how Kerry's brain figured out how to re-wire itself for greater overall functionality warrants further exploration.

Reconnecting Children's Brains

Once Kerry began receiving Neuro-Education interventions at the start of the time period for this study, their brain appeared to be making up for years of lost time in learning. When a child does not learn, for any reason, they remain starkly at risk of becoming 'developmentally stuck in time,' meaning that their bodies mature while their language, cognitive, and social functioning do not (McCroskery, 2000). Kaulitz (Arwood et al., 2018) describes these individuals as 'locked in learners,' in that conventional teaching methods do not appear to alter their comportment in consequential ways.

Crucially, literature demonstrates that children experience specialized periods of brain development, where neuronal connections proliferate rapidly and are then pruned for maximum neurobiological efficiency (Baars & Gage, 2010). Simpler neural connections typically form first during this time period, but more complex circuitry associated with higher order cognitive functions continue to grow rapidly until at least age 5 or 6 (Shaffer & Kipp, 2013). Functionally, this means that children who cannot effectively process provided sensory input during these critical time periods are precluded from acquiring the neurobiological building blocks needed to learn past rudimentary conceptualizations of the world (Squire et al., 2014). Indeed, some severely impacted students whose brains can only process a fraction of the sensory input around them never progress past the facets of developmental functioning most closely associated with toddlerhood (Arwood et al., 2018).

Kerry's story provides an insight into what might have happened had they began receiving brain-compatible interventions from a much earlier age. The inherent neuroplasticity of the brain means that it can continuously reorganize itself to form new functional neuronal connections when previous pathways may have been previously interrupted (Li et al., 2014). Numerous stories exist of individuals harnessing the power of neuroplasticity to change their lives, such as young adults overcoming dyslexia or patients who had experienced a stroke learning how to speak again (Doidge, 2007). Kerry's case would appear to be one of these stories.

Essentially, the brain can only change its functionality when it receives input in a manner it can process. Therefore, not all types of sensory input are created equal, which means that merely exposing children with learning differences to conventional auditory teaching methods will not likely help them learn and develop (Arwood, 2011). Because the brains of every human process sensory input differently, this inherently means that all perceptions are valid (Gilley, Dean, & Bierema, 2001). But, because no two children experience the world the same way, this also means that educators must provide student-centered opportunities – informed by the process of deixis – that are not one-sized-fits all in order to truly help pupils learn.

The potential for utilizing the process of student-centered deixis to transform one's own teaching practices cannot be overstated (Arwood, 2011; Todisco et al., 2020). For example, when educators understand that each child must start where they are developmentally in order for them to neurobiologically attune to provided information, this illuminates that many of the 'one size fits all' direct instruction approaches cannot be considered truly individualized to the brains of each pupil (Klaver et al., 2016; Wood & Shears, 2018). Moreover, this study illuminated that carefully assessing students through the process of deixis rather than testing them on standardized metrics reveals many more exacting insights into how individuals learn best. In turn, these realizations cause one to reflect upon whether current special education practices might be transformed in order to better serve those students who have struggled to learn. These thought experiments are further explored next.

Re-Thinking Special Education Practices

Findings from this study may in particular help special educators to re-think how well their current practices match what is known about the brains of visual thinkers. This section argues that the field of special education could substantially benefit from the calls to action argued by disability scholars, where interventions would truly become student-centered and targeted towards meeting the language learning needs of each unique individual (Hornby, 2015; Kapp et al., 2013; Simpson, 2004).

More is not Always More. Chapter 2 established that students with moderate-to-severe developmental disabilities are served primarily in secluded life skills classrooms where they spend only a fraction of their school day working on academics (Bobzien, 2014; Katz & Mirenda, 2002). Moreover, the rigor and quality of the academics that these students receive has been called into question by scholars (Boutot & Bryant, 2005). When students are not meeting their IEP goals, current federal mandates dictate that their overall instruction hours be increased in an effort to better meet desired learning targets (Friend, 2018). Though providing students with more hours of academics may seem like a good idea on paper, the brains of these children may or may not benefit much from these increased hours because the brain can only fire when the provided sensory input is meaningful (Baars & Gage, 2010).

Comparing the substantial amount of progress that Kerry experienced in learning and development while receiving Neuro-Education interventions against the progress they made in their life prior to attending the clinic setting revealed noteworthy discoveries suggesting that the *quality* of instruction that children receive

– not the quantity – is ultimately of most importance (Berns, 2016; Gallagher, 2004; Vaughn et al., 2002). By all accounts, Kerry was a child who grew up in an educational system that did not understand how to help them learn and therefore become self-determined. During these years, Kerry was enrolled in special education classrooms where a conservative calculation estimates that they received a total of 5,000 hours in these settings over the course of 7 years (NCES, 2018). According to Bobzien (2014), students with severe disabilities who spend the majority of their time in life skills classrooms might be expected to spend approximately 40% of their day working on academics. Taking this statistic into account would yield a rough estimate of Kerry receiving approximately 2,000 hours of academic-specific instructional time while in school between the ages of nine and sixteen. By parental and practitioner report, Kerry was not academically successful or socially connected in school during this time frame. Moreover, it appeared that the gap between Kerry's chronological and function age widened each year during Kerry's childhood (see Figure 23 previously presented above).

This developmental trajectory changed radically, however, once Kerry began receiving Neuro-Education interventions. Though Kerry did not make it to the concrete level of developmental functioning within 2 years, the learning path that they embarked upon from the onset of the study could be categorized as surprising and inspiring. Most poignantly, Kerry made 2-3 years of developmental and functional progress within a 2-year period after receiving 458 hours of therapy. This resulted in the gap between their chronological age and their development ceasing to widen further during this time; in some cases, this gap shrank. Even more surprising was that

Kerry made significant progress in social-emotional function despite participating in only 1/10th of total socialization time in the clinic compared to their previous schooling.

It should be noted that Kerry continued to attend special education classes while enrolled in the clinic setting; thus, the influence that these settings had upon Kerry may be considered as a confounding variable. Nevertheless, the developmental and functional progress that Kerry made while in the clinic setting might be described as unanticipated to scholars who regularly study students with moderate-to-severe developmental disabilities (Ayres et al., 2011; Morningstar et al., 2017). This is because many of these students struggle to make substantial academic and social progress while being served in these settings (Katz & Mirenda, 2002). The surprising amount of progress that Kerry made during a relatively short amount of time in their life speaks to the potential changes that can occur within individuals when their brains become reengaged with learning. Moreover, these findings clearly demonstrated that neither exposing Kerry to schooling – nor increasing the quantity of instruction they received in their life skills classrooms – adequately met their needs. As such, Kerry made very little progress before intervention began on acquiring greater functional self-determination, a goal that disability scholars have advocated should be a priority for all individuals with disabilities (Morningstar et al., 2017).

Acquiring Self-Determination Above All Else. Though many disability scholars have numerous objections to the current ways that special education is provided in this country, one area of consensus among most advocates is that the ultimate goal when working with students who have developmental disabilities should be to help them become self-determined throughout their lives to the best of their abilities (Buntinx, 2013; Kapp et al., 2013). Engaging in this process requires educators to shift their lines of thinking from conceiving of instruction as something that happens *for* children to a mindset where learning is a process that educators embark on *with* their students (Singer, 2017). Doing this in an effective manner requires adults to meet students where they are and let student strengths continue to guide the learning process. Ultimately, making the shift towards building strength-based capacities for learning requires educators to reframe their relationship with their students and recontextualize their goals towards helping each child self-actualize to the best of each persons' abilities (Rappolt-Schlichtmann et al., 2018; Simpson, 2004).

The shift to helping all children build capacity towards self-determination is a noble pursuit that should be championed. For an individual to become fully self-sufficient, however, this means that they must hold the potential to become autonomous, advocate for themselves, and become socially empowered to enact their own futures (Watson et al., 2012). Therefore, just as empowering individuals is important, it is also crucial to understand that for an individual to become functionally autonomous they must reach the concrete level of development in each domain *and* acquire enough intellectual capacity to learn on their own (Arwood, 2011).

For this to happen, however, educators must understand more about their students' brains to ascertain what may be possible were they to try using interventions that target different neurobiological access points. Adding in this extra dimension to the empowerment of learners requires one to reflect upon the fact that not all learning is equal in overall effect (Bloom, 1956). Kerry's example of the trajectory of transforming from low-level, pattern-based learning to engaging in conceptual, long-term semantic learning can serve as an inspiration for educators to strive for. Kerry's story showcases that it can be possible for children of any age to re-connect with learning once their brains become engaged again.

On a larger scale, the macro shifts needed towards helping children become self-determined would require coordination between additional societal components beyond schools, such as universities, medical schools, psychological institutions and more. Kerry's story may be singular in nature, but it nevertheless holds the potential to impact the way special education is provided to students with developmental disabilities in this country.

Summary of Practical Implications

Because status quo methods of teaching students with developmental disabilities have been shown to be largely ineffective (Ayres et al., 2011; Vaughn et al., 2002), and because few studies show viable alternative pedagogies to these default practices (Hastings, 2005; Klaver et al., 2016), results from this investigation may hold social importance to the field of education. Wolf (1978) elaborates that studies such as this one hold social validity in that implications from results could inform not only future researchers, but also additional practitioners. Though the setting of this study consisted only of one private clinic, the significance of the findings could inspire practitioners in any location to re-examine their current practices to determine how well they are meeting the learning needs of students with developmental disabilities.

If thinking with a visual symbolizing system is as widespread a phenomenon as current scholarship would suggest, then research institutions and teacher preparation programs may benefit from incorporating such additional theoretical-based understandings of human learning into their studies. Pre-professional educators in the United States have yet to become expected to obtain a working knowledge of how the brain functions before they are deemed qualified to begin their teaching careers (Owens & Tanner, 2017). If this were to change, educators may eventually become better equipped to serve a much wider array of neurodiverse learners in any setting. Special education itself could uphold its promise of allowing services to follow students into whichever classroom will enrich them the most – not forcing students to settle for classrooms that most approximately serves their individualized education plans.

Society is at a crossroads regarding the way that students with developmental disabilities continue to be viewed, understood, and integrated into existing dominant cultures. Moore and Slee (2012) sum up these complex quandaries by stating that society must ultimately decide what is most important for children with developmental disabilities: helping them make their way through the existing systems the best that we can, or redesigning the systems so they actually serve the needs of those who experience the world differently. Educators can lead these redesign efforts by contemplating how they might shift their practices in their own classrooms. Though individuals with developmental disabilities comprise only a small percentage of this nation's population, this nevertheless means that there are millions and millions of Kerrys in this country who may stand to benefit from the adults in their lives better understanding what their brains require in order to learn. This study may play a part in helping educators better understand the academic needs of their own students – their own Kerrys – who each exhibit unique learning differences. This study provided one glimpse at how understanding more about the brain from a Neuro-Education perspective might help educators make the paradigm shift from engaging in teaching to helping their students facilitate their own learning journeys.

Limitations

Though the qualitative single case study model is often completed with only one student, having one total participant limited the potential scope of findings for this study. A study with a larger participant sample size would allow for students with more neuro-diverse backgrounds to be included and investigated. Including a wider variety of students could also investigate the impact of the studied intervention on other student populations that are less frequently represented, such as individuals from diverse social, cultural, or socioeconomic backgrounds. Similarly, this study was delimited to analyzing one practitioner operating in one clinic setting only. Including additional instructional settings, such as schools, with additional Neuro-Education based practitioners would strengthen the reliability and generalizability of the findings and enhance our understanding of the potential impact of these intervention practices.

In a pre-intervention evaluation of the participant, the practitioner utilized one formal instrument that to this date has not been internally or externally validated. This instrument was Arwood's Temporal Analysis of Propositions (TemPro - Arwood & Beggs, 1992). Similarly, Arwood's (2011) Neuro-Semantic Language Learning Pre-Language Assessment Protocol (ANSPA) was used as a guiding framework for interpreting participant-created language samples, despite the fact that this protocol has not been internally or externally validated. Lastly, the Sucher-Allred Reading

Placement Inventory (Sucher & Allred, 1986) was used by the practitioner to assess for Kerry's level of reading proficiency. While independent research has demonstrated that this test possesses a strong positive correlation with similar measurement devices (Hollingsworth & Reutzel, 1988), any internal or external validation completed on this device must be considered as outdated by current academic standards.

Relatedly, this study drew a priori codes from relevant literature to inform two cognitive frameworks; however, these a priori codes were not culled from a single standardized, validated source. As specified in Chapter 3, no standardized version of developmental milestones or markers of language function could be found in the literature to meet the specific research needs of this study. This may be construed as a limiting factor.

Chapter 3 identified multiple limitations inherent within the use of the retrospective document analysis design itself including that it was not possible for the researcher to be present during the artifact data collection process. Thus, these samples could not be independently verified for authenticity. Similarly, the researcher was not able to engage in direct observations of the participant and instead had to rely on case notes taken by the practitioner for these examinations. These constraints meant that first-hand access to the participant was limited only to the artifacts that they created. Thus, outside medical, educational, or psychiatric evaluations conducted by the participant's parents were not able to be independently verified. Similarly, the supports that the participant received while being enrolled in the public school setting outside of the clinic were not ascertained. The remainder of the data used for this study was limited to the second-hand source of the practitioner. In addition, the analysis of the clinical notes was limited to the assumptions or beliefs that formed the lens the practitioner brought to their observations and were therefore inherent in any notes later analyzed.

The scope of the retrospective time period analyzed for this study was delimited to 2 years. This decision was made because the data gathering and analysis periods allowed for this study were greatly accelerated, thus making the investigation of additional participants and artifacts impracticable. This limited time frame also made conducting additional interviews impractical. Moreover, because all of the findings for this study were situated many years in the past, this made profiling a current day depiction of the participant unfeasible. Thus, it is possible that the participant exhibited additional noteworthy changes after the two-year retrospective time period of the study concluded.

Lastly, though Chapter 3 identified numerous efforts that were made to uphold trustworthiness during the research process, certain methodological limitations were still evident. For example, when compiling a brief developmental profile of the participant's childhood, the researcher relied solely on findings gleaned from the semi-structured interview with the practitioner and from the practitioner's case notes. These findings were not independently verified through additional research, such as by interviewing the participant's parents.

This section identified the limitations inherent within the design and procedures of this study. Potential future areas of research are explored next.

Future Research

Future research on the topic of helping individuals with developmental disabilities learn through Neuro-Education based methods would benefit from including more participants who represented a wide array of developmental backgrounds. Kerry was an individual with autism whose learning needs reflected the realities that many students face who have moderately to severely impacted learning systems. However, studying how Neuro-Education interventions might meet the needs of individuals who experienced higher or lower levels of developmental functionality would illuminate additional vantage points into their unique strengths and challenges. In turn, acquiring a more robust series of findings on a much larger scale would increase the social validity of future studies and lead to greater transferability into a wide range of educational settings.

Conclusion

Research is clear that many students who have developmental disabilities are not getting their needs met while attending public schools that operate using status quo models (Alquraini & Gut, 2012; Stalker, 2012). At the beginning of the study, Kerry appeared to reflect the realities that many students from this population face. For example, Kerry's developmental functioning was severely delayed below what would be expected of a typical 16-year-old adolescent. Moreover, Kerry did not use oral language to successfully learn past a lower-level, pattern-based degree, which meant that much of their time spent in school receiving auditory-based instructional methods was largely unproductive. As a result, Kerry was left without many pro-social friendships. Moreover, Kerry could not be expected to care for themselves in any functional capacity.

At the end of the study, however, Kerry made substantial gains in learning and development. Lamentably, quantifying these gains and comparing Kerry's progress to what might be expected from other children like them remains an unrealizable task because every child is unique. On the one hand, utilizing developmental milestones to track progress can serve as a useful shorthand for determining whether a child is evolving. After all, though learning is impossible to measure directly, one can nevertheless 'see' learning happening within a child as they create increasingly complex developmental products that reflect a deepening capacity for thinking, socializing, and using language. On the other hand, using these age-based markers does not tap into the essence of 'who' a child is, nor do these markers help gather information about that child's strengths for learning. Moreover, the measurement of development ultimately plateaus around eight years of age, while the measurement of learning is never finished. These conundrums speak to the paradoxical and inextricable relationship between learning and development: one truly cannot exist without the other.

Constructing a working hypothesis to explain why Kerry changed so dramatically after receiving Neuro-Education based interventions requires one to possess a working knowledge of how the brain learns. If one thinks carefully back to the developmental stage of infancy, one can observe that typically developed children experience thousands and thousands of hours of parents and caregivers assigning meaning to their actions through oral language. It is not difficult to imagine what effect it might have upon a child to miss out on the vast majority of these efforts because their brain could not functionally process the input that was provided to them.

It is evident based upon this researcher's knowledge of impacted learning systems that Kerry missed out on years and years of opportunities to learn because their brain did not strengthen, inhibit, and integrate countless neuronal connections during this time period. This is because the brain operates with an 'all or none' principle, meaning that the action potentials guiding these neuronal firings either occur or do not occur (Squire et al., 2014). When the action potentials do not occur, the brain remains vastly underutilized and does not develop or function to its potential (Wilczynski et al., 2007). In reality, this meant that Kerry was in fact developmentally stuck in time due to these neurobiological challenges.

The all or none principle, however, works both ways. This means that brains can in fact fire when sensory input is meaningful. As has been stated numerous times throughout this study, the potential for Neuro-Education based intervention methods to help individuals like Kerry learn cannot be understated because these methods appear to help the brains of visual thinkers meaningfully fire. Once one understands this principle and has found an intervention that helps a child where others had not, it would remain ethically unconscionable to omit this knowledge in one's future workings with children.

Kerry did not develop the capacity to become self-determined within the timeframe used for this study, as this competency requires one to function at a concrete level of development. Nevertheless, as the intervention progressed Kerry became more valued as a learner because their needs were better understood. This actualization allowed Kerry to develop more as a unique individual rather than someone who required remediation – a philosophical position that critically differs from current expectations for students with developmental disabilities.

Table 11 compares the tenets that comprise society's current understanding of working with students who have learning differences with these viewpoints presented through the Neuro-Education paradigm. It is by understanding the value that both paradigms bring to the study of learning and development that the educational needs of children may best be met. Moreover, it is this researcher's aspiration that this applied research study further inspires individuals to reconceptualize their relationship with students who are different, as well as seek out additional understandings of what these individuals need in order to learn best.

Table 11

Comparing Educational Paradigms

Paradigm	Developmental Psychology / Special Education	Neuro-Education
What is language?	Language consists of a set of surface structures that are used to communicate ideas (Saxton, 2017)	The language students use represents the neurobiological complexities of their thinking (Arwood, 2011)
What is learning?	Learning in the mind results in a set of developmental products that can be observed (Piaget, 1959)	Learning is a never-ending process that is neurobiological in nature (Arwood, 2011)
How is learning measured?	Testing: learning is measured by comparing student responses to normed data (Overton, 2016)	Assessment: learning results in a changed capacity to think and use language to function in the world (Arwood, 2011)
What is development?	Development is the acquisition of increasingly complex physical, mental, and social-emotional functioning (de Souza & Verissimo, 2015)	Neurobiological development results from learning: learning must be achieved in the brain for the act of development to occur (Salkind, 2004)
How is development measured?	Development is measured through a progression of changes in each developmental domain (Francis et al., 2005)	Development is measured through an analysis of how one uses their language to act and think (Arwood, 2011; Semrud-Clikeman, 2010)
Guiding theory translated into classroom practices	Emphasis on teaching: psycholinguistics, direct instruction, behavioral analysis (Betts et al., 2009)	Emphasis on acquiring learning: assigning meaning to one's actions, neurobiological language acquisition processes are harnessed in the brain (Robb, 2016)
Philosophy of education	The educator's role is to ensure that each child has demonstrated proficiency on a set of agreed-upon goals and standards (Moore & Slee, 2012)	The educator's role is to help each learner become self-determined to the maximum extent possible (Arwood & Merideth, 2017)

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Appendix A: Semi-Structured Interview Questions

1) What were your impressions of the participant the first time you met them, before your intervention began?

2) What interventions did you generally do with the participant in this study?

3) Why did you provide the interventions that you did?

4) What is your assessment of the changes that the participant exhibited in learning over time during the period measured for this study?

5) What is your assessment of the changes that the participant exhibited in development over time during the period measured for this study?

6) Are there specific factors of the intervention that you provided that you would attribute to the changes in learning and development that you witnessed over time in the participant?

7) Is there anything else that you would like to add that would help illuminate why the participant changed over time from your perspective?

Appendix B: TemPro Behavioral Checklist

(Arwood & Beggs, 1992)

TEMPRO BEHAVIORAL CHECKLIST

Name ______________________________ Grade ______________

Check the statements that apply to this student.

_____ 1. Has difficulty following a schedule.

_____ 2. Has difficulty following directions.

_____ 3. Has difficulty paying attention in class. Seems to "tune out".

_____ 4. Does not finish work in class.

_____ 5. Does not get homework assignments done.

_____ 6. Is often described as "hyperactive".

_____ 7. Is disorganized.

_____ 8. Talks at inappropriate times. Interrupts or "blurts out".

_____ 9. Moves around the room at inappropriate times.

____ 10. Is sometimes disruptive in class.

____ 11. Has difficulty working with other students and/or adults.

____ 12. Is reading significantly below grade level.

____ 13. Is writing and/or spelling significantly below grade level.

_____Other concerns:

Appendix C: ANSPA Questions

Arwood's Neuro-Semantic Language Learning Pre-Language Assessment Protocol

(ANSPA) From Arwood (2011, p. 187)

1. Does the participant address others and expect others to respond? This assesses the function of the participant (agent) in relationship to others (relational function).
2. Are the participant's utterances appropriate for the context? This assesses the function of whether the child's language refers to the topic (referential function).
3. Does the child use the utterances to share the meaning of the context? This assesses the child's ability to develop a variety of meanings (semanticity function).
4. Does the child use the utterances to share the meaning of the context? This assesses the child's shared-referent function (shared function).
5. Does the listener have to interpret the child's intent or specific meaning? This assesses the child's ability to develop a variety of meanings (semanticity function).
6. Does the child talk about the "here and now?" This is assessing how well the child can talk about ideas that the child cannot see or touch or may be in time or place that is at a distance from the child (displacement function).
7. Does the child talk about a variety of different topics? This assesses the child's ability to use a variety of different types of utterances (flexibility function).
8. Are the child's utterances semantically accurate in meaning? This assesses another aspect of how well the child is acquiring concepts (semanticity function).
9. Are the child's utterances succinct in meaning or redundant? This assesses how well the child can use the English language to mean exactly what is intended who, what, where, when, why, how?
10. Does the listener understand the speaker's meaning without having to take on more than a "shared" level of understanding? This assesses whether or not the language functions in the concrete way of sharing meaning.