PERCEPTUAL AND ACOUSTICAL COMPARISONS OF MOTOR SPEECH PRACTICE OPTIONS FOR CHILDREN WITH CHILDHOOD APRAXIA OF SPEECH

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PERCEPTUAL AND ACOUSTICAL COMPARISONS OF

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Children with childhood apraxia of speech (CAS) need intensive and accurate practice to establish an accurate motor plan and improve their speech production. Computer-led practice led to a greater quantity of practice and was preferred over parent-led practice. Further knowledge regarding children's accuracy of speech during independent practice is needed to determine if computer-led practice is a viable practice tool. Twelve children diagnosed with CAS, between 3-0 and 7-11 years of age, participated in speech practice during computer-led, parent-led, and clinician-led practice. Comparisons of perceptual accuracy of consonants and vowels, acoustical accuracy of stops, vowels, and fricatives, and variability of stops, vowels, and fricatives were examined.

The first study found no significant differences between perceptual accuracy of consonants and vowels during the three practice conditions. Additionally, speech productions in the computer-led condition led to greater precision in back sounds and fewer out-of-class substitutions and deletion errors compared to the parent-led and clinician-led conditions. Therefore, computer-led practice led to speech productions that were as accurate as current practice.

The second study found vowel productions were consistent across all three conditions. Production of fricatives were consistent across all three conditions, with greater accuracy in the computer- and clinician-led condition on two fricatives compared to the parent-led condition. There were no significant differences in over half of the stop productions. The computer- and clinician-led conditions led to the longest durations, which may have led to increased accuracy, while the parent-led condition led to the shortest durations. Overall, the greatest variability occurred in the parent-led condition across all manners of production, followed by the clinician-led condition, and the computer-led condition revealed the least variability. These findings suggest that computer-led practice led to speech productions that were comparable or better than clinician-led and parent-led conditions.

These studies provide evidence that computer-led speech practice is a viable practice tool for children with CAS to achieve accurate speech productions.

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CHAPTER 1 – LITERATURE REVIEW

Introduction

Children diagnosed with a speech sound disorder (SSD) that is suspected to be childhood apraxia of speech (CAS) struggle to communicate basic needs to even those closest to them. CAS leaves children with severely unintelligible speech as they struggle to develop sounds, strain to blend sounds together to form words, and cannot control the inflection of their voice, despite no muscular deficits (ASHA, 2007). Exact prevalence is unknown, however differing reports state 1-2 of every 1,000 children (Shriberg, Aram, & Kwiatkowski, 1997a) and 3.4-4.3% of speech-impaired preschoolers (Delany & Kent, 2004) have CAS. CAS is often accompanied by language and literacy deficits (ASHA, 2007; Lewis, Freebairn, Hansen, Stein, Shriberg, Iyengar, et al., 2006; Mirenda & Mathy-Laikko, 1989), academic difficulties (Lewis, Freebairn, & Taylor, 2000; Overby, Carrell, & Bernthal, 2007; Teverovsky, Bickel, & Feldman, 2009) deficits in phonological processing and literacy (Lewis, et al., 2000; Lewis, Freebairn, Hansen, Iyengar, & Taylor, 2004; McNeill, Gillon, & Dodd, 2009), and social disadvantages (Overby, et al., 2007), although it is unknown if they are co-occurring deficits, or if the lack of speech causes additional deficits. Language deficits were found in 82% (Thoonen, Maassen, Gabreels, Schreuder, & de Swart, 1997) to 100% (Lewis, et al., 2004) of children with CAS. Teachers report lower expectations for children with decreased intelligibility and often view them as having more behavior problems than children with typical speech intelligibility for their age (Overby, et al., 2007).These children need appropriate services at an early age to alleviate difficulties with speech, reduce the co-occurring deficits that

occur with significant speech difficulties over an extended time, and ensure they have the same opportunities as other children for achieving academic success.

The American Speech-Language-Hearing Association (ASHA) recently convened a panel to review existing research regarding childhood apraxia of speech (CAS) and, among many conclusions, recommended CAS as a distinct speech sound disorder, indicated a preferred diagnosis of suspected CAS (hereafter referred to as CAS), established identifying characteristics, and determined appropriate treatment techniques. In order for children with CAS to truly demonstrate improvement through learning of speech targets, intensive and individualized therapy and practice are necessary to improve repetitive planning and programming to enhance speech production (ASHA, 2007; Maas, Robin, Hula, Freedman, Wulf, Ballard, et al., 2008). Research revealed improved speech productions in nine to ten year old children given practice (Walsh, Smith, Weber-Fox, 2006). However, there are significant constraints limiting the amount and type of speech therapy a child may receive, including health care reimbursement and caseload size (Maas, et al., 2008). Traditionally, speech-language pathologists provide instruction on challenging speech targets during therapy sessions, with little time devoted to motor speech practice. Home practice allowed children to extend their performance towards mastery through practice beyond scheduled therapy, which led to optimal success (ASHA, 2007; Hudson & Kendall, 2002). Research across multiple disciplines has shown that people who adhered to a home practice routine experienced significantly greater improvements than those who did not practice (Behrman, Rutledge, Hembree, & Sheridan, 2008; Kazantzis, Dattilio & MacEwan, 2005; Kazantzis, Deane & Ronan, 2000; Kazantzis & Lampropoulos, 2002). Therefore, adherence to a practice routine may

help children with CAS learn speech skills they initially acquired in the therapy room. Two types of practice, parent-led and computer-led practice, have been identified as potential ways to provide these children with the additional practice they need.

Clinicians frequently rely on parents to practice with their child at home. Although children with a variety of speech disorders have experienced some success with parent-led practice (Bowen & Cupples, 2004; Eiserman, McCoun, & Escobar, 1990; Eiserman, Weber, & McCoun, 1992; Eiserman, Weber, & McCoun, 1995), parents can be extremely busy and struggle to complete home practice with their child due to meeting their basic family obligations as well as maintaining employment outside or inside of the home. Additionally, the established parent-child relationship may change the dynamics of practice when the parent tries to take on a new role of practice partner, practice can become more language-based (Bowen & Cupples, 2004), and cueing trajectories can change (Gardner, 2006), which all can reduce the overall compliance and effectiveness of home practice. Research also revealed limited quantity and integrity of speech practice provided by parents (Pappas, McLeod, McAllister, & McKinnon, 2008). Due to the limitations of parent-led practice, another means of motor speech practice, computer-led practice, has been explored.

Initial success has been reported with computer-supported motor speech practice with children with SSDs (Shriberg, Kwiatkowski, & Snyder, 1989; Shriberg, Kwiatkowski, & Snyder, 1990), children with hearing loss (Clendon, Flynn, & Coombes, 2003), and adults with acquired apraxia of speech (AOS) (Choe, Azuma, Mathy, Liss, & Edgar, 2007), although it has not been studied in children with CAS. Computer-supported speech production tasks led to increased motivation and attention to the task (Nelson &

Masterson, 1999; Shriberg et al., 1989; Shriberg et al., 1990), elicitation of successful practice for those who have already acquired the speech skill (Nelson & Masterson, 1999), and the ability to support therapy through home practice (Clendon et al., 2003). Past studies revealed computer-led practice was equally as effective, efficient, and engaging as clinician-led practice for children with SSDs (Shriberg, et al., 1989; Shriberg, et al., 1990) and in adults it led to greater improvements in speech production when combined with traditional therapy compared to traditional speech therapy alone (Choe et al., 2007). Due to initial evidence supporting computer-led motor speech practice, this technique may hold potential for children with CAS to provide motor speech practice to enhance motor learning.

In order to analyze computer-led practice, the researcher conducted two pilot studies to investigate 1) the impact of parental accountability on various types of motor speech practice patterns and 2) the accuracy of motor speech practice of clinician-led and computer-led practice strategies with children diagnosed with CAS. The first pilot study monitored motor speech practice completion in children with SSDs and CAS during unmonitored practice, computer-led practice, and parent-led practice utilizing a withdrawal design (Nordness & Beukelman, 2010). Eight children, ages 2-7 to 13 years, and their parent(s) were expected to practice their individually selected speech targets 10-minutes a day, seven days a week, in each of the conditions. The researcher created individualized computer programs using Microsoft PowerPoint (2004), which included audio-video clips of the child's SLP modeling the target words. The parent completed a homework record sheet each week of the treatment phases but did not complete a record sheet in the baseline and withdrawal phases.

A review of results revealed only three of eight participants practiced before accountability monitoring, while 100% of the participants increased their overall practice time when recording and reporting parent-led practice with an average increase of 34.3 minutes per week. Six of the eight participants had an additional increase of practice time when recording and reporting computer-led practice, with an additional average increase of 13.5 minutes per week. In the parent-led practice condition, three of the eight participants met the goal of 70 minutes per week and three met half of the goal. In the computer-led condition, three participants met the goal, two met 75% of the goal, one met half of the goal, and two met 25% of the goal. During the withdrawal phase, only one child met the goal and two children met 25% of the goal. During the final computer phase, one participant met the goal, three met 75% of the goal, and the remaining four met half of the goal. Holding families accountable for motor speech practice increased overall practice time. In addition, computer-led practice appeared to offer an additional increase in overall practice time as compared to parent-led practice. At the completion of the study, a social validity survey was conducted with a 62.5% return rate. Parents and children preferred, and were more inclined, to practice in the computer-led condition than in the parent-led condition. Additional comments revealed the computer-led practice helped increase confidence and independence and was more motivating than the parent-led condition (Nordness & Beukelman, 2010).

Due to the greater quantity of practice and the preference for computer-led practice, it was necessary to further study the feasibility of computer-led motor speech practice. Although the first pilot study encouraged accurate practice by selecting targets that were approximately 80% accurate in therapy, accuracy of speech practice was not

measured. It is imperative that motor speech practice is accurate to ensure the motor plan is learned correctly (Maas et al., 2008; Schmidt, 1975). Before a computer-led speech practice program is utilized, it is necessary to determine that children can maintain accurate speech productions when practicing with the computer. The standard judgment of whole word accuracy is broad phonetic transcription using the International Phonetic Alphabet (IPA). All speech-language pathologists are trained in phonetic transcription and no additional software or equipment is required for measurement. Unfortunately, reliability of phonetic transcription was reduced when transcribing disordered children's speech (Shriberg & Lof, 1991) and it provided little detailed information. However, phonetic transcription was reported to be a valid measurement tool for research, as long as specific guidelines are consistently followed (Hustad, 2006). Acoustic analysis has been used in conjunction with perceptual analysis as it has been shown to provide more detailed, valuable quantitative data regarding specific sounds, confirm perceptual findings, and track the effects of intervention (Kent, Weismer, Kent, Vorperian, & Duffy, 1999; Mauszycki, Dromey, & Wambaugh, 2007; Shuster & Wambaugh, 2000). Acoustic analysis requires additional training and high-quality software and equipment for recording and analysis. Therefore, acoustic analyses are rarely used in a clinical setting, especially with children. Due to the need for a highly reliable measure of accuracy and clinical practicality, in addition to detailed information about the speech production of children with CAS, utilization of both perceptual judgments of accuracy and acoustic analyses would provide additional information to identify how their speech output varies.

The second pilot study compared the accuracy of speech productions of children with speech sound disorders in clinician-led and computer-led practice conditions. Six

children, ages 3-0 to 8-6 years and diagnosed with CAS, participated in the study, which utilized a repeated measures design. Therapy targets were identified by the child's speech-language pathologist, of which the researcher selected 10-15 targets that met the requirements for acoustic analysis. The targets included obstruents, monopthongs (with the exception of low back vowels), and fricatives. To determine if a word was produced accurately, the researcher conducted perceptual judgments using broad phonetic transcription. In addition, productions were analyzed on three acoustic measures: 1) the first and second formants (i.e., F1 and F2) of all monopthongs, 2) spectral base frequency of fricatives, and 3) the voice onset time (VOT) of obstruents. Perceptual scoring revealed children were 85.25% accurate on whole word productions in the clinician-led condition and 86.89% accurate in the computer-led condition. Performance in the computer-led and clinician-led conditions was comparable.

The importance of understanding children's accuracy of speech in various types of motor speech practice is crucial to the feasibility of continued practice outside of the therapy room for children with CAS. In order to further examine children's speech accuracy in various practice options, additional research is needed to compare speech accuracy in parent-led practice to computer-led practice and clinician-led practice. One type of practice that shows potential is computer-led practice due to findings of increased quantity of practice in computer-led practice and parent and children's preference for it. Initial pilot data revealed children's speech accuracy in the computer-led condition was comparable to clinician-led practice. Although these are encouraging results, selection of target words was based on a high standard, between 80-100% accuracy. It is necessary to determine children's accuracy on target words that are not as stable in all three types of

practice conditions to determine their ability to support ongoing therapy. Further evidence is needed to determine if this trend is consistent across a larger sample of children with CAS, to compare parent-led, computer-led, and clinician-led practice, and to assess accuracy on words that are less than 80% accurate in therapy.

The purpose of this dissertation is to a) compare the accuracy of speech of children with CAS in three different practice conditions, clinician-led, computer-led, and parent-led practice, measured perceptually, b) compare the mean VOT of obstruents, F1 and F2 frequencies of vowels, and lower frequency limit of spectral frequencies of fricatives in all conditions, and c) compare the variability of F1 and F2 frequencies of vowels, VOT of obstruents, and lower frequency limit of fricatives in all conditions.

Literature Review

Childhood Apraxia of Speech (CAS).

Children diagnosed with a speech sound disorder (SSD) struggle to produce speech sounds, which can lead to significant difficulties with communication. These speech errors may be due to a cognitive, linguistic, or motor impairment or a combination of impairments (Strand & McCauley, 2008). It is vital to understand the level of impairment as treatment techniques differ accordingly. One type of SSD is a motor-based impairment called childhood apraxia of speech (CAS). Although CAS is described as a type of SSD, CAS is reported to more closely resemble the adult acquired apraxia of speech (AOS) rather than children with developmental speech delays (Shriberg et al., 1997a). The primary clinical characteristics of acquired AOS include slow speaking rate, lengthened sounds and durations between sounds, sound distortions, consistent errors, and abnormal prosody (McNeil, Robin, & Schmidt, 1997; Wambaugh, Duffy, McNeil, Robin, & Rogers, 2006). Although not discriminatory of AOS, other characteristics may include articulatory groping, perseverative errors, increased errors with increased word length, difficulty initiating speech, and automatic speech is better than novel speech (McNeil et al., 1997; Wambaugh et al., 2006). A diagnosis of CAS has been difficult to determine in the past due to a lack of behavioral correlates and neural substrates of the disorder (ASHA, 2007). However after years of debate, the American Speech-Language-Hearing Association (ASHA), the national association of speech-language pathologists in the United States, conducted a thorough review of the research and determined that CAS is a definitive diagnosis and is associated with three core features, inconsistent errors in

repeated productions, lengthened and disrupted coarticulatory transitions, and inappropriate prosody (ASHA, 2007). These are not necessary and sufficient markers; rather, they are signs that lead one to suspect CAS (ASHA, 2007).

The first core feature of CAS is inconsistent errors on repeated productions of words and/or syllables. In an attempt to confirm a diagnosis of CAS in five children, Davis, Jakielski, and Marquardt (1998) and Marquardt, Jacks, and Davis (2004) reported inconsistent errors across productions as one feature indicative of CAS. They revealed it was a struggle to describe the pattern of errors due to the inconsistency across productions. McCabe, Rosenthal, and McLeod (1998) reported 88% of children with CAS in their study demonstrated inconsistent speech. Maassen, Nijland, and van der Meulen (2001) reported acoustic inconsistency within and in between children with CAS. Inconsistency was also detected across place and manner substitutions (Thoonen, Maassen, Gabreels, & Schreuder, 1994).

The second core feature of CAS is disturbed co-articulation between sounds and syllables. Past research found children with CAS to have more variable and idiosyncratic coarticulatory transitions compared to children with typical speech (Nijland, Maassen, van der Meulen, Gabreëls, Kraaimaat, & Schreuder, 2002). When attempting to sequence syllables on a diadochokinetic task, children with CAS demonstrated significantly more errors on trisyllabic sequence repetition (i.e., /p^t^k^/) than children with spastic dysarthria and children with typical speech (Thoonen, Maassen, Wit, Gabreëls, and Schreuder, 1996). Deficits in coarticulation have also been identified as researchers examined children's ability to program motor speech movements. When a perturbation (i.e., bite block) was imposed on the children with CAS's speech, their coarticulation was

impacted and they could not compensate, revealing less distinction between sounds, unlike children with typical speech (Nijland, Maassen, van der Meulen, Gabreëls, Kraaimaat, & Schreuder, 2003). Sussman, Marquardt, and Doyle (2000) also reported evidence that children with CAS have difficulties making maximal distinctions between stop consonants and vowels due to difficulties with coarticulation.

The third core feature of CAS is inappropriate prosody (e.g., rhythm, intonation, and stress). It is frequently reported in the literature as deficient in children with CAS. Davis et al. (1998) identified inappropriate prosody only in CAS as compared to other speech disorders. Although Munson, Bjorum, and Windsor (2003) found children with CAS marked stress acoustically, listeners perceptually could not perceive these distinctions. Shriberg and colleagues have consistently reported deficits in stress as a key feature of CAS (Shriberg, Aram, & Kwiatkowski, 1997b; Shriberg, Aram, & Kwiatkowski, 1997c; Shriberg, Campbell, Karlsson, Brown, McSweeny, & Nadler, 2003; Shriberg, Green, Campbell, McSweeny, & Scheer, 2003). Of all the components of prosody, inappropriate stress was found to distinguish children with CAS from children with a speech delay (Shriberg et al., 1997b), which was consistent in five locations across the United States (Shriberg et al., 1997c). Stress has since been pursued as a possible diagnostic marker for CAS using a lexical stress ratio (Shriberg, Campbell, et al., 2003). A second possible diagnostic marker being considered for CAS, which also reflects prosodic deficits, is the Coefficient of Variation Ratio, a measure of the relationship between variations in pause time and speech time (Shriberg, Green, et al., 2003).

Although research continues to study the level of articulatory breakdown in CAS and AOS, it is generally thought to be a result of deficits in the motor programming or