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Integrated approach on the acquisition of phonological targets in 4-to-6-year-old children

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Abstract

The purpose of this study was to examine the effects of an integrated approach on the acquisition of phonological targets in 4-to-6-year-old children enrolled in maximum oppositional therapy (MOT). MOT is an alternative approach to traditional phonological intervention designed to promote systemic changes to untreated phonemes from the same or different manner class.

Two groups of children 4 to 6 years of age underwent MOT treatment, with one of the groups also receiving concurrent training in the use of self-cueing strategies (using tactile gestures phonemic cues) to promote self-generated feedback. MOT targeted phonemes with maximal contrasts in placement, manner and voicing in two groups of children. One group also received instruction in the use of two tactile cues to self-monitor production of phonological targets. A comparison of therapy duration required to meet target acquisition criteria was made between the two groups.

MOT and tactile self-cues demonstrated larger gains in phonological target acquisition over a 10-week period. The tactile self-cueing MOT group achieved target accuracy in less time across three phonemic contexts. The integrated approach using MOT resulted in an increase in phonological accuracy, including untreated phonemes across manner of classes.

This study offers preliminary support and extends prior research of a novel integrated phonological intervention approach in clinical practice. The results suggest potential increases in phonological self-awareness and accuracy, reduced duration of intervention, and an increase in phonological target acquisition. Further research in this area is merited.

Key words: *cues, self-cueing, integrated intervention, maximal opposition treatment approach, phonological processes*

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1. Introduction

Service delivery considerations widely impact clinical decisions for intervention practices (Tyler, 2006). As clinicians design phonological treatment programs, use of methods and strategies that are both efficacious and efficient in promoting behavior change is essential to an impactful treatment program (Amato-Zech et al., 2006; Gierut, 2001; Kamhi, 2006; G. Rogers, 2013). At present, we have limited empirical evidence regarding which phonological intervention approach is most efficient for children with phonological errors in comparison to others due in part, to individual, environmental or "within-in" child factors (Kamhi & Pollock, 2005; Preston et al., 2013). Considering the body of research, less is known on those intervention programs that may potentially shorten the duration of treatment. However, researchers suggest that a complexity approach is potentially among the most efficient; though less frequently the treatment program of choice by clinicians (Byun & Hitchcock, 2012a; Gierut, 2001; Gierut & Morrisette, 2005; Kamhi, 2006). Until recently, traditional approaches used in the treatment of speech sound disorders have been primarily clinician-directed instruction targeting phonological accuracy with less emphasis on child-driven strategies (Baker & McLeod, 2011b; Ertmer & Ertmer, 1998; King et al., 2013; Xi et al., 2020).

Across allied health professions (i.e., Occupational therapy, Speech-Language Pathology, Physical therapy, ABA therapy), self-monitoring has been synonymous with self-cueing. Different therapeutic professions have incorporated the use of an integrated, multimodal approach as an effective behavior changing strategy (Bialas & Boon, 2010; Levendoski & Cartledge, 2000; McDougall et al., 2012; Menzies et al., 2009; Nelson et al., 2009; Rafferty, 2010). For example, some clinicians integrate self-monitoring strategies to teach children to "talk" themselves through daily routines such as packing a bag for school (Bialas & Boon, 2010). Other professions may use self-monitoring to increase compliance in the classroom or use it to encourage on- task behaviors (Amato-Zech et al., 2006; Bialas & Boon, 2010; Levendoski & Cartledge, 2000; McDougall et al., 2012; Rafferty, 2010). In speech speech-language pathology, self-monitoring, also known as self-cueing, has been used as part of an integrated approach to potentially lead to less therapist driven instruction. Given the support for integrated approaches in other fields, it seems appropriate to examine the benefits of this approach in speech sound disorders research. Within the past decade, investigators have proposed the use of an integrated multimodal approach for acquiring phonological targets (Tyler, 2016; Xi et al., 2020).

Available literature exists in speech pathology on integrated, multimodal approaches that use external feedback such as speech tools (i.e., Speech Buddy, tongue depressors, etc.), charts, visual picture stimuli, gestures and augmentative and alternative communication (AAC) systems designed for children to acquire phonological targets (Amato-Zech et al., 2006; Byun & Hitchcock, 2012b; McDougall et al., 2012; Preston et al., 2014; Rogers, 2012; Ruscello, 1995; Rusiewicz & Rivera, 2017; Xi et al., 2020). However, less is known on the effects of using self-generated cueing strategies that may promote phonological target accuracy. Based on limited available research in phonological studies (King et al., 2013), this study provides support for phonological intervention approaches that are both integrated and multimodal. The integrated techniques may enhance a phonological treatment approach to be used and multimodal by incorporating self-generated strategies throughout intervention activities so that children may independently manage meaningful productions of phonological targets in words.

A method used by speech pathologists has been to incorporate student-driven activities into therapy that teach the client to independently, self-monitor their own target behaviors and use that feedback to self-correct phonological errors (Byun & Hitchcock, 2012b; Byun et al., 2016; Koegel et al., 1986; Landin, 1994; Rogers, 2012). In addition, Gierut (1989) posited that children often creatively find unique solutions to acquire the consistent use of phonological targets on their own; thus, teaching methods that facilitate target acquisition are critically important. Dr. Van Riper believed it was important for SLP's to focus on functional skills with prioritization of those skills that are most critical (Ertmer & Ertmer, 1998; Koegel, 1990; Koegel et al., 1986). The use of client-driven strategies with gradually less emphasis on therapist-directed support and more emphasis on client self-monitoring would potentially teach independence, promote learning, and perhaps encourage generalization of phonological intervention targets across children's phonemic inventory (Bialas & Boon, 2010; Dunlap et al., 1991; Koegel et al., 1986).

Children who are provided with self-cueing strategies they can use functionally in real world environments could potentially further develop speech and language skills outside of the therapy environment (Bialas & Boon, 2010). Researchers agree that skills can be incorporated into familiar everyday tasks that are practical since they serve to keep the child engaged in more communication opportunities (King et al., 2013). The emphasis of therapy is for children to achieve optimal performance of speech and language skills and extend these new, learned skills beyond the clinical setting into the real-world experiences (Kamhi, 2006; Kamhi & Pollock, 2005; Miccio & Powell, 2010).

Intervention strategies should be easily accessible, requiring very few steps to perform as not to create cognitive overload for the child, and practical for use with other communication partners in every-day situations (Dunlap et al., 1991; Koegel et al., 1988). Ideally, providing a system for children to use self-cueing and self-monitoring so they can take a more engaged and independent role in acquiring speech sounds would be of immense benefit to clinicians. Researchers posit though a variety of different integrated approaches may be equally effective in producing positive treatment outcomes on speech sound target accuracy, there is still need for further examination of such approaches that may support phonological target acquisition in speech pathology (Tyler, 2016). The potential benefit of the effects of integrated, multimodal phonological treatment programming is of great interest to clinical practice. Incorporating integrated activities and tasks using familiar and functional words and expressions may further allow children to potentially transfer skills across other phonological processes (i.e., different word positions or untrained phonemes and sound classes) within treatment conditions (Cole, 2013; Taps, 2007) and later may benefit from utilizing newly trained skills spontaneously in novel settings at home and in the classroom (McDougall et al., 2012; Rivers & Lombardino, 1998)

1.1. Overview of Phonological Treatment Approaches

All phonological treatment approaches use behavior modification as the basis for remediation of phonological disorders (Shriberg & Kwiatkowski, 1987). Treatment of articulation disorders began in the early 1900's and by the 1950's generalization had begun to receive significant attention in the field. The Sensory Motor Approach developed by McDonald in the 1960's focused on teaching sounds at the syllable level and in facilitative contexts where target sounds are correctly produced (McDonald, 1964). Subsequently, the multiple phoneme and paired stimuli methods were developed, and these approaches targeted working with multiple sound contrasts that differed across sound class (Gierut, 1989; Gierut, 2001; Gierut, 2007; Gierut & Hulse, 2010). In contrast, the Distinctive Feature Approach grouped sounds within specific distinctive features and worked to achieve generalization using sounds with similar and shared characteristics (e.g., voiceless labial obstruent as in /p, /f/) (Barlow & Gierut, 2002; Williams, 2003). Later, the Phonological Approach was developed, which included the use of minimal pairs, maximal opposition pairs, multiple oppositions, cycles, and complexity approaches to phonological treatment (Gierut, 2001; Peña-Brooks & Hegde, 2007; Saben & Ingham, 1991).

Considerations in service delivery widely affect clinical decisions. Selecting targets in phonological therapy are typically based on stimulability, intelligibility, visibility of the speech movements, degree of deviance, and severity of the phonological process disorder (Powell et al., 1991; Tyler, 2006). The first steps in selecting targets involve determining which approach to use that would result in the greatest phonological change within the child's unique sound system (Gierut, 2001). Researchers agree that there are two broad classification approaches from which to choose, either a developmental target-selection approach or complexity-based approach (Kamhi & Pollock, 2005; Tyler, 2006). It remains uncertain as to the duration needed to acquire phonological targets based on which approach one chooses. However, the selection of a phonological target may lead to potential gains in either within-class generalization or across-class generalization (Gierut, 2001; Gierut & Hulse, 2010; Kamhi & Pollock, 2005; Tyler, 2006) . Within-class generalization refers to changes that occur in untreated phonemes from the same manner class or to a target's cognate pair. Across-class generalization refers to acquisition of untreated sounds from a different manner class group of sounds or class from treatment of a targeted phoneme (Gierut, 2001; Kamhi & Pollock, 2005; Tyler, 2006). Researchers suggest that selecting a developmental target approach facilitates across-class generalization, while a complex target selection approach promotes both across-class as well as within-class generalization (Gierut, 2001; Tyler, 2006). Vertical strategies require that the child achieve mastery of specific therapy targets before progressing to the next set of target goals. Horizontal strategies are broader and target multiple processes. For example, cyclical strategies incorporate portions of both vertical and horizontal strategies, with practice on targets for a specific amount of time prior to progressing to the next goals or levels, and then rotating or cycling back through the multiple targets (e.g., three different sets of phonological

targets) across therapy sessions (Hodson, 1998). Various phonemes can be targeted in one cycle and mastery of the sound is not required in order to rotate to work on sounds in the next cycle (Lancaster et al., 2010).
Traditional phonological approaches focus on selecting distinctive treatment targets that are highly stimulable (potential to be trained) and pairing the target with a phoneme that already exists within the child's phonemic inventory to encourage system-wide changes (Barlow & Gierut, 2002; Miccio & Powell, 2010; Smit et al., 2015). Such approaches consider the number and types of feature differences that are being presented for treatment (Barlow & Gierut, 2002).

1.2. Alternative to Traditional Approaches

Unlike minimal pairs or distinctive features approaches, the maximal opposition treatment approach (MOT) is an alternative to the traditional phonological approach. The MOT approach is based on principles of complexity (Baker & McLeod, 2011b; Gierut, 1989; Hodson & Paden, 1983; Saben & Ingham, 1991), which researchers argue has the potential to facilitate across-class generalization as well as within-class generalization (Gierut, 1989; Gierut, 2001; Gierut, 2007; Tyler, 2006). This approach should be considered when speech sound errors persist beyond typical age range (Gierut, 1989, 2007; King et al., 2013). MOT approach involves using broad contrasts of maximally distinct phonemes that vary in voice, place, and manner (e.g., bilabial sonorant /m/ vs. voiceless velar /k/ or voiceless affricate /ʃ/ vs. nasal sonorant /n/) (Gierut, 1989). The maximal opposition treatment approach is designed to use paired words consisting of two maximally opposing phonemic feature contrasts to encourage system-wide phonological changes within the child's phonemic inventory (Gierut, 2001). The goal of MOT approach is to increase target acquisition and provide a basis for generalization. However, MOT is less frequently chosen as the phonological approach by SLP's (Storkel, 2018).
Donicht, Pagliarin, Mota, & Keske-Soares (2011) state that MOT does not contrast the phonemic error with the target, instead it contrasts the unknown phonemic target with a phoneme that the child correctly produces. Once the maximally opposing contrast sounds are mastered by the child, it is assumed that they will independently acquire sounds with minimally opposing features, as they are easier to produce (Gierut, 1989). Using this approach appears to have a positive impact on the child's phonological system by improving overall intelligibility with evidence that complexity-based approaches can potentially lead to generalization (Tyler, 2016). This approach involves treatment of later-acquired, difficult to train or non-stimulable sounds and has the potential to lead to greater system-wide changes, with some generalization occurring to untreated sounds (Gierut, 2007; Gierut et al., 1987; Storkel, 2018).

1.3. Phonology and Attentional Control

Gray and Shelton (1992) state that attention, holding and retaining information long enough to be process it, is an important factor in therapy for increasing correct articulatory productions. The brain mechanisms underlying attentional control are also associated with self-regulation, which is vital for effortful control; thus, attention may be potentially improved with the use of self-cueing training (Rueda et al., 2005). Ertmer and Ertmer (1998) reported that phonological treatment coupled with self-regulation training can transfer or generalize to independent, novel phonological skills. Shohamy and Wagner (2008) found that hippocampal and midbrain-dopamine region activity are highly correlated in that the two appear to work in tandem, overlapping and integrating with each other resulting in memories being encoded for retention of skills learned.

Memory involves three key processes: 1) encoding, 2) storing, and 3) recalling information (Bear et al., 2007). Additionally, consolidation is an associative part involved in the encoding and storage process. Researchers believe that consolidations re-access information from an engram (memory trace) of past experiences; therefore, it is a reconstructing of information from the past (Roozendaal, 2000). Encoding is the process of forming new memories and consolidation is the process of creating permanent representations of memories through physiological changes in the strength of connectivity between neurons (Bear et al., 2016). Storage involves holding information in the hippocampus until it is ready to be distributed to cortical areas. The cell bodies in the hippocampus store information, reinforcing learning and allowing new memories to be encoded, consolidated, formed, stored, and retrieved (Bear et al., 2016; Shohamy & Wagner, 2008). The final process involves recall of memories formed by accessing previously stored information and repeating the same pattern of neural activity formed when it was originally encoded (Shohamy & Wagner, 2008). Memory, then, is a type of perception linked to an experience-dependent event that is developed within the brain's neurophysiological system (Bear et al., 2016; Ullman, 2004). The brain possesses the ability to adapt to its environment, re-learn, re-associate, re-wire and reorganize when presented with new incoming information (Bear et al., 2016). Thus, memory and memory serving systems are important as they apply ingrained, long-term changes within the neuropsychological network (Demarin & Morović, 2014; Draganski et al., 2004; Ullman, 2004). New synaptic growth occurs that strengthens the connections between certain neural tracts making transmission easier over time, leading to neurological plasticity (Bear et al., 2016).

Researchers examined that self-generated cues are encoded, leaving behind a memory trace (engram) of the cue that is associated with a newly learned target or skill for retrieval (Roozendaal, 2000; Shohamy & Wagner, 2008; Ullman, 2004; Wheeler & Gabbert, 2017) (Fivush, 2008; Harris et al., 2014; Pansky et al., 2005). The unique relationship linking the cue to the target distinguishes it from other cues based on how each cue was originally matched to the target. This allows a person to remember to use self-generated cues across new experiences, making those experiences habitual (Wheeler & Gabbert, 2017).

1.4. Cueing Strategies

Investigators have proposed the use of different types of cueing strategies (e.g., written data collection, electronic vibrating beeper devices, tactile cues, auditory cues, visual cues, gesture cues) (Amato-Zech et al., 2006; Landin, 1994; Levendoski & Cartledge, 2000; Menzies et al., 2009) and have reported positive effects on the accuracy and generalization of correct phonological productions (Gray & Shelton, 1992; Hedrick, 1997; Koegel et al., 1986; Landin, 1994; Preston et al., 2014; Rogers, 2013; Rogers & Chesin, 2013; Xi et al., 2020). Rafferty (2010) stated that self-monitoring is an effective behavior changing strategy initiated by external cues (therapist driven instruction) with the child being an active participant in the intervention process using their own internal cues (self-initiated behaviors).

Amato-Zech et al., (2006) examined the effectiveness of an electric tactile self-monitoring device called the MotivAider 2000. Each time the device signals through vibration, it cues the student to document their on-task attention in a special education classroom. Results indicated that tactile self-monitoring treatment increased on-task attention from a mean of fifty-five percent to greater than ninety percent in the data intervals observed, and both teachers and students found this method of self-monitoring acceptable for use. Koegel et al., (1986) examined self-monitoring to improve correct production of /s, z/ in the clinical setting and to generalize productions to the natural environment. The subjects produced correct and incorrect target sounds and were trained to self-record correct phonemic productions in conversation. The subjects were required to complete take home data sheets and only earned points for recording correct responses in reading and conversation with another individual. Trained within therapy sessions, the subjects demonstrated immediate and rapid improvements outside of the clinic setting (Koegel et al., 1988; Rhode et al., 1983). Rogers (2013) developed Speech Buddies, which are hand-held, tactile (sensory), biofeedback devices placed intra-orally in the mouth to provide a direct tactile cue for remediation of the target phonemes /r. l. s, sh, ch/.

Utilizing the R Speech Buddy device in a case study, Rogers (2013) suggested that biofeedback also promotes increased physiological awareness of speech productions, thus increasing the subject's awareness of errored phoneme productions. By utilizing the Speech Buddy device, the subject was capable of correctly shaping and strengthening the tongue through external stimulation using his commercially sold device. Three independent evaluators examined the accuracy of /r/ production to determine whether the Speech Buddy device would effectively remediate the errored phoneme. Ten weeks post-treatment, the subjects' accuracy of /r/ production increased from 23 percent to 75 percent accuracy at the word level and, at the sentence level, increased from 10 percent to 60 percent post-treatment. In a comparison study by Rogers and Chesin (2013), the Speech Buddy device was also used to remediate the targeted /s/ phoneme. The authors used a randomized, controlled, single blind research design to test two groups of subjects, those with and without the use of the Speech Buddy device, to see which group would more efficiently remediate the misarticulated phoneme /s/. The authors analyzed speech production accuracy at six data points, across and within-subject conditions. The investigators reported continual increases in speech production accuracy by the experimental group using the Speech Buddies device (e.g., 73.8%, 74.0%, and 74.0%) for the final three measurable data points while the control group experienced no significant changes in percent of accuracy across the same measured data points (e.g., 44.3%, 45.4%, and 43.7%). Within group differences showed that measured treatment responses in seven out of eight of the experimental subjects increased to 87.5% while only three of the seven control subjects experienced increases of only 42.8% in measurable treatment responses. Results in this study reported greater increases exhibited across and within the experimental group from baseline to the final data point measured. Simply teaching correct production of a sound in the treatment environment is not consistent with best practice as generalization activities are recommended as an integral part of the intervention process (Byun & Hitchcock, 2012b; Koegel et al., 1986). Practice is important both within the treatment environment and in additional contextual environments (Baker & McLeod, 2011b; Kamhi & Pollock, 2005; Mcleod & Baker, 2014). Crafting treatment programs that promote child-driven, self-cueing techniques instead of relying heavily on SLP-directed cueing or an external feedback device should be further investigated to determine if they can be effective and efficient in remediating phonological process disorders as an integral part of treatment approaches.

1.5 Purpose of this Research

MOT is an alternative phonological treatment approach to traditional phonological intervention designed to promote systemic changes to untreated phonemes from the same or different manner class. Although highly recommended for persistent speech errors, this approach is not widely used among therapists. In addition, less is known about the effects of MOT when coupled with self-generated cueing strategies. The purpose of this study was to examine the effects of an integrated approach on the acquisition of phonological targets in 4-to-6-year-old children enrolled in maximum oppositional therapy (MOT). This study addressed the following research questions:

1) What is the effect of using MOT accompanied by the use of tactile self-cueing on overall phonological accuracy (%) as compared to the performance of a control group using MOT without the use of tactile self-cueing?
2) What is the effect of using tactile self-cues on the duration of MOT treatment required to meet criteria for acquisition of phonological targets (80% accuracy across 3 consecutive sessions in initial, medial, and final phonemic contexts)?
3) What are the parents' perceptions of the child's speech accuracy when comparing pre- and post-treatment surveys?

2. Methodology

2.1. Participants

This study was approved by the Loma Linda University Institutional Review Board and parents of participants read and signed informed consent forms explaining the benefits and limitations of participating in this study. On-site recruitment as well as letters and flyers were given to school administrators to recruit participants for this study. Of the 37 participants assessed, 32 qualified however, 20 continued to the end of the study. In addition, 15 potential participants declined from the study after they were screened. The twenty study participants consisted of typically developing monolingual English-speaking children, ages 4 to 6 years, who were identified by their parents or teachers as exhibiting one or more speech sound errors in conversational speech. They comprised a heterogeneous sample from a center-based early childhood development program, a private clinical setting, public schools, private schools, and a virtual academy. The recruited convenience sample was age stratified (4, 5 and 6-years) and randomly divided into two groups. One group received tactile self-cueing training with MOT and the other group received MOT approach only. Inclusionary criteria were age-appropriate receptive language skills, oral motor abilities, and normal peripheral hearing sensitivity in both ears. Participants were required to have an email address and electronic device to receive and access a zoom link throughout the study. Participant exclusion criteria consisted of attention deficits (e.g., ADHD, ADD), developmental delay (ASD), chronic behavior challenges affecting ability to learn (e.g., tantrums, self-injury, biting, hitting), presence of neurological deficits, legally blind, and hearing impairment.

Throughout the study, participants were required to attend maximal opposition therapy (MOT) sessions, either with or without the use of accompanying self-cueing strategies, or prompts, twice weekly for 10 weeks. There were some expectations required of parents or caregivers. Parents who expressed an interest in the study and whose children met the criteria were scheduled for a pre-study interview. During the interview, parents who chose to participate in the study read and signed the informed consent form. The children were given a start date and parents completed an initial parent survey regarding their child's phonological development (e.g., I understand what my child says; Other people have trouble understanding what he/she says, I correct my child's speech) by giving a response of always, sometimes, or never. A parent or a caregiver was required to agree to serve as a reading partner for their child, outside of therapy sessions. They also had to consent to be videotaped engaging in story retell tasks a minimum of 3 times throughout the study. These videos were used to code for either phonological accuracy or phonological inaccuracy, and the use/non-use of accompanying tactile self-cueing strategies outside of the therapy environment. The parent/caregivers were also required to have an electronic device (e.g., Smartphone, iPad, tablet) or equivalent computer capability with a web camera to perform and record live, on-screen interactions and follow-up sessions outside of treatment setting, using the Zoom videoconferencing software. While not required to purchase the Zoom software, parental access to an internet connection via a hyperlink to join the live, zoom sessions was a requirement.

2.2. Personnel and equipment

The first author and two research assistants who provided intervention and collected data during story retell visits consisted of licensed and practicing speech-language pathologists and a speech-language pathology assistant. The first author (SLP) and research assistants used either a desktop or laptop computer with dual-core processors and access to high-speed internet consisting at a minimum of at least the ASHA recommended bandwidth of 3.0 mbs per second. Computers were equipped with either an internal or external webcam and a built-in or external microphone. Although face-to-face intervention did not require the use of headsets while participants were seated in a private, controlled treatment room, the use of ear buds or headsets were required for all computer-based, data collection. Throughout the study, each session was recorded via Zoom video-conferencing platform. However, the pandemic surge of 2020 forced an unexpected shift in the study from clinic-based interaction to the computer-based, Zoom platform only for the health and safety of the community.

2.3. Data collection and processing

Several pre- and post-therapy assessments were given as part of this study. The Goldman-Fristoe Test of Articulation-Third Edition (GFTA-3) (Goldman & Fristoe, 2015) and the Khan-Lewis Phonological Assessment-Third Edition (KLPA-3) (Khan & Lewis, 2015) were used to diagnose the presence of phonological disorders for potential participants. The GFTA-3 is a norm-referenced and standardized assessment tool used to examine phonemic inventory in Standard American English. It provides information concerning spontaneous and imitated sound productions in single words and connected speech and provides stimulability information. It is frequently used in combination with the KLPA-3, a norm-referenced instrument which was used to determine the presence of phonological processes. GFTA-3 and KLPA-3 scores were measured using standard scores, percentile ranks, confidence intervals, by gender and age. The Oral and Written Language Scales-Second Edition (OWLS-II) (Carrow-Woolfolk 2011) is a comprehensive assessment of language comprehension that includes lexical, semantic, syntactic, supralinguistic and pragmatic language abilities. It is a standardized, norm referenced assessment tool which is measured using standard scores, confidence intervals, percentile ranks, descriptive range and test age equivalence.

A pre-and post-treatment parent survey was collected using a 3-point ordinal Likert scale (i.e., Always, Sometimes or Never). The survey consisted of 12-questions used to assess the participant's accuracy of speech productions, overall speech intelligibility, how others (i.e., family members, friends and people in the community) rate the participant's speech productions, and the child's independent, spontaneous use of tactile self-cues outside of study treatment while producing target sounds trained during the therapy sessions (See Appendix A).

Throughout the study, a data collection form and coding rubric developed by the first author (See Appendix B). Data was collected during video recorded treatment sessions and story retelling tasks to code for phonological accuracy, the presence of using tactile self-cues (C) or whether a prompt facilitated a response during intervention. The information data form was comprised of a numerical identifier, participants age, session date, and the phonemic target and finally a notes section. The purpose of the notes section was to document qualitative information such as observed, untreated sound changes during a session or parent and child subjective reporting and feedback (see Appendix B).

Similar to other investigations, we adopted/incorporated a criterion-based intervention requirement to determine the accuracy of target sounds and the duration to target acquisition (Smit et al., 2015; Williams, 2003). Participants were to reach 80% accuracy or greater, across three consecutive sessions in any phonemic word position (initial, medial, and final). A coding rubric was used by both SLP's and the SLP-A to code for the data collection on 1) the percentage of correct phonological targets produced by each participant; 2) whether or not participants simultaneously used cueing strategies during story retell visits ; and 3) to code for the number of prompts (i.e., Did you use your strategy?, Let's try that again) that were provided in treatment to remind participants to use a trained strategy (either a finger cue on tubercle or hand cue on larynx) or to offer a second attempt to correct the phonemic production

2.3.1. Zoom Platform

The Zoom video-conferencing platform was used in this study to collect and record data and monitor participants progress, through live camera interaction, across treatment sessions and story retell visits throughout this study. This web-based video-conferencing tool is HIPAA compliant as governed by the 2003 Rules and Standards published Health Insurance Portability and Accountability Act (HIPAA) Security Rule in the Federal Register (45 CFR Parts 160, 162, and 164 Health Insurance Reform: Security Standards; Final Rule). Zoom can also be accessed through a mobile application. Through this online platform, users have the ability to meet live, with or without the use of a video camera, record sessions, share documents and annotate on shared screens with communication partners. The online video-conferencing program utilized in this study was the Zoom Pro which offers the benefit of unlimited meeting time as opposed to the cost-free version which limits meetings to 40 minutes.

2.3.2. Picture word pairs

From the maximum opposition approach to treatment, activity sheets were generated with pictured word pairs embedded with maximal feature differences (Bowen & Rippon, 2013; Gierut, 1989; Gierut, 2001; Gierut, 2007). A minimum of 10-word pairs on double-sided sheets were chosen from a combination of commercially available MOT worksheets and online pictures (See Appendix C). Participants were included in the selection process of online pictures for targeted word pairs by incorporating their unique interest in a familiar theme, character or athlete (e.g., Cookies, Koby Bryant, Om Nom, Princess Elsa).

2.3.3. Story booklets

Commercially available and printed story booklets were created with words inclusive of each participants' targeted phoneme. The booklets were short in length (10-25 words per page, 4-8 pages). Black and white or colorful picture illustrations accompanied the printed text. The purpose of the illustrations was to support early or non-readers as they describe the story, irrespective of printed words they may not recognize. Story booklets provided to subjects were at low cost, reproducible, foldable, and easy to print or color.

2.3.4. Tactile Self-Cues

Tactile hand cues were chosen to accompany the production of phonological targets as self-generated feedback for children to self-correct phonological errors and to further distinguish a target sound from other phonemes using the maximal opposition treatment approach. Participants were provided one of two tactile self-cues examined in this study; placement of a finger on the tubercle of the upper lip when producing a targeted phoneme or placement of the hand over the larynx to cue production of velar phonemes /k, g/. The development of self- generated cues is considered to be an active process which may ultimately allow children to become increasingly aware of phonemic productions (Wheeler & Gabbert, 2017).

2.3.5. Tokens and incentives

Throughout the study, participants received fun stickers, stamps, small toys, online games and movie clip choices as incentives. Upon completion of the study, a gift bag of small toys and treats were provided either in person or by mail for their valued participation.

2.3.6. Interrater Reliability Measures

Prior to identifying study participants, three pilot non-participants were recruited and videotaped while using MOT with and without the use of self-cueing strategies to establish interrater reliability among the first author (SLP), second SLP and licensed speech and language pathology assistant (SLPA). The first author (SLP) conducted a 1-hour training session with the second SLP and the SLPA. Both were given explicit instructions to identify the MOT approach and code for phonological accuracy of target phonemes. First, both SLP's independently applied codes using a coding rubric to the middle segment (20 seconds into the recorded session) of 3-prerecorded story telling sessions among 3-non-participants. The two SLP's compared and discussed findings to resolve any discrepancies in coding regarding the use of tactile self-cues or phonological accuracy. The two SLP's then re-applied the codes to the segments using the coding rubric for the three non-participants a second time and confirmed interrater reliability at greater than 80% accuracy.

The same process was used between the first author (SLP) and the licensed SLP-A. The first author and the SLP-A achieved interrater reliability of greater than 80% accuracy on phonological target identification and the use of verbal prompts when re-applying coding on a second attempt to the middle segment of 3 pre-recorded training participant videos. Next, the second SLP was trained to identify the two types of self-cueing strategies (i.e., finger cue vs. hand to larynx cue) participants may use to accompany MOT approach. Both SLPs identified self-cue strategies, applying code to the middle segment of the 3 pre-recorded sessions. Interrater reliability was achieved with no discrepancies found on observed use of tactile self-cues when reapplying the coding. The second SLP was given the two written parent-sentence prompts to monitor whether parents used them or used more than two prompts to encourage child participation during story retell for generalization data. The SLP-A used specific written instructions to administer treatment or prompts across all participants (See Appendix D).

2.3.7. Phonological Assessment

At either the participant's respective school site, or via tele-practice using Zoom software, the first author administered the GFTA-3 and the KPLA-3, pre-treatment, to assess articulation and for the presence of phonological processes (e.g., phonemic substitutions, omissions, distortions, and additions). Data from pre-treatment assessment measures were used to identify the presence of speech sound errors and to identify specific, individual phonological processes for the participants and establish target selections for therapy. The Listening Comprehension subtest of the OWLS-II was administered to participants to document that receptive language abilities are age-appropriate. To balance age groups of children (4, 5 and 6-years old), the participants were selected by consecutive sampling once they met inclusion and exclusionary criteria, and the parents and child agreed to participate in the study.

During the assessment process, the parents received a one-hour story re-telling training session and were provided the story retell materials, including two-written story retell prompts (i.e., one statement prompt and one open ended question) to use with their child during the story retell task (See Appendix E). During this training, the parents participated in mock story-retelling interaction with the first author and the SLP-A using the two-written story retell prompts. In addition, the first author also explained and demonstrated for parents how to access and open a Zoom link so one of the SLPs could then record parent-child storytelling interactions through the study.

From the phonemic inventory of the GFTA, participants targeted phonemes for intervention were chosen. Participants were randomly assigned a numerical identifier which was pulled from a list and then placed in either an experimental or control group. The first author (SLP), and a trained research assistant who is a licensed speech-language pathology assistant (SLPA), performed MOT intervention using a list of word pairs containing each child's targeted phoneme (one known phoneme in the child's phonemic inventory and one unknown phoneme with at least two distinctive features that were maximally different from each other (Gierut, 1989; Gierut, 2001; Gierut, 2007). The SLP provided MOT treatment along with training of the accompanying tactile self-cue (to the experimental group) while the SLPA provided treatment without the use of tactile cue training to the control group of participants. MOT was performed twice weekly for 30 minutes across both groups of participants over 10 weeks. The SLP and SLP-A also performed all coding during intervention. Coding was used to determine 1) correct and incorrect treatment responses and 2) if children used or did not use either of the 2-types of tactile self-cues or required prompts as reminders to use their trained strategy. The second speech-language pathologist (SLP) observed and coded phonological accuracy and participant-driven cueing to record generalization during story retell three to five times across the 10 weeks of intervention.

2.3.8. Story Retelling

To examine generalization of targeted phonological productions, subjects in both experimental and control groups received an articulation story booklet at the end of each week embedded with their targeted phoneme. Each parent or caregiver was instructed to read a story booklet with their child for at least 20 minutes a day, four times per week. After being read to by a parent or caregiver, children in both groups were instructed to practice retelling the same story to their parent or caregiver outside of the intervention environment. Every two weeks, each parent from both groups received an email from the second SLP instructing them to open the Zoom hyperlink and complete an SLP monitored story retell session online. The second SLP used Zoom to then record and collect data during story retell tasks to capture whether or not each child used self-cueing strategies to correct phonological errors outside of the treatment setting. The second SLP also collected data on the percentage of correct phonemes produced out of the total number attempted.

2.3.9. Post-Therapy Assessment

After participants continued demonstration of correct target production at 80% accuracy or greater, the first author (SLP) re-administered the GFTA-3 and applied that data to the KLPA-3. Changes in phonological target acquisition from both groups were then analyzed.

Each participant received an incentive reward that did not exceed more than a $5.00 value for participation in this study. The parents of the participants in both groups completed a post-treatment parent survey used to represent their perception of their child's independent, spontaneous use of tactile self-cues and phonological gains observed (e.g., I understand what my child says; Other people have trouble understanding what he/she says, I correct my child's speech). Parents provided feedback by giving a response using a 3-point Likert scale of Always, Sometimes, or Never (see Appendix B).

2.4. Data analysis

Differences in the overall phonological accuracy (%) on the GFTA-3 and KLPA-3 pre-treatment and posttreatment while using MOT approach and pre-test/posttest parent survey were analyzed using a non-parametric Related Samples Sign test. Analyses were stratified between the groups (tactile self-cue group vs. non-tactile self-cue group). Time-to-event analyses with Kaplan-Meier Curve and a Log Rank Test in Statistical Package for Social Sciences (SPSS) were used to analyze the duration of MOT intervention to reach phonemic target accuracy criteria of 80% accuracy or greater between the two groups of participants.

KLPA phonological processes before and after treatment were assessed using a McNemar's Test after stratification between treatment and posttreatment groups, with percent improvement reported (a participant going from not being able to produce a sound, to being able to produce a sound). Two-tailed p-values were used for all analyses, with the exception of McNemar's Test (one-tailed directional hypothesis). $P<0.05$ was used to determine statistical significance for all statistical tests in the study.

3. Findings

3.1 The impact of MOT and tactile self-cueing on phonological accuracy

Table 1 presents the median scores from GFTA-3 pre-test and post-testing raw scores (RS), standard scores (SS) and percentile scores (%). A nonparametric Related-Samles sign test was performed for male and female participants in a tactile self-cueing (tactile SC) treatment group and non-tactile self-cueing (non-SC) treatment group. Differences were found in 6 out of 9 assessment measures investigated (Table 1). As seen in Table 1, results were statistically significant in median raw scores on the GFTA-3 phonemes within words, GFTA-3 standard scores (SS), percentiles in words only, and KLPA raw scores and percentiles. No statistically significant differences were found in the GFTA-3 percentiles in sentences, GFTA-3 standard scores in sentences, or KLPA-3 Standard scores.

Table 1
Related-Samples sign test on MOT no cue – MOT self-cue group median comparisons from GFTA and KLPA-3 raw scores, standard scores and percentile measures, p values

Assessment	MOT Non-Tactile SC		MOT Tactile SC	
	Pre	***p* value**	**Pre**	***p* value**
GFTA3 Word Raw Score (RS)	9.5 (1.8,17.3)	.125	13.0 (11.0,15.0)	.001**
GFTA3 Sentences Raw Score (RS)	9.0 (3.5,27.8)	.070	7.0 (3.0,12.0)	.021*
GFTA3 Words (SS)	-6.5 (-28.3,0.0)	.219	-10.0 (-18.0,-4.0)	.001**
GFTA3 Words (%ile)	-9.0 (-22.7,0.0)	.062	-13.0 (-25.0,-2.0)	.002**
GFTA3 Sentences (SS)	-9.5 (-16.5,-1.3)	.070	-4.0 (-13.0,4.0)	.754
GFTA3 Sentences (%ile)	-12.0 (-40.8,-0.1)	.070	-2.0 (-21.0,9.0)	.754
KLPA3 Raw Score (RS)	21.5 (9.5,27.0)	.070	11.0 (10.0,19.0)	.001**
KLPA3 (SS)	-11.0 (-23.5,0.0)	.062	-11.0 (-16.0,-3.0)	.065
KLPA3 (%ile)	-11.0 (-39.8,0.0)	.062	-14.0 (-27.0,-2.0)	.004**

Values expressed as median difference and interquartile range.
Significance for Treatment *p<0.05, **p<0.01 for Related-Samples Sign Test
Goldman-Fristoe Test of Articulation- Third Edition (GFTA-3)
Khan-Lewis Phonological Analysis - Third Edition (KLPA-3)
*p <0.05, ** p <0.01

In Table 1, raw scores on the GFTA-3 represent the total number of misarticulated phonemes for each group of participants based on their phonemic inventory. Although the median raw score decreased (median difference and IQR: 9.5 (1.8,17.3)) from pretest to posttest performance for participants without tactile SC training, results were not statistically significant (*p*=.125) (see Table 1) between the experimental and control groups. The median raw score of errored phonemes from pre-test to posttest in the treatment group while using tactile SC also decreased (30 to 11). Differences in raw scores in the treatment group from pretest to posttest after tactile self-cue training were statistically significant (median difference and IQR: 13.0 (11.0,15.0), *p* = .001, 2-tailed), however, a statistically significant difference was not found for the control group.

When examining results for raw scores of sounds in sentences, the non-TSC group median difference decreased (median difference and IQR: 9.0 (3.5,27.8)) from pretest to posttest, however results were not statistically significant (*p* = .070, 2-tailed) (see Table 1). The GFTA-3 pretest to posttest median difference in the treatment group with tactile SC decreased (median difference and IQR: 7.0 (3.0,12.0)), indicating statistical significance (*p* =.021, 2-tailed).

The non-parametric Related-Samples Sign test was also used to evaluate differences for GFTA-3 standard scores in words pre- and posttreatment. Although scores for participants without tactile SC yielded a 6.5-point median difference increase, the result was not statistically significant, *p*=0.219*,* 2-tailed*).* The tactile SC treatment group median standard scores from pretest to posttest yielded a 10-point median difference increase and was statistically significant (*p* =.001, 2-tailed). Additional median differences and *p* values are reported in Table 1. Statistically significant differences were found between pretest to posttest percentile scores for the treatment group receiving MOT and tactile self-cueing training (*p* =.002, 2-tailed).

Table 1 also displays KLPA median raw score differences in pre-and posttest performance for both treatment groups. A decrease in median difference and IQR (21.5 (9.5,27.0)) for the non-tactile SC group was found to be non-significant (*p* = .070, 2-tailed), however findings from the decrease in median difference of the tactile SC treatment group revealed statistical significance (median difference and IQR: 11.0 (10.0,19.0), *p* = .001).

Median percentile increases of KLPA-3 pretest to posttest to the 11th percentile for the non-tactile SC treatment group (median difference and IQR: -11.0 (-39.8,0.0)) were compared to the tactile SC treatment group median increase to the 14th percentile (median difference and IQR: -14.0 (-27.0, -2.0)). Findings from the increase in KLPA-3 median percentile scores in the non-tactile SC treatment group were non-significant (*p* = 0.062, 2-tailed) compared to the statistically significant gains seen in the tactile SC group (*p* = 0.004, 2 tailed).

The KLPA-3 pretest scores were analyzed using the percentiles to classify both groups of participants into four quartile groups to confirm that comparisons were equivalent across participants. Results indicated that all participants fell within the same comparison group (with the exception of one participant in the tactile SC treatment group) and no significant differences among participants in the study (data not shown). In further analysis of the KLPA-3 from pretest to posttest, all participants in the treatment group did not show any significant difference in improving in phonological processes in either the non-tactile SC group or tactile SC group (Table 1, Related-Samples Sign Test, p>0.05).

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3.2. The effect of using tactile self-cues on the duration of MOT treatment.

The second research question in this descriptive investigation examined the impact of using a tactile self-cueing strategy on the duration of MOT treatment required to reach target accuracy across all phonemic contexts within words. Figure 1 displays a between-group analysis in the initial phonemic context of words on the duration to meet the percent accuracy criteria, across 3 consecutive sessions. The vertical axis presents the median percentage of participants in the study who met the treatment criteria. The horizontal axis represents the number of sessions across the 10-week study.

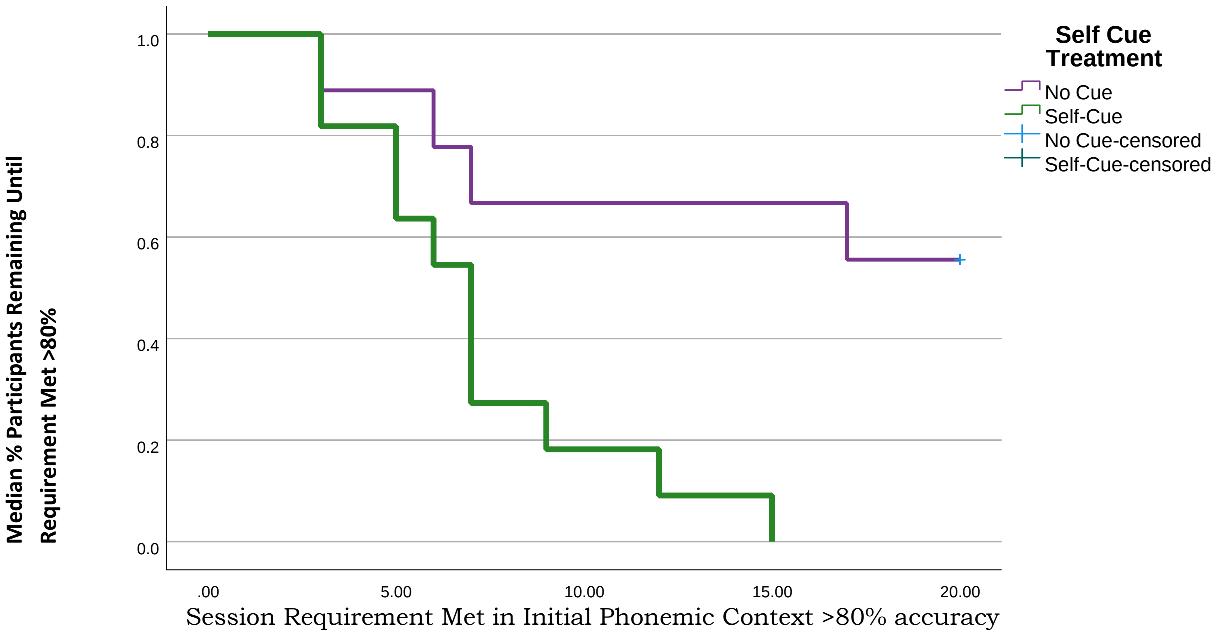

Figure 1. Duration to Meet Target Requirement % accuracy for initial phonemic context within words (goal of meeting greater than 80% accuracy, across 3 consecutive sessions). Observations were considered censored if the participant did not reach the threshold by the end of the 20th session.

In the initial phonemic context, results revealed that by the 7th session, half of the participants using tactile self-cues met the requirement of 80% accuracy or better across three consecutive sessions (see Figure 1). Results also revealed that by the 15th session, 100% of the participants taught the tactile self-cue met the requirement of 80% or better accuracy across three consecutive sessions. In comparison, participants without tactile self-cues (non-TSC) continued until session 20, with only 44.4% of the participants meeting accuracy criteria. Findings were statistically significant. Results show a positive trend on the duration of teaching young children to self-cue as they acquire phonological targets. Participants in the treatment group without tactile SC (non-TSC) may require an extended duration beyond the number of sessions to reach 100% accuracy in the initial phonemic context (Figure 1).

To meet the second requirement in the final phonemic context, Figure 2 displays a comparison between the percentage that each group of participants reached with 80% accuracy or better by a given session. The vertical axis presents the median percentage of participants in the study who met the treatment criteria. The horizontal axis represents the number of sessions across the 10-week study. Findings here were also statistically significant. In the word final phonemic context, results revealed that by the 10th session, 50% of the tactile SC group met the requirement with 80% accuracy or greater across three consecutive sessions. By the 20th session 81.8% of the tactile SC group met the requirement. In comparison, only 33.3% of non-tactile SC participants reached the requirement of 80% accuracy or greater in three consecutive sessions by the 20th session.

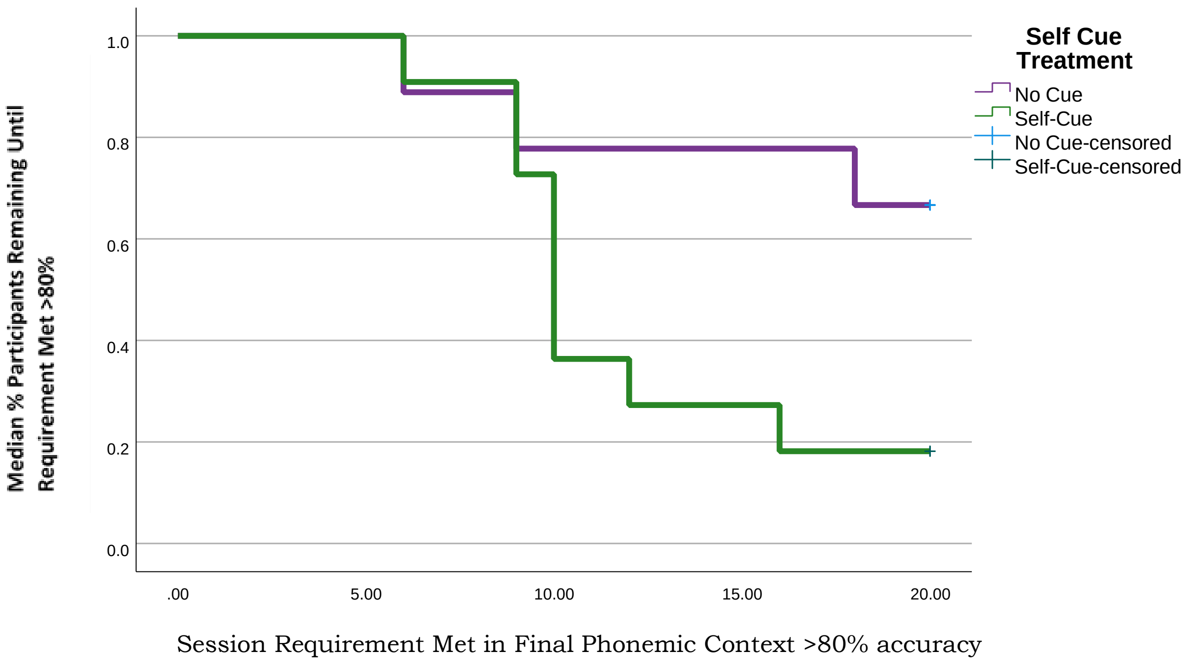

Figure 2. Duration to Meet Target Requirement % accuracy for final phonemic context in words (Goal of meeting greater than 80% accuracy, across 3 consecutive sessions). Observations were considered censored if the participant did not reach the threshold by the end of the 20th session.

In Figure 3, a Kaplan-Meier analysis was used to measure treatment group differences on duration until participants acquired targeted phonemes in medial phonemic context. As seen in the previous Figures 1 and 2, the vertical axis presents the median percentage of participants in the study who met the treatment criteria. The horizontal axis represents the number of sessions across the 10-week study. Findings were statistically significant. By the 15th session, 50% of the tactile SC group met the requirement of 80% accuracy or better across three consecutive sessions for the medial phonemic context. By the 20th session, 63.3% of the tactile SC group met the requirement while

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11.1% of the non-tactile SC treatment group met the requirement by the 20th session. Of the three phonemic word positions, results displayed the largest differences between the two groups of participants in the medial phonemic context within words.

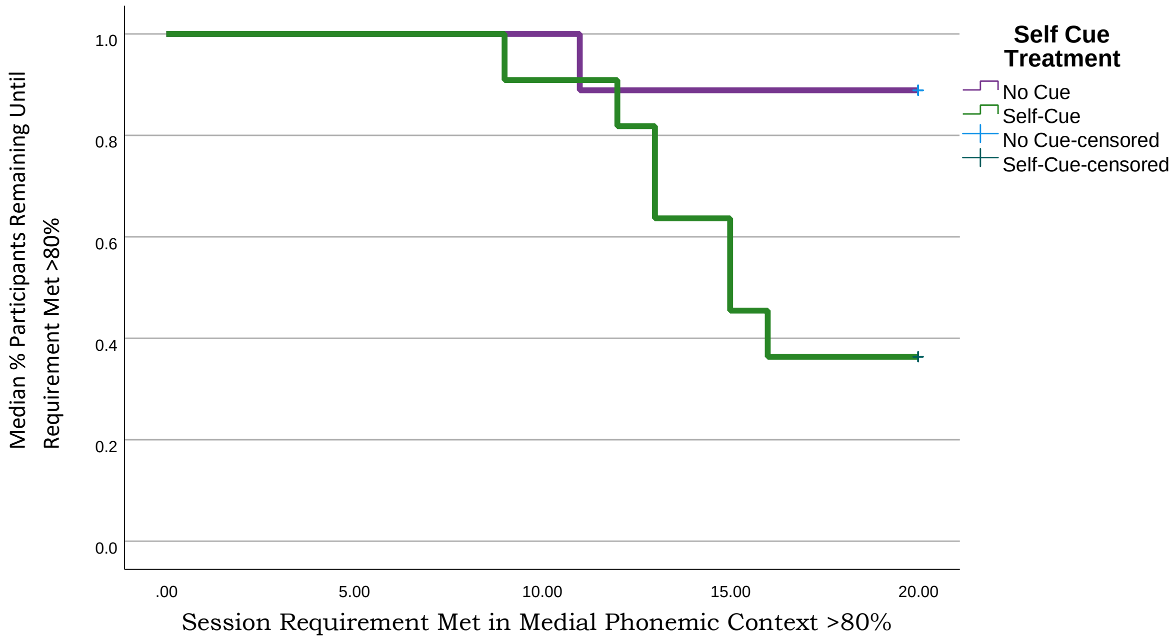

Figure 3. Duration to Meet Target Requirement % accuracy for medial phonemic context in words (Goal of meeting greater than 80% accuracy, across 3 consecutive sessions). Observations were considered censored if the participant did not reach the threshold by the end of the 20th session.

3.3. Parents' perceptions of speech sound accuracy

Table 2 represents the parent survey results obtained from both groups of participants' parents before and after 20 treatment sessions. Of 12 survey questions on parents' perceptions of speech accuracy, responses were statistically significant for the participants in the tactile self-cue group on question number 7 (see Table 2). Parents of this group reported that strategies trained were simple or easy to use (p = 0.016). Parents' survey responses to question number 7 from pre-treatment to posttreatment among the group learning the tactile cueing strategy consistently increased from sometimes to always. No other responses to the parent survey were significantly different.

Table 2
Parent survey questions and results between pre and post therapy (20 sessions twice weekly across 10 weeks) for control and treatment groups

	Control No Cue			Treatment Self Cue		
Parent Survey Items	Pre	Post	p	Pre	Post	*p*

1. Difficult for family to understand	1.00 (0.00)	1.00 (0.00)	1.000	1.00 (0.00)	1.00 (1.00)	0.688
2. Difficult to understand by strangers	1.00 (0.00)	1.00 (0.00)	1.000	1.00 (0.00)	1.00 (1.00)	0.625
3. Parent feedback/cues helps correct speech	1.00 (2.00)	1.00 (0.75)	1.000	1.00 (0.00)	1.00 (1.00)	0.500
4. Effect participation with family or friends	0.00 (1.00)	0.50 (1.00)	1.000	0.00 (1.00)	0.00 (1.00)	1.000
5. I understand my child's speech	1.00 (1.00)	2.00 (0.00)	0.125	2.00 (1.00)	2.00 (0.00)	0.500
6. Child is aware of speech errors	1.00 (1.50)	1.00 (1.75)	0.500	1.00 (0.00)	1.00 (0.00)	1.000
7. Speech cueing strategies are simple/easy to use	1.00 (1.50)	2.00 (1.75)	0.250	1.00 (0.00)	2.00 (1.00)	0.016*
8. Read to child at home at least 4x weekly	2.00 (1.00)	2.00 (1.00)	1.000	1.00 (1.00)	1.00 (1.00)	1.000
9. Child frustrated when speech is not understood	1.00 (0.00)	1.00 (0.75)	1.000	1.00 (1.00)	1.00 (0.00)	0.453
10. Parent corrects child's speech errors	1.00 (1.00)	1.00 (1.75)	1.000	2.00 (1.00)	2.00 (1.00)	1.000
11. Child self-corrects speech errors	1.00 (1.00)	1.00 (0.75)	1.000	1.00 (0.00)	1.00 (0.00)	0.500
12. Child uses cueing strategies to correct errors	0.00 (1.00)	1.00 (1.50)	0.500	1.00 (0.00)	1.00 (1.00)	0.062

Values expressed as median (IQR)

Significance for Treatment *<0.05 for Related-Samples Sign Test

4. Discussion and Conclusions

The purpose of this study was to investigate the effects of an integrated approach to the acquisition of phonological targets in two groups of 4-to-6-year-old children who exhibited evidence of phonological processes. One group of participants were taught to use a self-cueing strategy to accompany the maximum opposition treatment approach (MOT) across 10 weeks of intervention. The second group received MOT without tactile self-cueing training. In addition, whether or not the learning effects from tactile self-cue training could influence within-class and/or across class generalization was also examined. Previous investigations regarding the efficacy of the maximum oppositions approach have found that, in comparison to other contrastive approaches, results support phonological generalization to untreated phonemes and/or sound classes. Consistent with previous research, we targeted phonemes to which participants had the least phonological knowledge and paired the targeted sound with a known phoneme within the child's unique phonological inventory (Gierut, 1989; Gierut, 2001; Storkel, 2018; Tyler, 2006). We then integrated this approach with a tactile, self-generated modality that was not previously incorporated into prior phonological studies.

This study extends prior research that demonstrates positive effects of self-monitoring and the use of tactile cues in training young children to improve phonological accuracy (Bialas & Boon, 2010; Rogers, 2012; Rogers & Chesin, 2013). Similar to earlier studies using self-cues, the participants in this study demonstrated increased gains over the control participants when using tactile self-cues to enhance maximum opposition treatment approach as they acquired new phonological targets. Therefore, it is important to consider whether MOT alone is enough to correct speech sound errors. While a large body of research exists on phonologically based treatment methods, researchers have discovered that pairing maximally opposed sounds can generalize to untreated targets that children may not have been expected to acquire on their own (Brumbaugh & Smit, 2013; Gierut & Hulse, 2010; Hodson, 1998; Tyler, 2006). However, there is limited research using randomized control trials (RCT) examining the effects of using tactile, self-generated cues to self-monitor and self-correct phonological errors as they acquire and generalize phonological targets. Of the 134 efficacy studies examined by Baker & McLeod (2008, 2011), they found that phonological intervention studies were primarily comprised of quasi-experimental designs (e.g., single subject designs), small sample or case studies. In their review, efficacy studies with larger samples using randomized control trials comprised 14.8% while meta-analyses represented 1.5% of the phonological treatment studies.

Clinicians want to know whether incorporating elicitation techniques as an integrated, multi-modal approach (e.g., audio-visual gesture training, electrograph biofeedback and tactile biofeedback, etc.) to train young preschool-aged children could be a fundamental tool to facilitate phonological target acquisition. The combination of self-cueing strategies associated with phonological treatment approaches may perhaps lend insight into a useful and functional, multi-modal approach that has positive learning benefits for this young population. Examining new ways to approach phonological target acquisition is an area of great interest to clinicians.

4.1 Tactile self-cue effects on phonological accuracy

Training participants to use tactile self-cues to increase phonological accuracy while using a maximum opposition approach to phonological treatment resulted in significant between-group differences in pre- and post-testing scores for standardized instruments. The treatment group using tactile self-cueing strategies exhibited larger gains in the majority (6 out of 9) of the assessment measures investigated. It may be that, incorporating the integrated approach of tactile self-cueing for the treatment group and MOT may have led to increased encoding and retention of novel skills. While both groups experienced changes in phonological accuracy using the MOT approach, this was likely facilitated by the focus of a meaningful, language rich environment (Bernthal et al. 2000; (Hodson & Paden, 1983). These findings are similar to the Speech Buddy tactile biofeedback randomized controlled studies for /R/ that found that participants in the experimental group had greater phonological accuracy when supported by the use of a tactile cue, in comparison to a control group across multiple data points (Rogers, 2012). Training young children to use self-generated tactile cues serves as an endogenous strategy to promote both target speech productions in meaningful contexts and retention of novel skills for phonological target generalization. MOT alone may not be enough to promote rapid change in the phonological system of young preschool children (Hodson & Paden, 1983; Williams, 2000a, Williams 2000b, Williams, 2009). We found it interesting that no statistically significant differences were found in GFTA-3 percentile scores or standard scores in sentences, as well as KLPA-3 standard scores between the groups. This may be related to the low number of participants in this study, characteristics of the assessment tools, and the 10 weeks of intervention used in this project. From a descriptive analysis, there were 11 participants in the MOT group receiving tactile self-cueing training that exhibited some across-class and within-class generalization and only four participants in the control group that showed this pattern (data not shown). The statistically significant results in some groups indicated a trend, where tactile SC treatment median differences were consistently and statistically greater than the median difference for the non-tactile SC treatment group. This may merit investigation for future study.

4.2 Effects of self-cues on duration

While phonological treatment programs have been reported to be successful in the remediation of speech sound disorders (Baker et al., 2018; Hodson & Paden, 1983; Kamhi, 2006; Williams, 2000; Williams, 2009; Williams et al., 2010), little research has focused on comparisons of efficiency and efficacy among different phonological intervention programs (Allen, 2013; Baker & McLeod, 2011a, 2011b). Regarding duration to phonological accuracy, both groups of participants benefited from the use of MOT. By integrating a tactile self-cueing strategy with MOT during intervention, it is possible that retention of the strategy may have contributed to differences in intervention duration between the two groups. In addition, running the study beyond 10 weeks duration may have provided closer examination to accurately determine the median time point where at least half of the control group not using tactile self-cues might have achieved 80% accuracy to make a qualitative comparison. From the findings, it seems promising that tactile self-cueing training may have potentially contributed to a reduction in treatment duration to acquire phonological targets with 80% accuracy or more for the children in the TSC group. Given the small number of participants (11 in the experimental or TSC group, 9 in the control or non-TSC group) additional data is needed on a larger scale to verify this finding beyond the scope of this study as these results represent a pilot study.

When examining the duration to reach phonological acquisition criteria in final word position, results might have been influenced by within-child factors in rate it took participants to identify regularities associated with contrastive word pairs or perhaps some targets are more sensitive than others to MOT approach. Incorporating the use of self-cues to elicit target acquisition may

offer multi-modal benefits that assist young children to better reorganize their knowledge about their own phonological sound system, potentially leading to more efficient acquisition of speech sounds.
Considering phonemic contexts, the medial position appeared to be the most challenging for all participants to acquire, particularly the participants who did not use tactile, self-cues. The tactile self-cue group overall did perform better in terms of meeting phonological acquisition criteria and did so over a shorter period of time. These pilot results suggest that the gains made by the self-cueing participants may be partially due to development of self-monitoring skills t used in conjunction with MOT. Overall, considerations should be made to address the possibility that younger children may need additional support to efficiently achieve phonological accuracy and to generalize these skills outside of the therapy environment. Perhaps the use of tactile self-cues integrated with MOT is one approach to consider in this endeavor.

4.3 Parents' perceptions of speech accuracy

From the parent survey (Table 2), we wanted to determine whether parents found value and benefit from the use of tactile self-cues in addition to MOT. It is encouraging that parents of participants who used tactile self-cues perceived them as easy to use. In review of the other 11 questions, the survey could have had robust results if there were more options in response choices for parents beyond 'Always', 'Sometimes' or 'Never'. Parent survey questions may not have been specific enough to capture parent's perception on whether their child uses tactile self-cues to correct his/her own speech productions to increase speech sound intelligibility. We were unable to ascertain whether parents focus during story retell shifted to word reading or content (e.g., child's ability to decode words, recognize letters, etc.) rather than observing their child's speech sound productions during articulation stories. In addition, parents' survey responses may have been affected by the small sample size examined as well as potential parent perceptions of the expectations on intervention outcomes as compared to SLP's perceptions. As discussed by other researchers, these differences may have resulted from parent's predictions on participation benefits (e.g., gains in socialization, gains in communication, ability to answer questions in class) and concerns related to personal factors including temperament (e.g., shyness, frustration, reluctance to participate (Baker & McLeod, 2011a, 2011b; McLeod et al., 2013).
The use of tactile, self-cueing in conjunction with MOT phonological intervention may have potential for greater gains in phonological accuracy and potentially reduce treatment duration in therapy. Our findings provide preliminary support for the MOT program paired with tactile, self-generated cues as an integrated approach to potentially remediate phonological targets in young children. Participants using tactile self-cues in addition to MOT also showed strong and positive trends of across and within-class generalization patterns as did some of the control participants. For those participants trained in the use of tactile, self-cues, the duration it took them to reach criteria was reduced substantially in comparison to the control group, once the strategy was learned. These results, though preliminary, may be of potential interest

to clinicians working with younger populations in phonology as well as those with larger caseloads.

Given the feedback received from parents, it is reassuring that these tactile self-cueing strategies also appeared to increase parent awareness of changes that occurred in their child's speech sound intelligibility. Participants also self-reported independence from having to use strategies. For emergent learners with developing phonological systems, the use of tactile self-cues could be a positive supplement to MOT or other potential phonological intervention programs.

While this study suggests positive results by supplementing the MOT phonological treatment approach in this young population, there is limited research regarding the use of tactile, self-cueing techniques to supplement phonological intervention. Given the limited number of participants in this study, further research in this area would benefit from larger samples and the use of a blind, randomized control design. Additionally, limited research exists examining the use of an integrated, cross-modal, self-generated approaches such as the one used in this study in treating phonological disorders. Of the available literature and systematic reviews on phonological intervention approaches, future clinical research would benefit from studies that compare phonological treatment approaches and cross-modal techniques or strategies used as an integrated approach to phonological target acquisition in young preschool populations (Amato-Zech et al., 2006; Baker & McLeod, 2011a, 2011b; Kamhi, 2006; Lancaster et al., 2010; McDougall et al., 2012; Rogers, 2013; Wheeler & Gabbert, 2017; Xi et al., 2020). SLP's might then apply this evidence into clinical practice as they make informed decisions in planning intervention programs.

The present study was also affected significantly by the 2020 pandemic, both in terms of participant enrollment and how pre- and post-testing and intervention was implemented. State and County Health Department policy necessitated that all methods and materials (i.e., testing and intervention) had to be implemented online. This change in study design included more digital, tele-practice interaction with the participants than was originally intended for some of the participants. In addition, the reduction in sample size was affected with 15 participants discontinuing participation in the study after screened, due to relocation, pandemic related issues, or unspecified reasons in completing the study. Future studies would benefit from considering the potential influence of socio-demographic conditions (e.g., online learning, noise distractors) as well as influence of technology use (e.g., listener perception through electronic device, headphones, internet quality, Wi-Fi disruption) and parent participation on child performance. Parents were given two written prompts to use, as children retold stories to them to examine generalization of targets trained during intervention. Some parents who provided more than the two prompts to a participant may have influenced child responses (e.g., reduced use of strategy, reluctance to participate).

Research conditions tend to require study participants to continue to use the training modality (tactile self-cues) until the condition criteria is met. This could result in user fatigue, lack of motivation, or both. Some participants in this study became disenchanted by the requirement of continuous use of a cue once the technique was self-managed/learned. Since the use of cues is typically used to facilitate correct speech sound production during the elicitation stages of treatment, it may be beneficial for future research to examine when and how to fade and discontinue the use of cues, as there may be clinical implications for how self-cueing is managed during treatment (Riley & Heaton, 2000). The rationale behind this integrated, multimodal method is to supplement phonological treatment in young children with speech sound disorders with a method and the opportunity to become more independent learners; thus, facilitating speech sound acquisition that will generalize outside to more meaningful, natural contexts.

References

Allen, M. M. (2013). Intervention efficacy and intensity for children with speech sound disorder. *Journal of Speech, Language, and Hearing Research*, *56*(3), 865-877. https://doi.org/10.1044/1092-4388(2012/11-0076)

Amato-Zech, N. A., Hoff, K. E., & Doepke, K. J. (2006). Increasing on-task behavior in the classroom: Extension of self-monitoring strategies. *Psychology in the Schools*, *43*(2), 211-221.

Baker, E., & McLeod, S. (2011a). Evidence-based practice for children with speech sound disorders: part 1 narrative review. *Language, Speech, and Hearing Services in Schools*, *42*(2), 102-139. https://doi.org/10.1044/0161-1461(2010/09-0075)

Baker, E., & McLeod, S. (2011b). Evidence-based practice for children with speech sound disorders: part 2 application to clinical practice. *Language, Speech, and Hearing Services in Schools*, *42*(2), 140-151. https://doi.org/10.1044/0161-1461(2010/10-0023)

Baker, E., Williams, A. L., McLeod, S., & McCauley, R. (2018). Elements of phonological interventions for children with speech sound disorders: The development of a taxonomy. *American Journal of Speech-Language Pathology*, *27*(3), 906-935.

Barlow, J. A., & Gierut, J. A. (2002). Minimal pair approaches to phonological remediation. *Seminars in Speech and Language*, *23*(1), 57-68. https://doi.org/10.1055/s-2002-24969

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2007). Neuroscience: exploring the brain. Ed. In: Baltimore: Lippincott Williams & Wilkins.

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2016). *Neuroscience: Exploring the Brain*. Wolters Kluwer. https://books.google.com/books?id=vVz4oAEACAAJ

Bialas, J. B., & Boon, R. (2010). Effects of self-monitoring on the classroom preparedness skills of kindergarten students at-risk for developmental disabilities. *Australasian Journal of Early Childhood*, *35*(4), 40.

Bowen, C., & Rippon, H. (2013). Consonant clusters: Alliterative stories and activities for phonological intervention. Retrieved from https://www.blacksheeppress.co.uk/product/consonant-clusters-alliterative-stories-activities-phonological-intervention/

Brumbaugh, K. M., & Smit, A. B. (2013). Treating children ages 3–6 who have speech sound disorder: A survey. *Language, Speech & Hearing Services in Schools*, 44(3), 306-319.

Byun, T. M., & Hitchcock, E. R. (2012a). Investigating the use of traditional and spectral biofeedback approaches to intervention for/r/misarticulation. *American Journal of Speech-Language Pathology,* 21(3), 207-223.

Byun, T. M., & *Hitchcock*, E. R. (2012b). Investigating the use of traditional and spectral biofeedback approaches to intervention for/r/misarticulation. *American Journal of Speech-Language Pathology*, *21*(3), 207-221. https://ajslp.pubs.asha.org/article.aspx?articleid=1762864

Byun, T. M., Swartz, M. T., Halpin, P. F., Szeredi, D., & Maas, E. (2016). Direction of attentional focus in biofeedback treatment for /r/ misarticulation [Article]. *International Journal of Language and Communication Disorders*, *51*(4), 384-401. https://doi.org/10.1111/1460-6984.12215

Cole, M. A. (2013). *Use of concurrent treatment in phonological treatment and across-phoneme generalization.* (MA thesis, California State University, Fresno). Retrieved from https://repository.library.fresnostate.edu/bitstream/handle/10211.3/105352/AllisonCOLEpdfA.pdf?sequence=1

Demarin, V., & Morović, S. (2014). Neuroplasticity. *Periodicum biologorum*, *116*(2), 209-211.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature*, *427*(6972), 311. http://www.nature.com/articles/427311a

Donicht, G., Pagliarin, K. C., Mota, H. B., & Keske-Soares, M. (2011). The treatment with rothics and generalization obtained in two models of phonological therapy. *Jornal da Sociedade Brasileira de Fonoaudiologia*, 23, 71-76.

Dunlap, L. K., Dunlap, G., Koegel, L. K., & Koegel, R. L. (1991). Using self-monitoring to increase independence. *Teaching Exceptional Children*, *23*(3), 17-22.

Ertmer, D. J., & Ertmer, P. A. (1998). Constructivist strategies in phonological intervention: Facilitating self-regulation for carryover. *Language, Speech, and Hearing Services in Schools*, *29*(2), 67-75. https://lshss.pubs.asha.org/article.aspx?articleid=1780187

Fivush, R. (2008). Remembering and reminiscing: How individual lives are constructed in family narratives. *Memory studies*, *1*(1), 49-58.

Gierut, J. A. (1989). Maximal opposition approach to phonological treatment. *Journal of Speech and Hearing Disorders*, *54*(1), 9-19. https://jshd.pubs.asha.org/article.aspx?articleid=1775376

Gierut, J. A. (2001). Clinical forum. Complexity in phonological treatment: clinical factors. *Language, Speech & Hearing Services in Schools*, *32*(4), 229-305. http://0search.ebscohost.com.catalog.llu.edu/login.aspx?direct=true&db=rzh&AN=106906661&site=ehost-live

Gierut, J. A. (2007). Phonological complexity and language learnability. *American Journal of Speech-Language Pathology*, *16*(1), 6-17. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2553565/pdf/nihms62117.pdf

Gierut, J. A., Elbert, M., & Dinnsen, D. A. (1987). A functional analysis of phonological knowledge and generalization learning in misarticulating children. *Journal of Speech, Language, and Hearing Research*, *30*(4), 462-479.

Gierut, J. A., & Hulse, L. E. (2010). Evidence-based practice: A matrix for predicting phonological generalization. *Clinical Linguistics & Phonetics*, *24*(4/5), 323-334. https://doi.org/10.3109/02699200903532490

Gierut, J. A., & Morrisette, M. L. (2005). The Clinical Significance of Optimality Theory for Phonological Disorders. *Topics in Language Disorders*, *25*(3), 266-280. https://journals.lww.com/topicsinlanguagedisorders/Fulltext/2005/07000/The_Clinical_Significance_of_Optimality_Theory_for.9.aspx

Gray, S. I., & Shelton, R. L. (1992). Self-monitoring effects on articulation carryover in school-age children. *Language, Speech, and Hearing Services in Schools*, *23*(4), 334-342.

Harris, C. B., Rasmussen, A. S., & Berntsen, D. (2014). The functions of autobiographical memory: An integrative approach. *Memory*, *22*(5), 559-581.

Hedrick, M. (1997). Effect of acoustic cues on labeling fricatives and affricates. *Journal of Speech, Language & Hearing Research*, *40*(4), 925. http://0search.ebscohost.com.catalog.llu.edu/login.aspx?direct=true&db=aph&AN=9710010603&site=ehost-live&scope=site

Hodson, B. W., & Paden, E. P. (1983). *Targeting intelligible speech: A phonological approach to remediation*. College-Hill Press.

Hodson, D. (1998). *Teaching and learning science: Towards a personalized approach*. McGraw-Hill Education (UK).

Kamhi, A. G. (2006). Treatment decisions for children with speech–sound disorders. *Language, Speech, and Hearing Services in Schools*, *37*(4), 271-279. https://lshss.pubs.asha.org/article.aspx?articleid=1762925

Kamhi, A. G., & Pollock, K. E. (2005). *Phonological disorders in children: Clinical decision making in assessment and intervention*. Paul H. Brookes Baltimore, MD.

King, A. M., Hengst, J. A., & DeThorne, L. S. (2013). Severe speech sound disorders: An integrated multimodal intervention. *Language, Speech, and Hearing Services in Schools*, *44*(2), 195-210. https://doi.org/10.1044/0161-1461(2012/12-0023)

Koegel, L. K., Koegel, R. L., & Ingham, J. C. (1986). Programming rapid generalization of correct articulation through self-monitoring procedures. *Journal of Speech and Hearing Disorders*, *51*(1), 24-32.

Koegel, R. L., Koegel, L. K., Ingham, J. C., & Van Voy, K. (1988). Within-clinic versus outside-of-clinic self-monitoring of articulation to promote generalization. *Journal of Speech and Hearing Disorders*, *53*(4), 392-399. https://jshd.pubs.asha.org/article.aspx?articleid=1775200

Lancaster, G., Keusch, S., Levin, A., Pring, T., & Martin, S. (2010). Treating children with phonological problems: does an eclectic approach to

therapy work? *International Journal of Language and Communication Disorders*, *45*(2), 174-181.
Landin, D. (1994). The role of verbal cues in skill learning. *Quest*, *46*(3), 299-313.
Levendoski, L. S., & Cartledge, G. (2000). Self-monitoring for elementary school children with serious emotional disturbances: Classroom applications for increased academic responding. *Behavioral Disorders*, 25(3), 211-224.
McDonald, E. T. (1964). *Articulation testing and treatment: A sensory-motor approach*. Stanwix House.
McDougall, D., Morrison, C., & Awana, B. (2012). Students with disabilities use tactile cued self-monitoring to improve academic productivity during independent tasks. *Journal of Instructional Psychology*, *39*(2), 119.
Mcleod, S., & Baker, E. (2014). Speech-language pathologists' practices regarding assessment, analysis, target selection, intervention, and service delivery for children with speech sound disorders. *Clinical Linguistics & Phonetics*, *28*(7-8), 508-531.
McLeod, S., Harrison, L. J., McAllister, L., & McCormack, J. (2013). Speech sound disorders in a community study of preschool children. *American Journal of Speech-Language Pathology (AJSLP)*. 22(3), 503-522.
Menzies, H. M., Lane, K. L., & Lee, J. M. (2009). Self-monitoring strategies for use in the classroom: A promising practice to support productive behavior for students with emotional or behavioral disorders. *Beyond Behavior*, *18*(2), 27-35.
Miccio, A. W., & Powell, T. W. (2010). Triangulating speech sound generalization. *Clinical Linguistics & Phonetics*, *24*(4/5), 311- 322. https://doi.org/10.3109/02699200903537150
Nelson, A., Copley, J., Flanigan, K., & Underwood, K. (2009). Occupational therapists prefer combining multiple intervention approaches for children with learning difficulties. *Australian Occupational Therapy Journal*, *56*(1), 51-62. https://doi.org/10.1111/j.1440- 1630.2007.00712.x
Pansky, A., Koriat, A., & Goldsmith, M. (2005). Eyewitness recall and testimony. Retrieved from https://iipdm.haifa.ac.il/images/publications/Ainat_Pansky/Pansky,%20Koriat,%20&%20Goldsmith%202005.pdf
Peña-Brooks, A., & Hegde, M. N. (2007). *Assessment and treatment of articulation and phonological disorders in children: A dual-level text*. Pro-ed.
Powell, T. W., Elbert, M., & Dinnsen, D. A. (1991). Stimulability as a factor in the phonological generalization of misarticulating preschool children. *Journal of Speech, Language, and Hearing Research*, *34*(6), 1318-1328.
Preston, J. L., Hull, M., & Edwards, M. L. (2013). Preschool speech error patterns predict articulation and phonological awareness outcomes in children with histories of speech sound disorders. *American Journal of Speech-Language Pathology*, *22*(2), 173-184. https://doi.org/10.1044/1058-0360(2012/12-0022)

Preston, J. L., McCabe, P., Rivera-Campos, A., Whittle, J. L., Landry, E., & Maas, E. (2014). Ultrasound visual feedback treatment and practice variability for residual speech sound errors. *Journal of Speech, Language & Hearing Research*, *57*(6), 2102-2115. https://doi.org/10.1044/2014_jslhr-s-14-0031

Rafferty, L. A. (2010). Step-by-step: Teaching students to self-monitor. *Teaching Exceptional Children*, *43*(2), 50-58.

Rhode, G., Morgan, D. P., & Young, K. R. (1983). Generalization and maintenance of treatment gains of behaviorally handicapped students from resource rooms to regular classrooms using self-evaluation procedures. *Journal of Applied Behavior Analysis*, *16*(2), 171-188.

Riley, G. A., & Heaton, S. (2000). Guidelines for the selection of a method of fading cues. *Neuropsychological Rehabilitation*, *10*(2), 133-149.

Rivers, K. O., & Lombardino, L. J. (1998). Generalization of early metalinguistic skills in a phonological decoding study with first-graders at risk for reading failure. *International Journal of Language and Communication Disorders*, *33*(4), 369-391.

Rogers, G. (2012, November). Treating speech sound disorders with tactile biofeedback: A clinical review. Paper presented at the meeting of *American Speech-Language and Hearing Association Annual Convention*, Atlanta, GA.

Rogers, G. (2013). Hand-Held Tactile Biofeedback as a Cuing Mechanism to Elicit and Generalize Correct/R: A Case Study. *E-Hearsay*, 3(2), 39-55.

Rogers, G., & Chesin, M. S. (2013). Examining the clinical application of intra-oral tactile biofeedback in short-duration therapy targeting misarticulated/s. *PSHA*, 2013 issue, 5-18.

Roozendaal, B. (2000). Glucocorticoids and the regulation of memory consolidation. *Psychoneuroendocrinology*, *25*(3), 213-238. https://www.psyneuen-journal.com/article/S0306-4530(99)00058-X/fulltext

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology*, *28*(2), 573-594. https://www.tandfonline.com/doi/abs/10.1207/s15326942dn2802_2

Ruscello, D. M. (1995). Visual feedback in treatment of residual phonological disorders. *Journal of Communication Disorders*, *28*(4), 279-302. https://www.sciencedirect.com/science/article/abs/pii/002199249500058X

Rusiewicz, H. L., & Rivera, J. L. (2017). The effect of hand gesture cues within the treatment of /r/ for a college-aged adult with persisting childhood apraxia of speech. *American Journal of Speech- Language Pathology*, *26*(4), 1236-1243. https://doi.org/10.1044/2017_AJSLP-15-0172

Saben, C. B., & Ingham, J. C. (1991). The effects of minimal pairs treatment on the speech-sound production of two children with phonologic disorders. *Journal of Speech, Language, and Hearing Research*, *34*(5), 1023-1040.

Shohamy, D., & Wagner, A. D. (2008). Integrating memories in the human brain: hippocampal-midbrain encoding of overlapping events. *Neuron*, *60*(2), 378-389. https://doi.org/10.1016/j.neuron.2008.09.023

Shriberg, L. D., & Kwiatkowski, J. (1987). A retrospective study of spontaneous generalization in speech-delayed children. *Language, Speech, and Hearing Services in Schools*, *18*(2), 144-157. https://doi.org/10.1044/0161-1461.1802.144

Smit, A. B., Brumbaugh, K. M., Weltsch, B., Hilgers, M., & Early, B. T. (2015). Sensitivity of various PCC-Type measures and phoneme acquisition measures. Presented at the *Annual Convention of the Kansas Speech-Language-Hearing Association*

Storkel, H. L. (2018). The complexity approach to phonological treatment: How to select treatment targets. *Language, Speech & Hearing Services in Schools,* 49(3), 463-481.

Taps, J. (2007). Innovations for addressing single sound articulation errors in school settings. *ASHA Convention*, Boston Massachusetts,

Tyler, A. A. (2006). Commentary on "treatment decisions for children with speech–sound disorders": Revisiting the past in ebp. *Language, Speech, and Hearing Services in Schools*, *37*(4), 280-283. https://lshss.pubs.asha.org/article.aspx?articleid=1762926

Tyler, A. A. (2016). Integrated speech and language interventions. *American Speech-Language-Hearing Association*, *1*(Part 2), 8.

Ullman, M. T. (2004). Contributions of memory circuits to language: The declarative/procedural model. *Cognition*, *92*(1-2), 231-270.

Wheeler, R. L., & Gabbert, F. (2017). Using self-generated cues to facilitate recall: A Narrative Review. *Frontiers in Psychology*, *8*(1830). https://doi.org/10.3389/fpsyg.2017.01830

Williams, A. L. (2000). Multiple oppositions: Theoretical foundations for an alternative contrastive intervention approach. *American Journal of Speech-Language Pathology*, *9*(4), 282-288.

Williams, A. L. (2009). A systematic perspective for assessment and intervention: A case study. *Advances in Speech Language Pathology*, *8*(3), 245-256. https://doi.org/10.1080/14417040600823292

Williams, A. L., McLeod, S., & McCauley, R. J. (2010). *Interventions for speech sound disorders in children*. Paul H. Brookes.

Williams, L. (2003). *Target Selection and Treatment Outcomes* (Vol. 10). https://doi.org/10.1044/lle10.1.12

Xi, X., Li, P., Baills, F., & Prieto, P. (2020). Hand gestures facilitate the acquisition of novel phonemic contrasts when they appropriately mimic target phonetic features. *Journal of Speech, Language, and Hearing Research*, *63*(11), 3571-3585. https://doi.org/10.1044/2020_JSLHR-20-00084

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Appendices

Appendix A
Parent Survey

Based on your perception of your child's speech productions, please rate each statement as to how often it occurs.

1) My child's speech is difficult to understand even by familiar listeners (For example, family and friends).
a) Always b) Sometimes c) Never

2) My child's speech productions in conversation are difficult to understand by strangers.
a) Always b) Sometimes c) Never

3) The feedback/cues that I give my child help correct his/her speech sound errors.
a) Always b) Sometimes c) Never

4) My child's speech productions have an effect on participation in activities with family and friends.
a) Always b) Sometimes c) Never

5) As the parent, I typically understand what my child is trying to say.
a) Always b) Sometimes c) Never

6) My child is aware of his/her speech problem.
a) Always b) Sometimes c) Never

7) The speech cueing strategies have been simple and easy to use.
a) Always b) Sometimes c) Never

8) Parents or family members read with my child at home at least 4 times per week.
a) Always b) Sometimes c) Never

9) My child becomes frustrated when people don't understand him/her.
a) Always b) Sometimes c) Never

10) I correct my child's speech sound errors.
a) Always b) Sometimes c) Never

11) My child corrects his/her own speech sound errors.
a) Always b) Sometimes c) Never

12) My child uses cueing strategies to correct his/her speech sound errors.
a) Always b) Sometimes c) Never

Appendix B

Subject Number:				
Age:				
Date:	**Activity:**	**Objective:**	**Data:**	**Notes:**
/ /				
/ /				
/ /				
/ /				
/ /				
/ /				
/ /				

APPENDIX C

MOT WORD PAIR M-K	MOT WORD PAIR M-K
 MAT	 CAT
 MANE	 CANE
Who is DIZZA? ME ME	 KEY
 MAN	 CAN
 MAP	 CAP
 MAKE (A CAPE FOR ME)	 CAKE
 MISSING	 KISSING
 MOP	 COP (BATMAN MOVIE)
 MALL	 CALL
  MIGHT (Get Batman)	 KITE

APPENDIX D

Researcher instructions to train M.O.T and prompts

1. Provide the following instructions to the PARTICIPANTS.
   a. Today we are going to look at pairs of pictures!!
   b. First, I want you to practice this sound with me. Listen carefully (Clinician to model target sound)
   c. Now it's your turn (subject attempts target sound)
   d. Subject imitates sound (or not) …
   e. YOUR TURN -subject imitates (or not)
   f. Ok. Let's look at the pictures (place two pictures on the table)
   g. Using the sound XXXX (clinician models target) What is this? (subject attempts target sound on the picture card)
   h. Let's try another one, what is this? (second example)
   i. Subject attempts to produce target sound in word; clinician can model 1x if needed then subject imitates second example.
   j. Now, I am going to show you two pictures. The pictures should look different to you."
   k. Clinician models …this is Bun/sun …and this is Bun/sun… "Do they sound the same?" (subject answers YES or No).
   l. Begin data collection here: Ok, now you try it …Clinician prompts "This is… (subject says …bun) and This is …. (subject says… sun)
   m. Ok, let's try more…

2. TO END SESSION:
   a. PROVIDE STAMPS OR STICKERS.
   b. OFFER A FEW MINS OF online video game or clip from a Movie (e.g., Paw Patrol, Minecraft, etc., Bendy, Om Nom)
   c. Offer short bathroom break and snack break (as needed)

FOR RESEARCHERS USE TO TRAIN TACTILE SELF-CUEING: Participant instructions for M.O.T and with Tactile Self-Cues

a. Use same training steps from MOT.
b. add: *Sometimes we need strategies to help us say sounds correctly and clearly.* For example, touch your…. (Larynx) or (Mouth) like this.
c. Now, try to say your sound…
d. If participant does not use strategy, provide the following prompt: *Don't forget to use your strategy.*

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APPENDIX E

WEEKLY READING TASK AT HOME

Please read to your child for 20 minutes, 4x per week using the following steps

Step 1. Read the story to your child.

Step 2. Read the story to your child and explain unfamiliar words.

Step 3. Have your child read the story to you and explain unfamiliar words

Step 4. Ask your child questions about the story.

Page 1 of 2

<u>Instructions for Story Retell videoconference</u>

Give yourself (participant) a Disney character or a superhero name to use during the study.

Every two weeks, you and your child will be asked to participate in a short, parent-child story retell task on your electronic device (e.g., computer, cell phone, iPad, etc.). You will receive a link to a video conference with a research assistant. The interaction is going to be video recorded by a speech and language pathologist through your device.

On this day, please say the following phrase(s) to your child. Do not add any other words or questions. This is for study purposes.

- "Tell me what's happening on this page."
- "Tell me more."

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