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**Case Study of Improving the Speech Intelligibility of Children with  
Down Syndrome Using Pacing Boards**

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**Case Study of Improving the Speech Intelligibility of Children with  
Down Syndrome Using Pacing Boards**

**by**

**Christine Ngoc Hong, B.S.**

**Thesis**

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

**Master of Arts**

**The University of Texas at Austin**

**May 2015**

## **Dedication**

This thesis is dedicated to my parents, Bobby and Jennifer Hong, who never stop giving of themselves in countless ways. Thank you for your endless love, support, and encouragement.

## **Acknowledgements**

I would like to thank Dr. Barbara Davis, my advisor and mentor, for the continual guidance and support she has provided me throughout my time as her student. Working with her has been truly a privilege. I would also like to thank Dr. Thomas Marquardt for his bountiful humor, words of encouragement, and for serving as my second reader.

This academic journey would not have been possible without the support of my family, friends, and especially Dave. Thank you for encouraging me in all of my pursuits.

Thank you to my research assistants, Matt and Keila, for their time and assistance with transcribing the data. Furthermore, I am grateful to my clinical supervisor, Reagan Rives, for supporting and helping me throughout this research process.

Finally I would like to thank Olivia and her family. Thank you for allowing me to spend time with such an amazing person. You have inspired and taught me more than I could have ever taught you!

## **Abstract**

### **Case Study of Improving the Speech Intelligibility of Children with Down Syndrome Using Pacing Boards**

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Abstract: The present study was designed to answer the following questions: (a) Can a child with Down syndrome (DS) increase speech intelligibility using a pacing board through a modified Core Vocabulary Approach (CVA)? (b) What are the effects of the pacing board as an intervention tool on the speech skills of children with DS? (c) What is a valid measurement of improved speech intelligibility? In this case study, the pacing board was used as an intervention tool in conjunction with a modified CVA with one child with DS to examine whether a child with limited speech skills could increase her speech intelligibility to enhance communicative competence. Data was collected on the child's speech production output patterns in order to provide information on the pacing board's efficacy. Results indicated that the pacing board was an effective intervention tool for this child. Increases on various speech intelligibility metrics were evident. The child's improvements on indices examined in this study were slow but significant, relative to her previous speech and language status.

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## **Chapter 1: Introduction**

Impairment in speech intelligibility is a distinguishing feature of children with Down Syndrome (DS). Deficits in speech production accuracy impair the speech intelligibility of individuals with DS, causing deficits in their ability to communicate effectively and interact with others. These differences persist throughout the lifespan (Roberts, Price, & Malkin, 2007). Lack of speech intelligibility decreases the individual's ability to be understood, a critical issue for children and adults with DS as they interact with family and peers and integrate within school and community settings. While provision of speech and language intervention to preschool individuals with DS is a priority, there is relatively little research focused on the effectiveness of general speech intervention strategies and techniques for improving speech intelligibility skills of individuals with DS (Roberts, Price, & Malkin, 2007).

Previous research has suggested that some promising intervention approaches exist for improving speech production accuracy in children with DS. Both the Core Vocabulary Approach (CVA; Dodd, McCormack, & Woodyatt, 1994) and an integrated speech and phonological awareness intervention (van Bysterveldt, Gillon, & Foster-Cohen, 2010) have been found to be beneficial for this population. Individual therapy utilizing these and other structured approaches have been found successful in increasing speech production accuracy and/ or consistency (Williams, McLeod, & McCauley, 2010). However, few studies provide specific techniques within intervention approaches for

speech-language pathologists (SLP) to successfully implement intervention with children who have DS.

The current study is a pilot investigation of the effects of a pacing board (Kumin, Council, & Goodman, 1995), an intervention tool used in conjunction with the CVA. The CVA is an intervention approach used to establish consistent word production for children with speech sound disorders (Dodd et al., 2010). The goal was to evaluate the efficacy of these two approaches for increasing the speech intelligibility of a preschool age child with DS. The pacing board has been considered an effective treatment for adults with dysarthria as a result of aphasia, traumatic brain injury, or other neurological disorders (Van Nuffelen et al., 2010). However, it has not been applied or evaluated as an intervention approach with children who have DS. This case study may provide information for future SLPs on the pacing board's effectiveness as an intervention technique for a child with a similar clinical profile.

## **EVIDENCE-BASED PRACTICE**

Sakett, Rosenberg, Muir Gray, Haynes, & Richardson (1996) defined evidence-based practice (EBP) as "...the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients... [by] integrating individual clinical expertise with the best available external clinical evidence from systematic research" (p. 71). The use of EBP provides SLPs with a framework of constructs and methods to make the best decision for therapy and provide improved

clinical services to the patient (Dollaghan, 2004; Zipoli & Kennedy, 2005). Therefore the effects of intervention to improve the speech intelligibility of a child with DS need to be carefully evaluated. In the field of speech language pathology, clinical decision-making has generally been guided by the client's wishes and the SLP's experiences (Gillam & Gillam, 2006). In a study by Zipoli & Kennedy (2005), 240 SLPs responded to a questionnaire examining attitudes toward the use of research and EBP. The investigators found that the SLPs relied predominantly on clinical experience and colleagues' opinions. This is contrary to the principles of EBP, which requires that clinical decisions stem from the integration of scientific research and evidence, clinician experience, and the client's needs (Gillam & Gillam, 2006).

Baker & McLeod (2011) adapted a process for SLPs to conduct evidence-based practice when working with children with speech sound disorders. Through this process, SLPs can integrate externally published evidence with internal evidence from clinical practice, along with individual client factors, including their values and preferences, to make clinical decisions. They suggest that EBP begins with asking a PICO clinical question that contains four elements: patient, intervention, comparison, and outcome, in order to examine applicable clinical information regarding the benefits and risks of using one intervention approach relative to another intervention approach (Baker & McLeod, 2011). The next step in the EBP process involves searching for external evidence to answer the PICO question.

Once the research has been gathered, the level of evidence must be critically evaluated. The highest level of evidence (Level 1) is a randomized clinical control trial

(RCT) or a systematic review (Gillam & Gillam, 2006). RCTs are experiments that require randomization of participants into treatment and control groups; systematic reviews are studies that gather and analyze various studies related to a specific therapy target. Level 2 external evidence includes comparisons of nonrandomized groups and quasi-experimental studies (Gillam & Gillam, 2006). Both types of studies evaluate change in two nonrandomized groups by measuring performance before and after the study. Multiple-baseline and single-subject design studies are also considered to be level 2. In these types of studies, the subjects serve as their own control, and two or more behaviors are measured and studied across no-treatment and treatment phases. The third level of evidence (Level 3) is a case-control study of individuals receiving a particular treatment (Gillam & Gillam, 2006). Case studies including detailed description of the individual and their treatment are considered Level 4 evidence. The lowest level of external evidence (Level 5) includes expert opinion and reports (Gillam & Gillam, 2006).

In the pursuit of a clinical decision, the SLP should evaluate the available research that provides evidence and information for a particular intervention or treatment. The SLP must then consider the individual values and preferences of children and their families. Examples of considerations include cultural values, beliefs, financial resources, level of child-parent engagement, and child-parent opinions (Gillam & Gillam, 2006). Lastly, clinician-agency factors, such as the SLP's knowledge, schedule, and employment setting, should be considered before choosing an intervention approach. SLPs that integrate EBP into their clinical practice may more likely select an intervention that will potentially have the most positive outcome for the child and their families.

## **CORE VOCABULARY APPROACH**

When choosing intervention approaches, SLPs face the challenge of analyzing a number of possible approaches presented by research with consideration to their client's profile and needs. A large number of intervention approaches exist for speech sound disorders. The present study incorporates the Core Vocabulary approach (CVA; Dodd et al., 2010) due to its compatibility with the child of this study.

The CVA is an intervention approach that establishes consistent word productions for individuals whose speech is characterized by inconsistent pronunciations of the same lexical item (Dodd et al., 2010). This intervention approach targets primarily children with inconsistent speech sound disorders; inconsistency is characterized by numerous error types, such as unpredictable variability among a large number of phonemes. The CVA is appropriate for children 2 years of age and older, including those who are bilingual or cognitively impaired (Dodd et al., 2010; Dodd, McCormack, & Woodyatt, 1994; Holm & Dodd, 1999).

CVA intervention typically involves individual, twice-weekly 30-minute sessions for approximately 8 weeks. The first session of the week focuses on approximately 10 target words from a compiled list of 70 words selected by the child, parents, and teachers. The SLP teaches best production of these 10 words; production is drilled sound by sound in order to elicit the best production of each word from the child. These words are then practiced in games or activities for the remainder of the session. In the second session of the week, the words are reviewed, followed by a test in which the 10 target words must

be produced three times in three trials, with the trials separated by another activity. Untreated probes, a set of 10 untreated words, are elicited three times to monitor generalization every 2 weeks. During the duration of the intervention, it is recommended that the child's parents and teachers reinforce use of the core vocabulary and implement daily practice (Dodd et al., 2010).

SLPs working with children with DS and inconsistent speech errors may utilize the CVA in order to improve speech intelligibility. Dodd et al., 2010 stated that the CVA has two general goals, with the first goal intending “for the child to achieve an appropriate productive realization of each target based on the child's phonological system and phonetic inventory” (p. 129). The second goal is for the child to consistently use established best production of the words. Therefore, a child who has a limited phonetic inventory and variability of errors, like the child whose speech profile will be described in this study, may be able to increase speech intelligibility. The present study will target consistency of word productions with the intention of increasing the child's phonetic inventory and speech production accuracy to enhance speech intelligibility.

## **PACING BOARD**

The pacing board is used as an external rate control technique for the purpose of regulating speech rate in order to improve articulation and speech intelligibility in individuals with dysarthria (Pilon, McIntosh, & Thaut, 1998). Thus far, the pacing board has not been investigated as an intervention tool for children with DS. The research and



literature on the efficacy of pacing boards with adults with dysarthria is described as a background for considering its implementation with a child with DS and low speech intelligibility.

Adults with dysarthria experience deficits in speech intelligibility similar to the deficits that children with DS experience. Often their speech production is negatively impacted by their inability to achieve articulatory targets in conversation due to uncoordinated movements or impaired movement of the muscles (Yorkston et al., 1990). The pacing board aids dysarthric speakers by acting as a visual representation of the segments of words. When using the pacing board, the speaker is required to point sequentially to dots on a board as word syllables are produced, thereby slowing speech rate. Yorkston, Downden, & Beukelman (1992) asserted that reduction of speaking rate, through the use of a rate control method, is a highly effective strategy for improving intelligibility. For individuals with dysarthria, reducing speech rate may improve intelligibility because the dysarthric speaker has more time to achieve accurate articulatory targets or because the number of articulatory breakdowns may occur less frequently during slower speaking rates (Pilon, McIntosh, & Thaut, 1998). Reduced speech rate may also allow listeners more time to process the intended message, thereby increasing listener's perception of speech intelligibility (Pilon, McIntosh, & Thaut, 1998).

Van Nuffelen and colleagues investigated the use of seven rate control methods on speech intelligibility in 27 participants with dysarthria (Van Nuffelen et al., 2010). The participants ranged in age from 17-88 years (mean age: 64 years). The etiology of dysarthria was varied among the participants, including stroke, Parkinson's disease,

amyotrophic lateral sclerosis, myotonic dystrophy, unilateral upper motor neuron, and progressive supranuclear palsy. The seven rate control methods were: speaking slower on demand, pacing board, alphabet board, hand tapping, and delayed auditory feedback with delays of 50 ms, 100 ms, and 150 ms (Van Nuffelen et al., 2010). For each rate control method implemented, the participants were asked to read a randomly selected reading passage for two minutes; the researchers also recorded two-minute speech samples for each rate control method from all participants. When using the pacing board, participants were required to touch one square for each pronounced word. At the conclusion of the study, intelligibility of the speech samples for all rate control methods was rated by three speech language pathologists with experience in dysarthria. Analysis of data revealed that the pacing board, alphabet board, and hand tapping were the most effective methods with a clinically significant increase in speech intelligibility (Van Nuffelen et al., 2010). Through the use of pacing boards, speech intelligibility improvement increases ranged from 6 to 59% (Van Nuffelen et al., 2010). This study, although only demonstrating the immediate effects of the pacing board, suggested that through continual use of this intervention tool, individuals may be able to improve and sustain increased speech intelligibility.

The current case study investigated the use of a pacing board in conjunction with a modified Core Vocabulary Approach (CVA) with one child with DS. The purpose of the study was to evaluate whether a child with low speech intelligibility can increase speech production accuracy to enhance effective communication. The pacing board was used as an intervention tool to aid in the achievement of speech accuracy. The study

targeted functional words important for the participant as with prior studies of the CVA (Dodd et al., 2006; Holm & Dodd, 1999). The pacing board's role and impact on the efficacy of this intervention was examined.

## **Chapter 2: Overview of Down Syndrome**

While there is variability across children in severity of symptomatology, most individuals with DS have an intellectual disability and speech and language difficulties. Typically impacted areas are poor speech production accuracy and speech intelligibility (Roberts, Price, & Malkin, 2007; Kent & Vorperian, 2013). In order to provide a framework for using the pacing board to increase speech intelligibility, the background and developmental speech profile of children with DS must be examined. This chapter will discuss current evidenced-based research and understanding of the speech profile of children with DS.

### **BACKGROUND**

DS is the most common chromosomal condition diagnosed in the United States (Centers for Disease Control and Prevention [CDC], 2014). The estimated national prevalence from 2004-2006 was approximately 15 per 10,000 live births, affecting nearly 6,000 infants in the U.S. per year (CDC, 2014). DS is a condition in which a person has an extra chromosome. There are three types. Trisomy 21, in which there is an extra copy of chromosome 21, is the most common cause of DS, affecting 95% of affected individuals. Translocation is another cause of DS, accounting for 3% of cases. Translocation occurs when part of or a whole extra chromosome 21 is attached to a

different chromosome. Mosaicism is the least common cause of DS, affecting 2% of children, and is characterized by the presence of some cells with three copies of chromosome 21 and others with the typical two copies of chromosome 21 (CDC, 2014; Sherman et al, 2007).

Physical characteristics often associated with DS include dysmorphic facial features, tongue protrusion, growth retardation, hypotonia, small hands and feet, and shorter height as children and adults (Bull, 2011; CDC, 2014). Other health issues prevalent among children with DS are hearing loss (up to 75% of individuals with DS may be affected), obstructive sleep apnea (between 50-70%), eye infections (up to 60%), and heart defects present at birth (50%) (CDC, 2014). Although variable, intellectual disabilities are common in individuals with DS. The degree of intellectual disability varies from the mildly-to-moderately low range (CDC, 2014).

## **SPEECH & LANGUAGE RELATED DOMAINS**

Children with DS are a heterogeneous population and thus present with a varied severity of symptomology. Health problems such as hearing loss and lack of oral motor skills are common in this population (Bull, 2011; Roberts, Price, & Malkin, 2007). In order to provide a construct for improving speech intelligibility in children with DS, their hearing and oral motor skills must be explored. This section will describe research findings related to deficits in these two domains, and their prevalence and impact on speech and language development in children with DS.

## **Hearing Loss**

Adequate hearing is critical for speech and language learning for all children. Roizen et al., 1993 conducted an auditory brainstem response (ABR) evaluation of 47 children with DS. The researchers found that hearing loss occurred in approximately two-thirds of the children due to conductive, sensorineural, or mixed hearing losses. This percentage was much higher in comparison to the percentage for the general population of children less than 5 years of age at the time of the study (Roizen et al., 1993). In a 5-year longitudinal study concerning otitis media, a major cause of conductive hearing loss, Shott et al. (2001) discovered that 96% of the 48 preschool-aged children with DS had at least one ear infection with 83% of the children requiring pressure equalizer tubes because of their chronic otitis media. Of those needing medical care, 81% had abnormal hearing previous to treatment, ranging from borderline normal mild loss to severe loss. Otitis media commonly occurs in children with DS for a variety of reasons, including narrow auditory canals, craniofacial anatomic anomalies, and a slowly developing immune system that places this population at risk for increased upper respiratory tract infections (Shott et al., 2001). Studies of typically developing children have shown that even a mild hearing loss can negatively affect children's ability to develop articulation and language skills (Dobie & Berlin, 1979; Jerger et al., 1983). As a result otitis media is of concern in children with DS, a population whose expressive language skills oftentimes lag behind their cognitive abilities, due to its high prevalence and accompanying mild to moderate fluctuating hearing loss (Shott et al., 2001). Although the relationship between

otitis media and hearing impairment should be considered in explanations of speech development difficulties, there is no definitive research that speech impairment in children with DS is the result of hearing loss (Vicari, 2006).

### **Oral Motor Skills**

Speech production differences in individuals with DS may be affected by differences of oral structural and function (Miller & Leddy, 1998; Stoel-Gammon, 2001). Although there is variability among individuals with DS, divergent oral structures may include a small oral cavity, a narrow, high arched palate, and missing or atypical dentition (Miller & Leddy, 1998). Historically, children with DS have also been described as having macroglossia (Guimaraes Donnelly, Shott, Amin, & Kalra, 2008). This early rationale led to surgical tongue reduction in individuals with DS, a practice that is currently considered ineffective (Swift & Rosin, 1990). Guimaraes et al. (2008) using magnetic resonance imaging (MRI) found that children with DS do not have true macroglossia, but rather relatively large tongues in comparison to their smaller oral cavity. In a study comparing 36 typically developing boys with 34 boys with DS, structural differences of the lips, tongue, and velopharynx were present for the latter group (Barnes, Roberts, Mirrett, Sideris, & Misenheimer, 2006). In addition to these findings, the researchers discovered that the boys with DS were less skilled at speech motor functions and coordinated speech movements involving the oral speech articulators, larynx, and velopharynx during speech function tasks (Barnes et al., 2006).

In terms of other divergent facial features, Bersu (1980) performed detailed anatomical dissections of Down syndrome bodies. He found that facial musculature was abnormal, characterized by missing, additional, or poorly differentiated muscles, hyper extendable joints, and nerve innervation differences. Hypotonia, a common muscle condition in this population, has been posited as an explanation for some dysarthric speech features observed in children with DS (Kent & Vorperian, 2013). Generalized hypotonia may support explanations for atypical functions in speech production subsystems (Kent & Vorperian, 2013). Therefore, structural and functional differences commonly found in individuals with DS may account, in part, for poor speech intelligibility through dysarthric factors such as reduced speed, limited range of motion, and difficulty with coordination of the articulators (Miller & Leddy, 1998). Considering the prevalence and possible effects of these factors on oral motor skills required for speech, clinical consideration should be taken in regards to how oral motor patterns in individuals with DS are related to speech development.

## **SPEECH CHARACTERISTICS AND INTELLIGIBILITY IN DOWN SYNDROME**

### **Speech Production**

Speech production in children with DS is marked by poor articulatory and phonological patterns (Kent & Vorperian, 2013). Perceptual studies of vowel and consonant errors in children with DS have shown a higher than average frequency of



articulatory errors, particularly with consonants (Kumin et al., 1994; Roberts et al., 2005; van Bysterveldt et al., 2010).

Kumin, Councill, and Goodman (1994) examined the speech records of 60 children with DS from 9 months to 9 years of age. They found that the children's emergence and mastery of consonant phonemes were extending across the developmental period, with substantial inter-individual variability. Furthermore, the emergence of consonants in the children's speech did not seem to follow the order of established norms for typically developing children (Kumin et al., 1994).

Barnes et al. (2009) examined and compared the phonological accuracy of 34 boys with DS (ages 4-16) to 45 typically developing boys of similar nonverbal mental age. The investigators found that the boys with DS scored lower on measures of phonological accuracy and had higher occurrence of phonological processes (Barnes et al., 2009). Phonological accuracy was measured using percent consonants correct (PCC; Shriberg & Kwiatkowski, 1982) in connected-speech samples; the boys with DS had a lower PCC (71.6%) in comparison to the typically developing boys (89.7%) (Barnes et al., 2009). The boys with DS also used significantly more syllable structure processes (6.1% compared to 1.5%) and substitution processes (13.2% compared to 6.5%) than their typically developing peers (Barnes et al., 2009). For the boys with DS, the most commonly occurring syllable structure process was cluster reduction, and the most commonly occurring substitution process was cluster simplification, followed by liquid simplification, palatal fronting, fricative simplification, stopping, and deaffrication (Barnes et al., 2009).

A few studies of speech in DS have also noted vowel errors (Bunton, Leddy, & Miller, 2007; van Bysterveldt et al., 2010). van Bysterveldt et al. (2010) completed an intervention study of 10 preschool aged children with DS. They found that both percent consonants correct and percent vowels correct (PVC) showed a relatively high mean PVC of 91.3% in comparison to the mean PCC of 50.6% (van Bysterveldt et al., 2010).

Bunton et al. (2007) studied adult individuals with DS (ages 18-39). They analyzed vowel errors using speech samples. Frequent errors of high versus low vowels and front versus back vowels were observed (Bunton et al., 2007). The authors suggested that these error patterns may be indicative of tongue height and advancement difficulties in individuals with DS, due to anatomic factors or motor limitations.

Dodd and Thompson (2001) compared the speech characteristics of children with DS ages 5-15 to those of intellectually average children with inconsistent phonological disorder ages 3 to 5. They analyzed phoneme repertoire, PCC, PVC, and percentage of whole-word inconsistency. The investigators found that analyses at the consonant level revealed that the number of whole words produced inconsistently by children with DS did not differ from those of phonologically disordered non-DS children who make inconsistent errors (Dodd & Thompson, 2001). Dodd and Thompson (2001) suggested that speech disorder in children with DS may not solely be the result of their intellectual disability or due to physiological factors associated with DS such as craniofacial anomalies or hypotonia. Instead, their results provide evidence that speech patterns observed in children with DS may be indicative of phonological disorder characterized by inconsistent errors.

## Speech Intelligibility

Definitions of speech intelligibility and assessment methods differ across published articles and research (Kent & Vorperian, 2013). Swift & Rosin (1990) use the term speech intelligibility to refer to the “articulator and prosodic parameters of speech production as well as contextual aspects such as listener experience, word predictability, and utterance length” (p. 140). Roberts, Chapman, and Warren (2008) added to this definition by defining intelligibility as the extent to which a listener can receive the message intended by a sender. Children with DS often have poor speech intelligibility, a problem that persists throughout life for many, and is therefore an important remediation issue (Kumin, 1994). Research focused on intelligibility in the literature on DS has been limited (Kent & Vorperian, 2013).

Poor speech intelligibility in this population has predominantly been substantiated by parental report and clinical testing. Kumin (1994) conducted a study using questionnaires to investigate the prevalence of poor speech intelligibility in individuals with DS. When the data for all age groups from 937 parents of individuals with DS were analyzed, 58.2% of parents reported that their children *frequently* had difficulty being understood and another 37.1% reported that their children had difficulty *sometimes*; subsequently, the data indicated that 95% of the children were reported as experiencing some difficulty in being understood, with only 5% rarely or never experiencing difficulty (Kumin, 1994).

Pueschel and Hopman (1993) employed questionnaires to obtain information and parental views regarding the speech and language skills of their children with DS. The parents reported that their children were generally capable of making themselves understood. However, 71-94% of the parents of children ages 4-21 years noted that their children had articulatory problems (Pueschel & Hopman, 1993).

Available research focused solely on speech intelligibility appears limited in the literature on DS. Currently, the underlying causes of diminished speech intelligibility are difficult to ascertain and has thus far been surmised from studies that examine aspects of speech production (Kent & Vorperian, 2013). Pueschel and Hopman's (1993) data suggests that perceived levels of unintelligibility are associated with variable phoneme production, a factor that increases the difficulty for understanding a spoken target word. Barnes et al. (2009) examined speech intelligibility of children with DS by analyzing various components in spontaneous connected speech. They looked at speech production in terms of PCC, phonological process occurrence, measurement of proportion of whole word proximity, and percentage of intelligible words in connected speech (Barnes et al., 2009). By doing so, the investigators studied the relationships between phonological accuracy in single words versus connected speech and how such skills relate to speech intelligibility. This is important to note because speech production analyses for information regarding speech intelligibility of connected speech may be a more sensitive context for assessment than single-word articulation tests (Barnes et al., 2009).

In the available literature on speech intelligibility in DS, reduced intelligibility is well documented, but the reasons and measurements have not been sufficiently explored

(Kent & Vorperian, 2013). More research is needed on the speech profile of children with DS to understand their ability to achieve phonemic accuracy and the impact of their intellectual disability, oral motor skills, and hearing loss on intervention. The present case study will address the following questions:

1. Can a child with DS increase speech intelligibility using a pacing board through a modified Core Vocabulary Approach?
2. What are the effects of the pacing board as an intervention tool on the speech skills of children with DS?
3. What is a valid measurement of improved speech intelligibility?

## **Chapter 3: Methods**

This study was implemented to investigate whether a child with limited speech skills could increase her speech intelligibility using a pacing board to enhance communicative competence and participation within family and school settings. Based on persisting speech intelligibility deficits in children with DS, intervention protocols should be investigated for their efficacy with this population. Data was collected on the child's speech production output patterns to provide information on the pacing board's effectiveness as a possible intervention technique for children with a similar speech and language profile.

### **PARTICIPANT**

The participant's name has been changed to Olivia to protect her identity. The following areas were assessed to provide context of her background and function: Developmental, Social, Medical, Educational, and Speech and Language history.

#### **Developmental and Social History**

Olivia is a 3;11 year-old female who lives with her parents and two brothers in a monolingual English speaking home. Olivia exhibited delayed motor milestones in addition to significantly delayed speech and language according to parent report. Olivia

learned to walk and began to say words at two years of age. She does not have bowel and bladder control and currently wears diapers. Olivia is a playful and social child. She enjoys playing with her 15 month old brother and family friends. Olivia's mother reports that she is frustrated with her communication when others are unable to understand her, especially regarding her needs and requests. Her mother also noted that recently, Olivia has been withdrawn with her friends due to communication difficulties. For example she often opts to play alone in her room when her friends visit.

### **Medical History**

Olivia was diagnosed with DS prenatally at 13 weeks gestation. Her mother reported a healthy pregnancy, carrying Olivia full term and experiencing no health concerns at birth. Olivia was delivered at 38 weeks by Caesarean section. Olivia had ear infections beginning at 9 months of age and had pressure equalization (PE) tubes placed when she was 2 years old. She currently has normal hearing thresholds but continues to have one to two ear infections per year. Olivia has been diagnosed with strabismus, a congenital eye condition, in her left eye and wears glasses. There is also a family history of dyslexia including Olivia's mother, uncle, and several cousins.

### **Education and Speech & Language History**

Olivia began receiving early childhood intervention at 4 weeks old and continued until she was 3 years of age. Currently she is enrolled in a private preschool and has been attending since 18 months of age. The preschool serves children with and without

disabilities in an inclusive classroom setting. Sixty percent of the children at her school are children with DS and other developmental disabilities and forty percent are typically developing children. Olivia receives speech therapy in school once a week for 30 minutes and has private speech therapy with the school's SLP after school once a week for 30 minutes.

Olivia's current goals in speech therapy are focused on increasing her expressive language skills and word shape inventory. The majority of her output consists of unintelligible vocalizations. Olivia's mother reports that she has recently begun putting two to three words together and has 10-15 words that are partially intelligible to unfamiliar listeners. Olivia's most recent progress report states that she uses primarily one-word utterances. Olivia's SLP also reported that Olivia is very shy and does not consistently attempt to produce words even with a model. Olivia uses predominantly CV words and a few CVCV words such as "momma", "daddy", and "baby." Olivia's report suggests that her spontaneous expressive language and word shape inventory is limited and that her motivation in therapy is low.

Olivia's current SLP uses a multisensory approach in therapy, using both the Kaufman to Speech Language Protocol (K-SLP; Kaufman, n.d.) and Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT; Hayden, 2006). The K-SLP is a treatment technique that focuses on shaping consonants, vowels, and syllable shapes from what the child is currently capable of producing toward higher levels of speech coordination (Kaufman, n.d.). The child is taught the "shell" of the words, therefore not all consonants and vowels are included in order to keep motor programming of words



simple. PROMPT is a sensorimotor technique that utilizes tactile prompts (Hayden, 2006). The prompts are subtle touch cues and manipulations of the structures involved in speech (i.e. lips, tongue, jaw, etc) to guide the individual through a targeted word. PROMPT aids the development of oral motor control and oral muscular movements (Hayden, 2006).

Olivia's speech and language status as well as goals for increasing expressive language skills and word shape inventory indicate that she is a good candidate to receive the Core Vocabulary Approach (CVA; Dodd et al., 2010) intervention. Since the CVA is not primarily used with children with DS, a modified form of the CVA was implemented including the use of a pacing board to evaluate whether a pacing board and the principles of CVA can be transferred to children with DS.

## **INTERVENTION**

Olivia currently presents with poor speech intelligibility. Her inability to make herself understood interferes with the ability to effectively communicate and interact with others, a necessary skill for family, school, and community integration. Use of a pacing board (Kumin, Councill, & Goodman, 1995) within a modified form of Core Vocabulary Approach (CVA; Dodd et al., 2010) was implemented to assess whether Olivia would increase her speech intelligibility.

## **Intervention Protocol**

The CVA's recommended service delivery model remained intact. Traditional CVA suggests that the SLP target 10-12 words per week. However, the researcher made clinical adaptations for Olivia. Dodd et al. (2010) suggested that a child should have little difficulty producing 150-170 responses in a 30-minute session of CVA intervention. During baseline measures, it was difficult to elicit this high number of best productions for the proposed number of words without Olivia exhibiting behavioral difficulties. As a result 5 target words per week were presented.

The CVA protocol recommends drilled practice to elicit best production of each word, followed by practice of targeted words in games for the remainder of the session. In addition, the CVA also recommends that the child's parents and teachers reinforce use of the core vocabulary by targeting words in functional daily communication (Dodd et al., 2010). The present study did not incorporate games and daily practice with parents and teachers. Due to Olivia's low volubility during sessions, drilling was primarily used to practice the target words and receive feedback on those words. Because the aim of the study was to measure Olivia's change in accuracy performance primarily in regards to the effects of the pacing board, parents' and teachers' roles in intervention were excluded. This aspect of treatment generalization should be included in future studies of CVA in children with DS because increased parent and teacher involvement may boost functional gains.

The CVA calls for a set of 10 untreated probes to be elicited during the second session every two weeks to monitor generalization (Dodd et al., 2010). However, this protocol was not followed due to time constraints and Olivia's relatively low frequency of productions of words in general. Instead, in order to investigate the effect of the pacing board on speech intelligibility, two tests were administered per week in which Olivia produced the targeted words with and without a pacing board.

### **Intervention Procedures**

Olivia received intervention for 30 minutes twice a week for 8 weeks. This is the typical recommended dosage and intervention period suggested for using the CVA (Dodd et al., 2010). Sessions occurred in a quiet classroom at Olivia's preschool during her school day. The initial treatment session of each week focused on drill work and sound-by-sound segmentation using the pacing board on five targeted words to elicit best production of each word. Target words in picture form were used to elicit a high number of repetitions during intervention sessions. The pacing board was a horizontal board with three large stars, acting as a visual representation of syllable units.

In order to establish best production, the researcher taught Olivia the words sound by sound, using the pacing board as a visual and tactile cue for sound segmentation. For example, during drill work Olivia was required to name the picture and use her finger to move across the stars, while articulating the target word sound-by-sound. When Olivia produced a word, for example, "Ti" for the target word, "Mickey," the researcher modeled the accurate production syllable-by-syllable, while pointing to the stars in

sequence from left to right. After Olivia’s attempts, she received feedback, and was allowed to make further attempts with the pacing board after being given models. In the event that the Olivia did not imitate the model, the researcher used hand-over-hand assistance to move her finger across the stars. Throughout the intervention study, the researcher provided cues, prompts, models, and hand-over-hand assistance to help Olivia progress to greater speech accuracy and syllable-word shape. Table 1 shows cues used during intervention.

Table 1: Cues Provided During Intervention

<b>Cue Types</b>	<b>Definition</b>
Auditory cue	Model singleton consonant and vowel sounds
Visual cue	Hand gestures used in conjunction with an articulatory movement of consonant sound
Tactile cue	Subtle touch and manipulations of the structures related to specific consonant sounds

In the second session each week, the researcher reviewed the five target words with Olivia. Afterwards, to evaluate the effect of the pacing board, Olivia was asked to produce the target words three times in two contexts. The three trials were separated by another activity. The first probe required Olivia to produce the target words without a pacing board; the second probe required the use of the pacing board. Session activities between the trials were based on Olivia’s preferences. She often played with dolls and a variety of high interest toys.

## **DATA COLLECTION**

### **Selection of Target Words**

Olivia's parents selected a core vocabulary of up to 50 functionally important target words. Selected words were chosen because Olivia frequently used them in functional communication. Her use of these functional words was intended to motivate the use of consistent word productions. See Table 10 for the list of stimulus words chosen by week of intervention. The types of words included were names (i.e., *siblings, friends, grand parents*), places (i.e., *potty, park*), function words (i.e., *tired, please, thank you*), and Olivia's favorite things (i.e., *Mickey Mouse, PJs, dance*). Five words were targeted per week. Olivia was presented with the list of words in picture form for three training sessions prior to beginning the intervention in order to establish a baseline measurement of the words prior to treatment. This is not consistent with CVA protocol, which introduced target words at the onset of treatment (Dodd et al., 2010).

## **DATA ANALYSIS**

Phonological assessment of target words included measures of consonant production accuracy, vowel production accuracy, proportion of whole-word proximity, and proportion of whole-word variability. Speech data were recorded and transcribed via broad phonetic transcription. Two trained speech language pathology undergraduate

research assistants transcribed targeted words. Clinical intervention data was analyzed to track changes over time in speech patterns during baseline and weekly intervention tests.

### **Percent Consonants Correct**

Percent Consonants Correct (PCC) is an accuracy measurement of consonant productions (Shriberg & Kwiatkowski, 1982). It is calculated by the total number of correctly produced consonants divided by the total number of consonant targets; PCC has been found to correlate with speech intelligibility in conversation (Shriberg, Austin, Lewish, McSweeny, & Wilson, 1997). PCC is an appropriate measure for individuals between 3 and 6 years old with speech delays. PCC also provides the most information reflecting three error types: omissions, substitutions, and clinical distortions. Moreover, it is a good index of speech disorder severity (Shriberg et al., 1997).

### **Percent Vowels Correct**

Percent Vowels Correct (PVC) is an accuracy measurement of vowel and diphthong productions (Shriberg, Austin, Lewis, & McSweeny, 1997). It is calculated by the total number of correctly produced vowels divided by the total number of vowel targets. PVC is an appropriate measurement of vowel speech errors with a focus on vowels and diphthongs of American English (Shriberg et al., 1997).

### **Proportion of Whole-Word Proximity**

The accuracy of whole target word productions was measured using the calculation of proportion of whole-word proximity (PWP; Ingram, 2002). PWP can yield information regarding the relationship between the child's forms and the targets they attempt, by providing a comprehensive phonological analysis of an entire word, taking into account the length and complexity of the production. PWP considers the accuracy of the production of all segments in a word. It is calculated by adding the number of all segments in the word and the number of correctly produced consonants in the produced word, divided by the total number of segments plus the number of consonants in the target word. For example, the production of the word "*slid*" (4 segments + 3 consonants = 7) as /sid/ (3 segments + 2 correct consonants = 5) yields a PWP of  $5/7 = 0.71$ . PWP can be used as an indirect measure of the child's intelligibility (Ingram, 2002).

### **Proportion of Whole-Word Variability**

The variability of word productions was measured using the calculation of proportion of whole-word variability (PWV; Ingram, 2002). PWP is a valuable method for measuring the consistency of word forms. PWP is best calculated when eliciting a pre-set number of productions for a pre-selected set of words, as is the case with this intervention study. It is calculated by dividing the number of distinct forms by number of productions. For example, the child is given three opportunities to say one word, thereby allowing three possible outcomes. The child can use one, two, or three distinct forms for

the three production opportunities. A hypothetical example is shown in Figure 1. In this example, the most variable case is 1c, where three distinct forms were produced. The resulting score is a 1.0, representing maximal variability. The least variable case is 1a (0.00), in which the same form was produced all three times.

Figure 1: Proportion of Whole-Word Variability Example

Child's Productions	Distinct Forms/ Productions
a. bath [bæ] (three times)	0.00 (0/3)
b. bath [bæ] (twice), [dæ] once	0.67 (2/3)
c. bath [bæ], [dæ], [bæt]	1.00 (3/3)



## Chapter 4: Case Study

Data includes the participant's speech and language status and baseline speech production patterns. Olivia was selected for this study because she presented with low speech intelligibility. Detailed information about the nature of the individual, disorder, intervention, and outcomes are presented to describe the participant and intervention in detail. Olivia's assessment procedures and speech production patterns during baseline are described to provide more detailed information about clinical decisions made and the effect of the course of intervention.

### SPEECH AND LANGUAGE STATUS

Standardized and experimental measures were used to assess Olivia's speech, expressive, and receptive language skills at baseline. Baseline measures were gathered at Olivia's preschool. Administration of assessments occurred 5 weeks before the onset of intervention. Standardized assessments included the *Preschool Language Scales—Fifth Edition (PLS-5; Zimmerman, Steiner, & Pond, 2011)* and the *Goldman Fristoe Test of Articulation—Second Edition (GFTA-2; Goldman & Fristoe, 2000)*. Olivia's speech production and inventory were assessed 4 weeks before the start of the intervention using spontaneous speech samples and target words from the intervention study. Speech and

language data were recorded using a high-quality digital video camcorder (Sanyo Xacti VPC-HD1000/1010) and digital voice-recording device (Olympus WS-321M).

## **Assessments**

The *Preschool Language Scales—Fifth Edition (PLS-5; Zimmerman, Steiner, & Pond, 2011)* was administered prior to intervention during baseline to assess Olivia’s expressive and receptive language skills. The *PLS-5* is a norm-referenced test used to assess the expressive (Expressive Communication) and receptive (Auditory Comprehension) language of children from birth to age 7;11. The assessment was administered and scored according to the examiner’s manual. Table 2 below shows Olivia’s *PLS-5* scores, percentile ranks, and age equivalencies. Based on her scores, Olivia currently showed greater difficulties with expressive communication than auditory comprehension. On the Expressive Communication subtest, Olivia achieved a basal (three consecutive accurate answers) beginning at the age 2;6-2;11 starting point rather than beginning at her chronological age start point. She was able to use words for a variety of pragmatic functions such as requesting and labeling actions/ objects, requesting assistance or repetition, and answering yes/no questions. However, she had limited different word combinations, using only noun + verb phrases, and often used gestures more than words to communicate.

On the Auditory Comprehension subtest, Olivia achieved a basal at the age 3;0-3;5 starting point. Olivia was able to follow directions without gestural cues, engage in symbolic play, recognize action in pictures (i.e., sleeping, eating, washing, playing), and

understand use of objects and spatial concepts (i.e. in, on, out of, off). However, she had difficulty understanding the following: more complex spatial concepts (i.e. under, in back of, next to, in front of), pronouns (i.e. he, she, his, her, they), and quantitative concepts (i.e. more, most). She also had difficulty in identifying colors. *PLS-5* results indicate that Olivia’s expressive and receptive language scores are lower relative to chronological age expectations. Olivia’s receptive and expressive language is limited. While her expressive communication is low, her auditory comprehension is a relative strength.

Table 2: *PLS-5* Results

<i>PLS-5</i>	Raw Score	Standard Score	Percentile Rank	Age Equivalent
Auditory Comprehension	34	78	7	2-8
Expressive Communication	27	68	2	1-11
Total Language Score	61	146		2-4

The *Goldman Fristoe Test of Articulation—Second Edition (GFTA-2*; Goldman & Fristoe, 2000) was administered to assess Olivia’s articulation of consonant sounds in single words. This norm-referenced test assesses articulation ability by sampling both spontaneous and delayed imitated sound productions. The *GFTA-2*, appropriate for individuals from 2;0 to 21;11, measures articulation of consonant sounds in all English word positions and allows comparison of individual performance to national, gender-differentiated norms. Examinees are required to respond with single-word answers to picture plates and verbal cues given by the SLP. Due to her low speech volubility, Olivia

required direct models during test administration. Table 3 shows Olivia’s *GFTA-2* scores, percentile, and age equivalence. Olivia produced many syllable structure and substitution phonological processes. Syllable structure processes present were final consonant deletion, cluster reduction, and weak syllable deletions. For example, Olivia omitted 11 of 19 possible final consonants and reduced 15 of 16 consonant clusters on the *GFTA-2*. Weak syllable deletion examples included [ʃʌ] for [ʃʌvəl] and [nænə] for [bənænə]. Olivia’s substitution phonological processes consisted of stopping, gliding, velar fronting, and palatal fronting. For example, she produced [dæum] for [vækjum], [wɛo] for [jɛlo], [də] for [gɜ:l], and [z:zɪŋ] for [fi:ŋ]. Olivia produced atypical errors; she frequently used a prolonged /z:/ to substitute for consonants and clusters such as [zɑ] for [wɑtʃ] and [zi] for [tri]. Olivia also showed difficulty controlling voicing, especially between [t]/[d] and [s]/[z].

Table 3: *GFTA-2* Results

<i>GFTA-2</i>	Raw Score	Standard Score	Percentile Rank	Age Equivalent
Sounds-In-Words	56	58	3	<2-0

## **BASELINE SPEECH PRODUCTION PATTERNS FOR INTERVENTION**

### **Speech Inventory**

Olivia’s speech sound repertoire was assessed using spontaneous speech output during baseline, 4 weeks before the start of intervention. Her spontaneous speech samples

consisted of 60 vocal forms. Table 4 lists her current speech inventory based on these samples. Olivia's spontaneous vocalizations included single elongated consonants such as /z:/, single elongated vowels such as /a:/, single-syllable words such as /di/ for "sleep" and two-syllable words such as /beibi/ for "baby." She produced the majority of vowels and the following 12 consonants spontaneously: /b/, m/, /w/, /t/, /d/, /n/, /s/, /z/, /l/, /r/, /h/, and /j/. Olivia has a restricted spontaneous consonant and vowel inventory. Olivia initiated words infrequently, resulting in a small sample size for her chronological age.

Table 4: Phonetic Inventory from Spontaneous Speech

<b>Consonant Inventory</b>			
<b>Place of Articulation</b>	Phonemes	<b>Manner of Articulation</b>	Phonemes
Bilabials	b, m, w	Stops	b, t, d
Labiodentals	-	Nasals	m, n
Interdentals	-	Fricatives	s, z, h
Alveolars	t, d, n, s, z, l, r	Affricates	-
Alveopalatals	-	Approximants	w, l, r, j
Palatals	j		
Velars	-		
Glottals	h	<b>Missing consonants:</b> p, f, v, θ, ð, ʃ, ʒ, k, g, ŋ, tʃ, dʒ	
<b>Vowel Inventory</b>			
<b>Height</b>	Phonemes	<b>Tongue Advancement</b>	Phonemes
High	i, I, u, ʊ	Front	i, I, e, ε, æ
Mid	e, ε, ə, ʌ, ø, o	Central	ə, ʌ, ø
Low	æ, a	Back	u, o, a
<b>Diphthong Inventory</b>	ai, aʊ, ei, oʊ	<b>Missing vowels:</b> ɔ, jʊ, ɔɪ	

### Phoneme Accuracy

Olivia's speech production accuracy was assessed using spontaneous speech samples. Spontaneous speech output with unclear referents was excluded from analyses.

Speech samples were limited, consisting of 49 vocal forms for 21 referent words. Tables 5 and 6 list Olivia's consonant, vowel, and diphthong accuracy across word and syllable positions.

Olivia demonstrated highest consonant accuracy overall for palatals and glottals. However, these sound opportunities did not occur in the medial or final position. She had 47% accuracy overall with alveolars and 25% accuracy with alveopalatals. Olivia had highest consonant accuracy in the initial position (49%). These production patterns may be due to Olivia's frequent omission of medial and final consonant sounds. In the initial position, Olivia produced both palatals and glottals with 100% accuracy. She also produced alveolars with 60% accuracy and bilabials with 33% accuracy. Examples of speech productions errors were /z:/ for "sleep", /di/ for "Mickey", /də/ for "pajamas" and /ba.i/ for "potty."

Table 5: Consonant Accuracy

Consonant Accuracy				
Place of Articulation	Initial	Medial	Final	Total
<b>Bilabial</b> (/b/, /m/, /w/)	5/15=33%	1/7=14%	0/9=0%	6/31=19%
<b>Labiodental</b>	-	-	-	-
<b>Interdental</b>	-	-	0/1=0%	0/1=0%
<b>Alveolar</b> (/t/, /d/, /n/, /s/, /z/, /l/, /r/)	12/20=60%	3/6=50%	3/12=25%	18/38=47%
<b>Alveopalatal</b>	-	0/6=0%	2/2=100%	2/8= 25%
<b>Palatal</b> (/j/)	5/5=100%	-	-	5/5=100%
<b>Velar</b>	0/7=0%	0/3=0%	-	0/10=0%
<b>Glottal</b> (/h/)	2/2=100%	-	-	2/2=100%
<b>Total</b>	24/49=49%	4/22=18%	5/24=21%	

Olivia's vowel accuracy for jaw height showed high vowels at 50%, mid at 63%, and low vowels at 80%. Her vowel accuracy in the parameter of tongue advancement showed front vowels at 67%, central 44%, and back at 89%. She had highest vowel accuracy in the first syllable position. Olivia's vowel accuracy may be lower in the second and third-syllable position due to her production preference for one-syllable words and omission of the following syllables. Within the first syllable, she produced mid vowels (88%) and back vowels (89%) with the highest accuracy. Olivia was least accurate with high vowels (33%) and front vowels (62%). This pattern is inconsistent



with patterns in typically developing children. Examples of vowel errors within her speech output were /də/ for “tired”, /wæ/ for “wow”, /bæɪ/ for “bottle.”

Table 6: Vowel Accuracy

Vowel Accuracy		Syllable 1	Syllable 2	Syllable 3	Total
<b>Height</b>	High	3/9= 33%	5/7=71%	-	8/16=50%
	Mid	15/17=88%	0/1=0%	0/6=0%	15/24=63%
	Low	10/13=77%	2/2=100%	-	12/15=80%
	<b>Total</b>	28/39=72%	7/10=70%	0/6=0%	
<b>Backness</b>	Front	13/21=62%	7/9=78%	-	20/30=67%
	Central	7/9=78%	0/1=0%	0/6=0%	7/16=44%
	Back	8/9=89%	-	-	8/9=89%
	<b>Total</b>	28/39=77%	7/10=70%	0/6=0%	
<b>Diphthongs</b>	ai	1/2=50%	-	-	1/2=50%
	aʊ	2/3=67%	-	-	2/3=67%
	ei	5/6=83%	-	-	5/6=83%
	oʊ	0/2=0%	-	-	0/2=0%
	<b>Total</b>	8/13=62%	-	-	

### Word and Syllable Shapes

Olivia’s phoneme accuracy was severely affected by her tendency to reduce target word shapes. Analyses of Olivia’s spontaneous speech production show a limited variety

of syllable shapes. Her most common syllable shapes were CV (i.e. “no”) with 37 occurrences and C (i.e. singleton consonant, /z:/) with 7 occurrences. The majority of spontaneous speech output consisted of one-syllable word shapes, characteristic of children at the onset of word use between 7 -15 months of age. Olivia’s repertoire of syllable and word shapes is shown in Table 7.

Table 7: Word and Syllable Shapes in Spontaneous Speech

<b>C</b>	7 occurrences
<b>V</b>	3 occurrences
<b>CV</b>	37 occurrences
<b>CVCV</b>	6 occurrences
<b>CVV</b>	4 occurrences
<b>CVC</b>	3 occurrences

### **Word Variability**

Dodd and Thompson’s (2011) study found that the number of whole words produced inconsistently by children with DS did not differ from patterns found in phonologically disordered non-DS children who make inconsistent errors. As a result, variability in word productions was considered an important area to analyze. During spontaneous speech samples, Olivia produced /n:/, /næ/, and /ma/ for “nap”, /s:/, /z:/, and /di/ for “sleep”, /di/, /didi/, and /ɪdi/ for “Mickey”, and /ə/, /də/, and /zə/ for “pajamas.”

Analysis using a Type- Token Ratio (TTR) yielded a percentage of 40.8%. TTR is a measure of vocabulary variation within spoken output (Richards, 1987). TTR is calculated by dividing the total number of words in a speech sample, referred to as tokens, by the number of types, the number of *different* words excluding repetitions. TTR analysis of Olivia’s words showed that she has low lexical density. Table 8 and 9 list the words and their frequency of occurrence in a 30 minute-spontaneous speech sample and the TTR calculation. Through both formal and informal analyses of her speech, Olivia appears to present with word variability.

Table 8: Type Token Ratio Words

Rank	Word	Frequency
1	pajamas	6
2	sleep	5
3	no	5
4	okay	5
5	yeah	5
6	nap	4
7	Mickey	3
8	daddy	2
9	Nola	2
10	car	2
11	me	1
12	down	1
13	potty	1
14	baby	1
15	house	1
16	bath	1
17	tired	1
18	wow	1
19	bottle	1
20	hi	1
		Total: 49

Table 9: Type Token Ratio Calculation

Type-Token Ratio = (number of types/ number of tokens)*100
= (20/49) * 100 = <b>40.8%</b>

## **BASELINE DATA ANALYSIS**

Because chosen Core Vocabulary Approach words were a part of the intervention protocol, words targeted in intervention were also targeted in baseline. Formal assessments of Olivia's targeted words during baseline were analyzed using the data analysis measurements described in the preceding chapter. The baseline measures and results of the study are further discussed in Chapter 5: Results.

## **Chapter 5: Results**

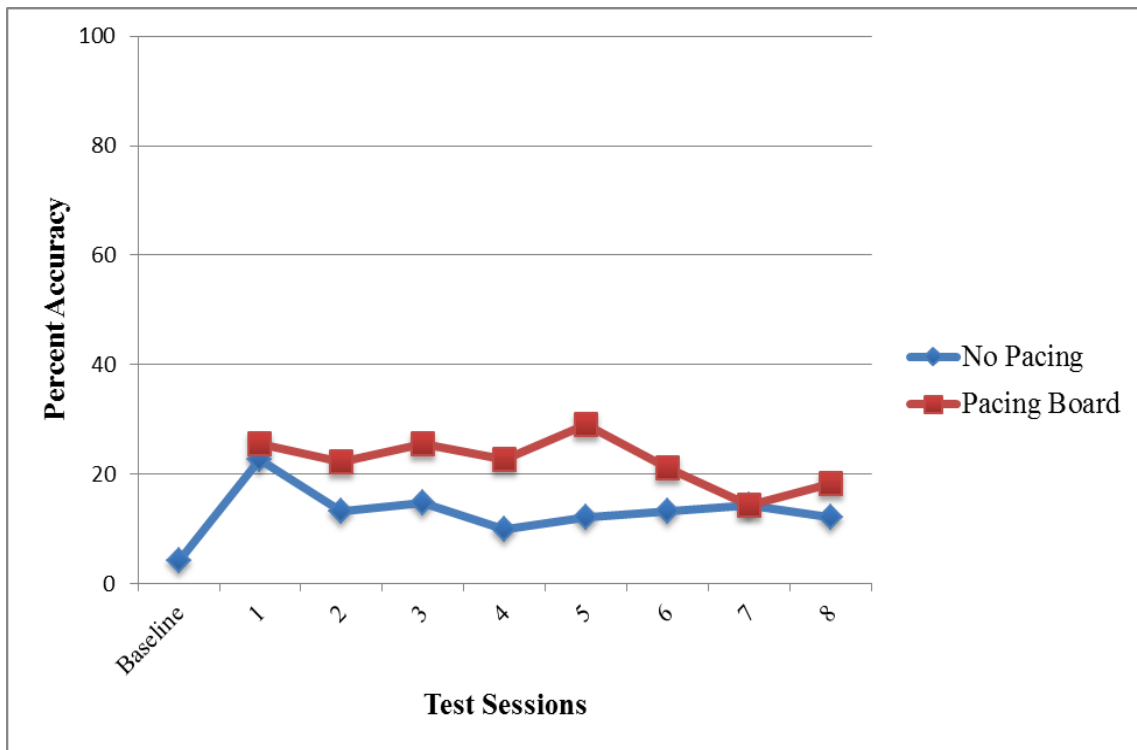
The pacing board was used in conjunction with a modified form of the Core Vocabulary Approach (CVA; Dodd et al., 2010). The goal of this case study was to investigate the effects of a pacing board as an intervention technique with a child with DS. The pacing board was used with the intention of increasing speech intelligibility of targeted words in intervention. These results include data on Olivia's mastery of core vocabulary target words, consonant and vowel speech production accuracy (PCC and PVC), proportion of whole-word proximity (PWP), and proportion of word variability (PWV) of all intervention target words. These measurements of targeted core vocabulary words were analyzed to identify the impact of implementation of a pacing board.

### **MEASUREMENT OF PERCENT CONSONANTS CORRECT**

Figure 2 displays the average percent consonants correct for all targeted words during the study's testing sessions. Phases of the study displayed in the graph include: (1) baseline and (2) the second session of every week during intervention in which Olivia was tested on targeted words with a no pacing and pacing board condition. The pacing board was not used during baseline in order to determine her baseline performance without the introduction of this intervention technique. Results showed that Olivia had greater percent consonants correct when using the pacing board compared to the no

pacing condition during intervention. Olivia’s percent consonants correct did not steadily increase throughout the course of intervention. This could be attributed to the introduction of new words containing more difficult target phonemes, such as velars and alveopalatals. For example, from week 4 through week 8 of intervention, the words “Gigi” and “Gogo” were targeted, both containing the phonemes /g/ and /dʒ/ that were not present in Olivia’s inventory at the onset of intervention.

Figure 2: Percent Consonant Correct With and Without A Pacing Board

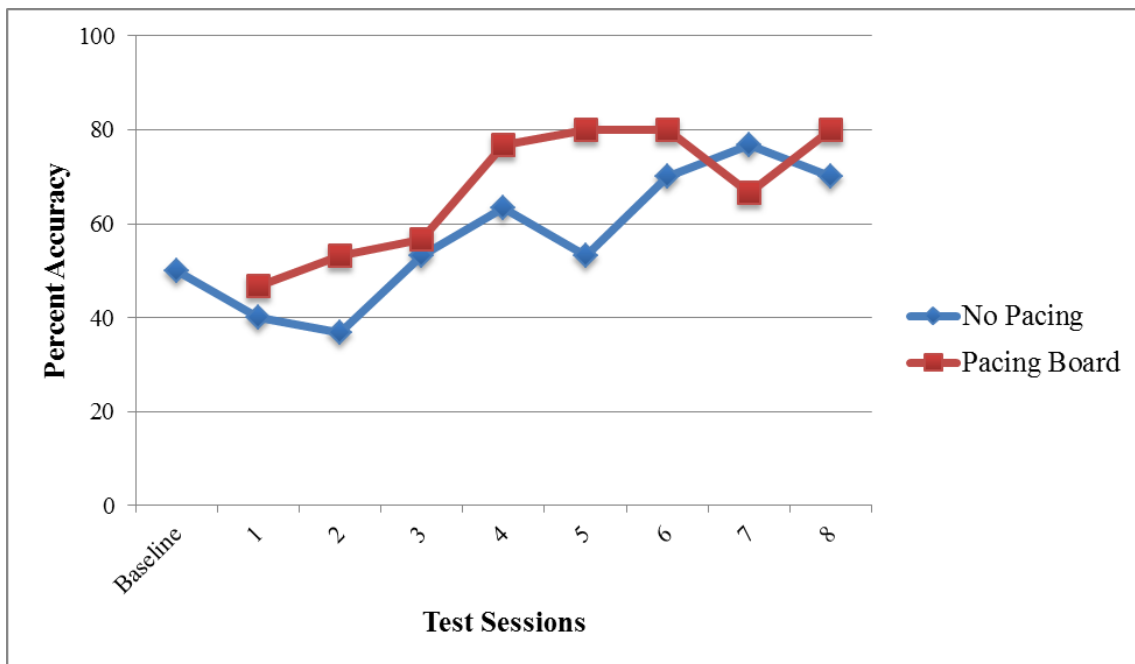


### MEASUREMENT OF PERCENT VOWELS CORRECT

Olivia’s average percent vowels correct during baseline and per testing session is displayed in Figure 3. Her percent vowels correct was calculated by averaging the

accuracy of her productions within each session for all target words. Results showed that Olivia had greater percent vowels correct with the pacing board. Within the no pacing condition, Olivia's percent vowels correct varied, ranging from 36% to 70%. With the use of the pacing board, her percent vowels correct increased from 46% to 80%. By the 5th session, Olivia's percent vowels correct appear to remain steady at 80%. Her week 7 testing session showed decreased percent vowels correct; within this session, Olivia demonstrated abnormal and perseverated substitution of /i/ for many of her vowel productions within target words.

Figure 3: Percent Vowels Correct With and Without A Pacing Board

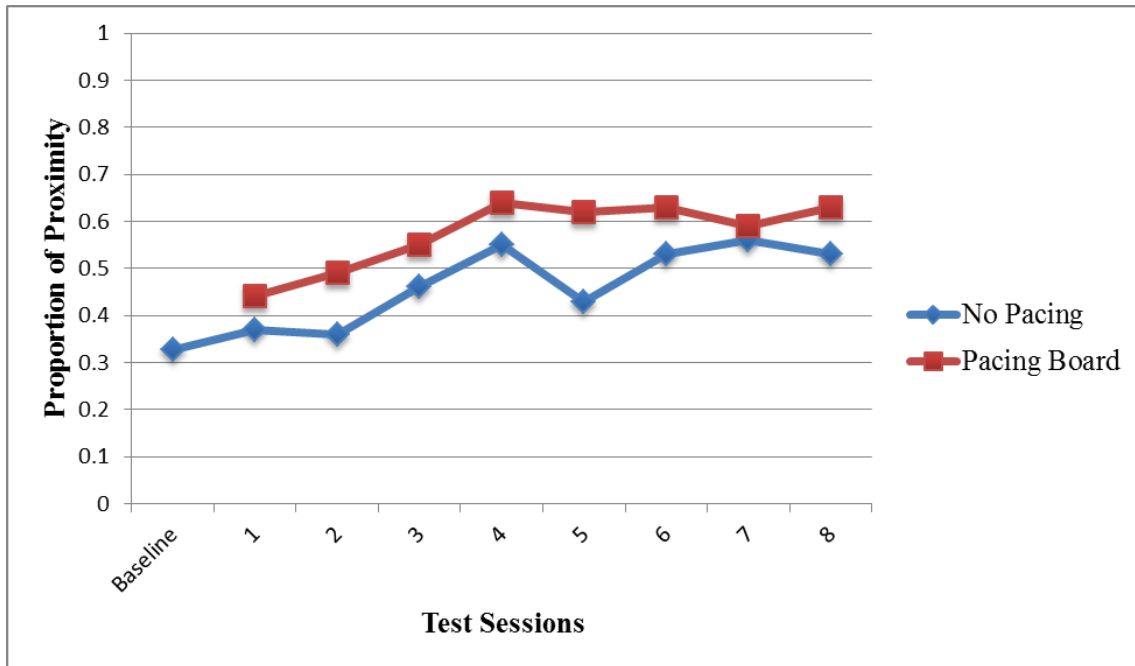


## **MEASUREMENT OF PROPORTION OF WHOLE-WORD PROXIMITY**

Olivia's approximation of words was measured using the measurement of proportion of whole-word proximity. Figure 4 displays her average approximation of target words during baseline and intervention testing sessions. Proportion of Whole-Word Proximity ranges from 0 to 1, with 1 being a completely correct production of the target word. Results from the data show that Olivia slightly increased her approximation of target words from .44 to .63 while using the pacing board. Her proportion of whole-word proximity remained steady in the .6 to .64 range from session 4 onwards, even with the addition of 2 new words through use of the pacing board. However, without the pacing board, Olivia's proportion of whole-word proximity showed more variability and ranged from .36 to .56. These results indicate that Olivia was able to achieve better approximation of target words when using the pacing board than without a pacing board.



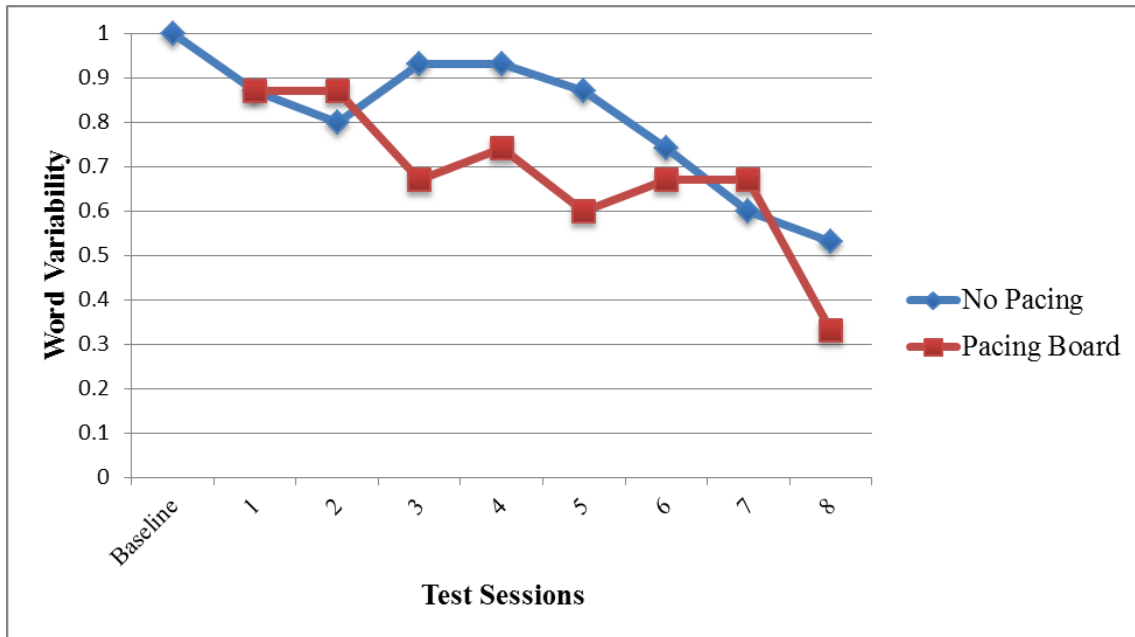
Figure 4: Proportion of Whole-Word Proximity With and Without A Pacing Board



### MEASUREMENT OF PROPORTION OF WHOLE-WORD VARIABILITY

Olivia's variability of word forms used was measured using the measurement of proportion of whole-word variability. Figure 5 illustrates Olivia's word variability during baseline and intervention testing sessions. Proportion of Whole-Word Variability ranges from 0 to 1, with 0 representing no inconsistent forms used and 1 as extremely inconsistent with different word forms used for all productions. Results from the data show that Olivia decreased variability across both conditions during intervention. During the no pacing condition, her variability measure decreased from 1 to .53. However, while using the pacing board, Olivia showed greater decrease in variability, from .87 to .33.

Figure 5: Proportion of Whole-Word Variability With and Without A Pacing Board



## RESPONSES TO INTERVENTION

Seven words were targeted during intervention. Tables 10 and 11 lists the words targeted during the study and the data on those words gathered during each week of the study. By the end of the intervention phase of the study, Olivia had mastered 4 words. New words were introduced during weeks 4 and 8. During week 4, a new word was introduced because Olivia had great difficulty with producing her brother's name. In the prior 3 weeks, Olivia often named her younger brother as "baby", using the form /bebi/ consistently, instead of his actual name. As a result, the word was dropped from the intervention study because of use of a target word for that name which was both consistent and intelligible. A target word was considered 'mastered' when Olivia

produced the word consistently using her best production across all three trials in both the no pacing and pacing condition. During week 7, she mastered the word “tired” using the form /aiə/ consistently. Within the testing session in week 8, Olivia mastered her grandfather’s name, Gogo, using /dodo/ and her grandmother’s name, Gigi, using /didi/. Within this week, she also consistently named “PJs” as /pizei/ during the pacing condition but not the non-pacing condition. This improvement may be due to the increased scaffolding that the pacing board provides as opposed to no pacing.

Overall, Olivia presented with a positive response to intervention. She consistently demonstrated greater progress overall during the pacing condition as demonstrated by the metrics of this study. Figure 6 is a compilation of Olivia’s PCC, PVC, PWP, and PWV measures during the pacing condition in intervention. Through use of a pacing board, Olivia showed a greater increase in PCC, PVC, and PWP measures and a decrease in variability as shown by her PWV. Olivia’s PCC did not steadily increase throughout the course of intervention during either pacing conditions; this was attributed to the introduction of new words containing more difficult target phonemes that were not present in Olivia’s inventory at the onset of intervention. However, her PVC during the pacing condition increased from 46% to 80%, while during the no pacing condition, it increased only from 40% to 70%. Olivia’s achievement of a significantly higher PVC using core words is an important gain for her ability to be understood. Olivia’s PWP, a measure of approximation of a target word, increased from .44 to .63 and remained steady in the .6 to .64 range while using a pacing board. However, without the pacing board, Olivia’s PWP showed great variability and ranged from .36 to .56.

These results indicate that Olivia was able to better approximate target words with the pacing board than without a pacing board. Likewise, Olivia's PWP measures were better during the pacing than no pacing condition. During the no pacing condition, her variability measure decreased from 1 to .53. However, while using the pacing board, Olivia showed greater decrease in variability, from .87 to .33. The effects of the pacing board as an intervention tool proved to be positive for Olivia. The implications of this study and the resulting positive intervention responses will be discussed in the Discussion chapter.

Table 10: Target Words Used During Baseline and Intervention

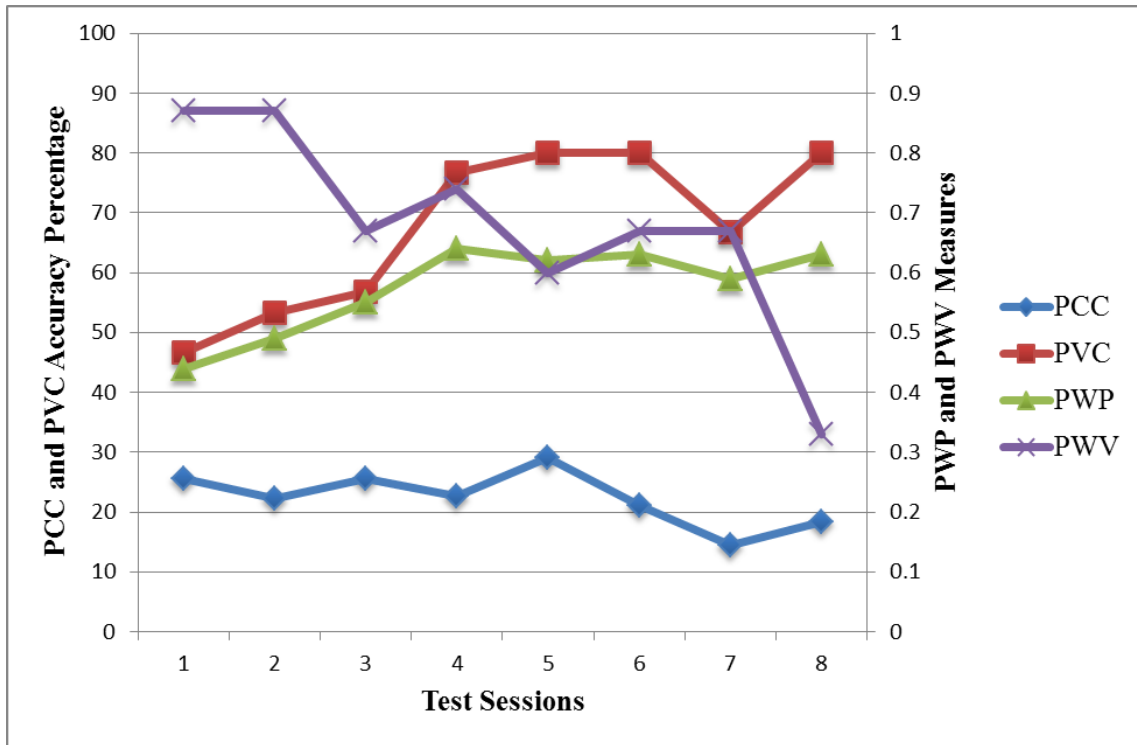
	<b>Baseline</b>	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>	<b>Week 8</b>
<b>Targeted Words</b>	Mickey Cormack Bathtub PJs	Mickey Cormack Bathtub PJs Tired	Mickey Cormack Bathtub PJs Tired	Mickey Cormack Bathtub PJs Tired	Mickey Gigi Bathtub PJs Tired	Mickey Gigi Bathtub PJs Tired	Mickey Gigi Bathtub PJs Tired	Mickey Gigi Bathtub PJs Tired	Mickey Gigi Bathtub PJs Gogo

Table 11: Intervention Responses

<b>Measure</b>	<b>Baseline</b>	<b>Week 1</b>		<b>Week 2</b>		<b>Week 3</b>		<b>Week 4</b>		<b>Week 5</b>		<b>Week 6</b>		<b>Week 7</b>		<b>Week 8</b>	
		<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>	<b>NP</b>	<b>PB</b>
<b>PCC</b>	4.20	22.7	25.5	13.3	22.2	14.7	25.5	10.0	22.7	12.2	29.1	13.3	21.1	14.4	14.4	12.2	18.3
<b>PVC</b>	50.0	40.0	46.7	36.7	53.3	53.3	56.7	63.3	76.7	53.3	80.0	70.0	80.0	76.7	66.7	70.0	80.0
<b>PWP</b>	0.33	0.37	0.44	0.36	0.49	0.46	0.55	0.55	0.64	0.43	0.62	0.53	0.63	0.56	0.59	0.53	0.63
<b>PWV</b>	1.0	0.87	0.87	0.80	0.87	0.93	0.67	0.93	0.74	0.87	0.60	0.74	0.67	0.60	0.67	0.53	0.33

*Note:* NP = No pacing board, PB = With the Pacing Board

Figure 6: Compilation of Intervention Measures with the Pacing Board



## **Chapter 6: Discussion**

The present pilot study investigated the effect of a pacing board (Kumin et al., 1995) as an intervention tool used in conjunction with the CVA (Dodd et al., 2010). The study's goal was to evaluate the efficacy of these two approaches for increasing the speech intelligibility of one child with DS. Olivia's speech production output patterns were examined in order to provide information on the effectiveness of the pacing board technique in the context of the CVA intervention approach as a possible intervention for children with a similar profile. Improvement in study measures of speech production was positive for Olivia, relative to her previous speech and language status. Results of this study and the potential factors that may have affected the results are explored. The efficacy of the chosen intervention approach and technique will be examined; recommendations for future research are also described.

### **CHOICE OF INTERVENTION APPROACH**

Olivia's positive progress in this speech intervention study reflects research findings that children with inconsistent speech benefit from the CVA (Crosbie et al., 2005; Dodd et al., 2006; McIntosh & Dodd, 2008). However, prior studies of the CVA have been primarily implemented with children who have inconsistent speech production patterns and intact cognitive abilities (Dodd et al., 2006; Dodd et al., 2010; McIntosh &

Dodd, 2008). This intervention study incorporated a modified form of the CVA because of Olivia's developmental and cognitive status. These adjustments to the traditional CVA's protocols were considered to be necessary adaptations to increase Olivia's volubility and to maximize intervention benefits.

Dodd et al. (2010) suggested that a child should have little difficulty producing 150-170 responses in a 30-minute session of CVA intervention and therefore the SLP should target 10-12 words per week. However, during baseline measures, it was difficult to elicit this high number of best productions for the proposed number of words without Olivia exhibiting noncompliance. As a result, only five words could be presented and targeted each week. Seven words were targeted in total and Olivia learned four of the words by the end of the study. Traditional CVA also calls for a set of 10 untreated probes to be elicited during the second session every two weeks to monitor generalization (Dodd et al., 2010). Generalization to untreated words is an indicator of success and transfer of learned skills to novel words. However, this protocol was not followed due to time constraints and Olivia's relatively low frequency of word productions in general. By modifying the CVA in this way, the researcher was able to maximize intervention time and increase Olivia's volubility for target core words.

In a study by McIntosh & Dodd (2008), 3 participants received traditional CVA therapy with varying frequency of intervention sessions. One participant received 12 therapy sessions and learned 53 words, a second participated in 27 sessions and learned 86 words, and the third had 38 sessions and learned 106 words. These participants showed larger gains compared to Olivia who had 16 therapy sessions and learned 4



words. However, they were all diagnosed with an inconsistent speech disorder with no other concomitant diagnoses. Relative to Olivia's diagnosis of DS and her speech and language status prior to the intervention study, the number of words she learned was consistent with her cognitive level and the frequency of therapy sessions received.

Traditional CVA protocol also recommends drilled practice to elicit best production of each word, followed by practice of targeted words in games for the remainder of the session (Dodd et al, 2010). The protocol followed in this study did not incorporate games during intervention sessions due to Olivia's low volubility. During play in baseline, Olivia appeared very quiet and did not engage in labeling or repeating words. As a result, drilling was primarily used for her to practice the target words. Drilling was deemed beneficial for Olivia because she had more direct practice and feedback on core vocabulary words. The structure of drilling seemed conducive to increasing Olivia's speech output and allowed the researcher to direct her attention to feedback on target words when best production was not produced.

Dodd et al. (2010) asserted that the CVA is appropriate for children with DS, citing another study by Dodd et al. (1994). In that study, the CVA was used as an intervention approach for a parent-training program. The goals of the program were to train parents in listening skills, to elicit acceptable productions, provide specific feedback to their children, and to reinforce only correct or consistently produced words (Dodd et al., 1994). The researchers assessed and collected speech samples at the start of the program, 8 weeks into the program, and within 4 months of the program's end at week 12 from the nine children participating in the study. The CVA techniques taught to parents

and therapy goals of Dodd et al. (1994) are similar to the present case study. However, Dodd et al.'s (1994) study is not applicable in clinical practice for SLPs and it failed to detail the modifications that may be necessary when working with children in the DS population. Ultimately, the CVA was successful for Olivia, but an adaptation was needed to provide these benefits. Many times descriptions of intervention approaches suggest their use and efficacy with diverse special populations but do not give any specific information about how adjustments might be made. As a result, one contribution of this case study is the description of modifications that should be made so that this may be a clearly helpful intervention approach for individuals with DS.

## **USE OF THE PACING BOARD**

This study investigated the use of a pacing board, an external rate control technique, to improve the articulation and speech intelligibility of one child with DS. Prior studies of the pacing board as an intervention tool have been completed with adults with dysarthria (Pilon et al., 1998; Van Nuffelen et al., 2010; Yorkston et al, 1990; Yorkston et al, 1992). In studies of adults with dysarthria, the participants experienced deficits in speech intelligibility similar to the deficits that have been observed in children with DS. The pacing board aids dysarthric speakers by acting as a visual representation of the segments of words. Yorkston et al., (1992) asserted that reduction of speaking rate, through the use of a rate control method, is a highly effective strategy for improving intelligibility. However, the pacing board has not yet been evaluated for children with

DS. As such, no research has been conducted studying its effectiveness and the treatment procedures have not been specified in the literature for this population.

In order to evaluate the efficacy of the pacing board, Olivia's speech production output patterns were measured and compared using PCC, PVC, PWP, and PWV during both the no pacing and pacing condition. Olivia consistently demonstrated greater progress overall during the pacing condition compared to the no pacing condition as demonstrated by the assessment metrics employed. Through use of a pacing board, Olivia showed a greater increase in PCC, PVC, and PWP measures and a decrease in variability, as shown by her PWV during every week of the study. Even with no significant increase over time, Olivia's PCC was still greater during pacing conditions compared to the no pacing condition. These results suggest that Olivia's speech intelligibility was better when using the pacing board. A possible explanation for the increases seen with the pacing board is its applicability as a multisensory tool. The pacing board that was used provided Olivia with visual and motor cues for imitating target vocabulary words, syllable by syllable. By providing Olivia this increased scaffolding, her metalinguistic awareness of the number of syllables in the target words may have allowed her to better approximate the words and achieve stability in word productions.

For a child like Olivia, an appropriate goal is for her to generalize her increased performance with the pacing board to a no pacing condition. Clearly a pacing board is not functional for Olivia while speaking to others in her day-to-day life. Instead, the purpose of the pacing board was to use it as an intervention tool during therapy to increase generalization of Olivia's speech intelligibility to the natural environment, as was

simulated in the no pacing condition. For the majority of intervention, once Olivia learned a word, she used her best production consistently across both no pacing and pacing conditions. However, during the last week of intervention, it was noted that Olivia used her best production for the word “PJs” consistently while using a pacing board, but not during the no pacing condition. Perhaps the pacing board, through its provision of increased scaffolding, allowed Olivia to begin stabilizing her best production for this target word. However, because the study had reached the end of intervention, there was no follow-up on her generalization of this word to the no pacing condition. Conceivably, with continued pacing board intervention, Olivia may have produced this word consistently with her best production in a natural context. Results of this study indicate that the pacing board enhanced Olivia’s performance compared to the no pacing condition. With more intervention sessions, Olivia may have generalized her speech intelligibility performance with the pacing board to the no pacing condition. Future research on frequency of intervention is needed to investigate prolonged effects of the pacing board and possible strategies for generalization. Ideally, follow up data collection should be implemented to assess longer-term retention of patterns produced during the study period.

## **MEASURES OF SPEECH INTELLIGIBILITY**

The chosen speech analysis metrics implemented in this study indicated that Olivia demonstrated an increase in speech intelligibility. Olivia’s speech production

output patterns were measured using PCC, PVC, PWP, and PWV. Definitions of speech intelligibility and the methods of assessing it were discussed previously. Poor speech intelligibility in this population has predominantly been substantiated by parental report and clinical testing using limited metrics and no direct evaluation of client speech patterns (Barnes et al, 2009; Kent & Vorperian, 2013; Roberts et al., 2006; van Bysterveldt, 2009). This detailed case study investigated the underlying aspects of speech production patterns associated with diminished speech intelligibility and evaluated the potential methods to measure it.

Kent & Vorperian (2013) stated that most studies reporting intelligibility indices measured speech intelligibility using rating scales and correlates of intelligibility such as PCC and PVC. Implementation of a rating scale was not possible in this study because of Olivia's low volubility and preference for one-word utterances. However, the analyses used enabled exploration of other potential measures of speech intelligibility. Although Olivia's PCC did not significantly increase, her gains in PVC, PWP, and PWV metrics were substantial.

van Bysterveldt et al. (2010) completed an intervention study of 10 preschool aged children with DS. They found that PVC showed a relatively high mean of 91.3% in comparison to the mean PCC of 50.6%. Therefore, for a child with DS such as Olivia, who started intervention with a lower PVC of 50%, her PVC increase to 80% at the end of the study is noteworthy.

Increases in PCC were desired but it appears that improvements for Olivia's PCC were related to her limited consonant inventory. From week 4 through week 8, new core

vocabulary words containing more difficult phonemes (“Gigi” and “Gogo”) were targeted, which Olivia did not have present in her inventory at the onset of intervention. However, the words “Gigi” and “Gogo” were two of the four words that Olivia learned as a result of this study. By the end of the intervention, she consistently named her grandmother, Gigi, as /didi/ and her grandfather, Gogo, as /dodo/, using the /d/ phoneme that was in her inventory as a substitute for /g/ which was not present. Her improved approximation of these words is reflected in her PWP scores, which increased and stabilized from .44 to .63. Approximation of words, as measured by PWP, does not necessarily entail the correct production of consonants and vowels. Rather it takes into account the length and complexity of the production, or ‘syllabicity’. As a result of intervention, Olivia improved her approximation of target words by producing more syllables in target words, making her more intelligible and qualifying PWP as an appropriate measure of speech intelligibility for a child with limited intelligibility.

Another significant finding of this study was Olivia’s decreased variability, as demonstrated by her PWV. Dodd & Thompson (2001) found through analyses at the consonant level that the number of whole words produced inconsistently by children with DS did not differ from phonologically disordered non-DS children who make inconsistent errors. Their findings suggested that speech patterns observed in children with DS may be indicative of phonological disorder characterized by inconsistent errors. Through formal and informal analyses at the onset of this study, Olivia presented with similar word variability to the children in Dodd & Thompson’s (2001) study. As a result, variability was targeted in this intervention protocol and measured using PWV. Olivia’s

speech intelligibility was considered improved based on the decrease in her PWV. Her elimination of variability for the four learned core words were significant because they serve as consistent functionally salient words that increase her speech intelligibility and lexicon.

## **CONCLUSION**

Olivia's case study suggests that inclusion of a modified CVA with the pacing board is a successful intervention method for increasing speech intelligibility in young low volubility children with DS. Olivia's entry speech and language status reduced her ability to be understood. Through this intervention study, Olivia acquired four additional and consistently produced functional words important to her and to her family. This result needs to be replicated with a larger group of children with DS so that this outcome can be generalized more effectively for the larger population of young children with DS who have intelligibility deficits.

Due to modifications of the CVA in this study, potential gains may have been reduced. A traditional CVA protocol recommends drilled practice to elicit best production of each word, followed by practice of targeted words in games for the remainder of the session (Dodd et al., 2010). Additionally, the CVA also recommends that the child's parents and teachers reinforce use of the core vocabulary by targeting words in functional daily communication (Dodd et al., 2010). The intervention protocol implemented here did not incorporate games and daily practice with parents and teachers.

Because the aim of the study was to measure Olivia's change in accuracy performance primarily relative to the effects of the pacing board, parents' and teachers' roles in intervention were not incorporated. Therefore Olivia's ability to produce the target words in a clinical situation does not necessarily mean it will be produced correctly in spontaneous speech outside of the treatment session. Future research is needed to investigate this aspect of treatment generalization in future studies of CVA in larger cohorts of children with DS. In addition, further research should be conducted around the role of parents and teachers and effective ways to include their participation.

In conclusion, this case study was conducted with a child with DS. The modified CVA and pacing board approaches were chosen as functionally applicable for her clinical profile. An expectation for children with cognitive differences is that they individually differ in progress as a result of therapy. Olivia's core vocabulary gains were smaller compared to previous studies of the CVA, but the addition of 4 words to her previously reported inventory of 10-15 intelligible words demonstrates functional and significant progress. Furthermore, Olivia's improvements were slower but there was change on the indices examined, particularly at the syllabicity and variability level. As a result, Olivia showed significant increases on certain indices that impacted her speech intelligibility. Based on this short intervention, the demonstrated improvements indicate that these metrics may be important in thinking about functional speech intelligibility and confirm the pacing board's efficacy as an intervention tool for children with DS.



## References

- Baker, E., & McLeod, S. (2011). Evidence-based practice for children with speech sound disorders: Part 2 application to clinical practice. *Language, Speech, and Hearing Services in Schools, 42*, 140-151.
- Barnes, E., Roberts, J., Long, S. H., Martin, G. E., Berni, M. C., Mandulak, K. C., et al. (2009). Phonological accuracy and intelligibility in connected speech of boys with Fragile X syndrome or Down Syndrome. *Journal of Speech, Language, and Hearing Research, 52*, 1048-1061.
- Barnes, E.F., Roberts, J., Mirrett, P., Sideris, J., & Misenheimer, J. (2006). A comparison of oral motor structure and function in young males with Fragile X syndrome and Down syndrome. *Journal of Speech, Language, and Hearing Research, 49*, 903-917.
- Bersu, E.T. (1980). Anatomical analysis of the developmental effects of aneuploidy in man: The Down syndrome. *American Journal of Medical Genetics, 5*, 399-420.
- Bull, M.J. & the Committee on Genetics. (2011). Health supervision for children with Down syndrome. *Pediatrics, 128*, 393-406.
- Bunton, K., Leddy, M., & Miller, J. (2007). Phonetic intelligibility testing in adults with Down syndrome. *Down Syndrome Research & Practice, 12*, 230-239.
- Centers for Disease Control and Prevention. (2014). Facts about Down Syndrome. Retrieved from <http://www.cdc.gov/ncbddd/birthdefects/DownSyndrome.html>
- Crosbie, S., Holm, A., & Dodd, B. (2005). Intervention for children with severe speech disorder: A comparison of two approaches. *International Journal of Language and Communication Disorders 40*(4), 467-491.
- Dobie, R. A., & Berlin, C.I. (1979). Influence of otitis media on hearing and development. *Annals of Otology, Rhinology, and Laryngology, 88*, 48-53.

- Dodd, B., Holm, A., Crosbie, S., & McIntosh, B. (2006). A core vocabulary approach for management of inconsistent speech disorder. *Advances in Speech-language Pathology*, 8(3), 220-230.
- Dodd, B., Holm, A., Crosbie, S., & McIntosh, B. (2010). Core vocabulary intervention. In A.L. Williams, S. McLeod, & R.J. McCauley (Eds.), *Interventions for speech sound disorders in children* (pp. 117-136). Baltimore, MD: Paul H. Brookes Publishing Co.
- Dodd, B., McCormack, P., & Woodyatt, G. (1994). Evaluation of an intervention program: relation between children's phonology and parents' communicative behavior. *American Journal on Mental Retardation*, 98(5), 632-645.
- Dodd, B., & Thompson, L. (2001). Speech disorder in children with Down's syndrome. *Journal of Intellectual Disability Research*, 45, 308-316.
- Dollaghan, C.A. (2004). Evidence-based practice in communication disorders: what do we know, and when do we know it? *Journal of Communication Disorders*, 37, 391-400.
- Gillam, S.L., & Gillam, R.B. (2006). Making evidence-based decisions about child language interventions in schools. *Language, Speech, and Hearing Services in Schools*, 37, 304-315.
- Goldman, R., & Fristoe, M. (2000). *Goldman-Fristoe Test of Articulation—Second Edition (GFTA-2)*. Circle Pines, MN: American Guidance Service.
- Guimaraes, C.V.A., Donnelly, L.F., Shott, S.R., Amin, R.S., & Kalra, M. (2008). Relative rather than absolute macroglossia in patients with Down syndrome: Implications for treatment of obstructive sleep apnea. *Pediatric Radiology*, 38, 1062-1067.
- Hayden, D. (2006). The PROMPT model: Use and application for children with mixed phonological-motor impairment. *Advances in Speech-Language Pathology*, 8(3), 265-281.

- Holm, A., & Dodd, B. (1999). An intervention case study of a bilingual child with phonological disorder. *Child Language Teaching and Therapy, 15*, 139-158.
- Ingram, D. (2002). The measurement of whole-word productions. *Journal of Child Language, 29*, 712-733.
- Jerger, S., Jerger, J., Alford, B.R., & Abrams, S. (1983). Development of speech intelligibility in children with recurrent otitis media. *Ear and Hearing, 4*(3), 138-145.
- Kaufman, N. (n.d.). The Kaufman Speech to Language Protocol. Retrieved March 10, 2015, from <http://www.kidspeech.com/specialized-treatment-methods/the-kaufman-speech-to-language-protocol.html>
- Kent, R., & Vorperian, H. (2013). Speech impairment in Down Syndrome: A review. *Journal of Speech, Language, and Hearing Research, 56*(1), 178-210
- Kumin, L. (1994). Intelligibility of children speech in children with Down Syndrome in natural settings: Parents' perspective. *Perceptual and Motor Skills, 78*, 307-313.
- Kumin, L., Councill, C., & Goodman, M. (1994). A longitudinal study of the emergence of phonemes in children Down Syndrome. *Journal of Communication Disorders, 27*, 265-275.
- Kumin, L., Councill, C., & Goodman, M. (1995). The pacing board: A technique to assist the transition from single word to multi-word utterances. *Infant-Toddler Intervention, 5*(1), 23-29.
- Miller, J.F., & Leddy, M. (1998). Down syndrome: The impact of speech production on language development. In R. Paul, S.F. Warren, & M.E. Fey (Eds.), *Exploring the speech-language connection* (pp. 163-177). Baltimore, MD: Brookes Publishing Co.

- McIntosh, B., & Dodd, B. (2008). Evaluation of core vocabulary intervention for treatment of inconsistent phonological disorder: Three treatment case studies. *Child Language Teaching and Therapy*, 25(1), 9-30.
- Pilon, M.A., McIntosh, K.W., & Thaut, M.H. (1998). Auditory vs visual speech timing cues as external rate control to enhance verbal intelligibility in mixed spastic-ataxic dysarthric speakers: a pilot study. *Brain Injury*, 12(9), 793-803.
- Pueschel, S., & Hopman, M. (1993). Speech and language abilities of children with Down syndrome. In A.P. Kaiser & D.B. Gray (Eds.), *Enhancing children's communication* (pp. 335-362). Baltimore, MD: Paul H. Brookes Pub.
- Richards, B. (1987). Type/Token Ratios: What do they really tell us? *Journal of Child Language*, 14(2), 201-209.
- Roberts, J. E., Chapman, R. S., & Warren, S. F. (2008). Increasing speech intelligibility in Down syndrome and Fragile X syndrome. *Speech & language development & intervention in Down Syndrome & Fragile X Syndrome* (pp. 219-228). Baltimore: Paul H. Brookes Pub.
- Roberts, J., Long, S.H., Malkin, C., Barnes, E., Skinner, M., Hennon, E.A., & Anderson, K. (2005). A comparison of phonological skills of boys with Fragile X syndrome and Down syndrome. *Journal of Speech, Language, and Hearing Research*, 48, 980-995.
- Roberts, J. E., Price, J., & Malkin, C. (2007). Language and communication development in Down Syndrome. *Mental Retardation and Developmental Disabilities Research Reviews*, 13(1), 26-35.
- Roizen, N.J., Wolters, C., Nicol, T., & Blondis, T.A. (1993). Hearing loss in children with Down syndrome. *The Journal of Pediatrics*, 123(1), S9-S12.
- Sackett, D.L., Rosenberg, W.M.C, Muir Gray, J.A., Haynes, R.B., & Richardson, W.S. (1996). Evidence based medicine: What it is and what it isn't. *British Medical Journal*, 312, 71-72.

- Sherman, S.L., Allen, E.G., Bean, L.H., & Freeman, S.B. (2007). Epidemiology of Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews*, *13*, 221-227.
- Shriberg, L.D., Austin, D., Lewis, B.A., & McSweeney, J.L. (1997). The speech disorders classification system (SDCS): Extensions and lifespan reference data. *Journal of Speech, Language, and Hearing Disorders*, *47*, 226-241.
- Shriberg, L.D., & Kwiatkowski, J. (1982). Phonological disorders III: A procedure of assessing severity of involvement. *Journal of Speech and Hearing Disorders*, *47*, 256-270.
- Shott, S.R., Joseph, A., Heithaus, D. (2001). Hearing loss in children with Down syndrome. *International Journal of Pediatric Otorhinolaryngology*, *61*, 199-205.
- Stoel-Gammon, C. (2001). Down syndrome phonology: Developmental patterns and intervention strategies. *Down Syndrome Research and Practice*, *7*(3), 93-100.
- Swift, E., & Rosin, P. (1990). A remediation sequence to improve speech intelligibility for students with Down Syndrome. *Language, Speech, and Hearing Services in Schools*, *21*(3), 140-146.
- van Bysterveldt, Anne Katherine, Gail Gillon, and Susan Foster-Cohen. (2010). Integrated speech and phonological awareness intervention for pre-school children with Down syndrome. *International Journal of Language & Communication Disorders*, *45*(3), 320-335.
- Van Nuffelen, G., De Bodt, M., Vanderwegen, J., Van de Heyning, P., & Wuyts, F. (2010). Effect of rate control on speech production and intelligibility in dysarthria. *Folia Phoniatica Et Logopaedica*, *62*(3), 110-119.
- Vicari, S. (2006). Motor development and neuropsychological patterns in persons with Down syndrome. *Behavior Genetics*, *36*(3), 355-364.

- Williams, A.L., McLeod, S., & McCauley, R. J. (2010). *Interventions for speech sound disorders in children*. Baltimore: Paul H. Brookes Publishing Co.
- Yorkston, K.M., Dowden, P.A., & Beukelman, D.R. (1992). Intelligibility measurement as a tool in the clinical management of dysarthric speakers. In R.D. Kent (Ed.), *Intelligibility in Speech Disorders* (pp. 245-285). Philadelphia, PA: John Benjamins Company.
- Yorkston, K.M., Hammen, V.L., Beukelman, D.R., & Traynor, C.D. (1990). The effect of rate control on the intelligibility and naturalness of dysarthric speech. *Journal of Speech and Hearing Disorders*, 55, 550-560.
- Zimmerman, I.L., Steiner, V.G., & Pond, R.E. (2011). *Preschool Language Scale, Fifth Edition (PLS-5)*. San Antonio, TX: Pearson.
- Zipoli, R.P., Jr., & Kennedy, M. (2005). Evidence-based practice among speech-language pathologists: Attitudes, utilization, and barriers. *American Journal of Speech-Language Pathology*, 14, 208-220.