


Effect of Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT) on Compensatory Articulation in Children With Cleft Palate/Lip

Global Pediatric Health
Volume 6: 1–12
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DOI: 10.1177/2333794X19851417
journals.sagepub.com/home/gph


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Abstract

Objective. This investigation researched the effectiveness of the PROMPT (Prompts for Restructuring Oral Muscular Phonetic Targets) method to address compensatory articulation errors in children with cleft palate. **Design.** Single-subject AB multiple baselines across participants and behaviors. **Setting.** Pediatric outpatient rehabilitation department in a local hospital in a metropolitan city. **Participants.** The investigation consisted of 3 participants (ages = 4:4 to 12:8) born with bilateral complete cleft lip and palate. All participants underwent several reconstructive surgeries to repair their lips and palates. **Interventions.** The PROMPT treatment was provided for 45 minutes 3 times a week for 4 weeks (3 weeks for Participant 2). **Main Outcome Measure.** Therapy sessions addressed anterior lingual speech motor phonemes across 3 tiers (syllables, words, and phrases). **Results.** Direct visual observation of data obtained throughout this investigation indicate potential positive effects and significant correlation between improvements in sound production at 3 tiers and the implementation of the PROMPT technique. Speech intelligibility was judged by 3 blinded listeners who were unfamiliar with children with speech disorders or with cleft palate speech. All listeners identified and judged improvement in overall speech intelligibility over the course of this investigation. Listeners examined speech samples selected from sessions 3, 6, 9, and 12. **Conclusion.** The findings in this investigation provide a potential relationship on the effectiveness of the PROMPT method and attainment of accurate speech productions in children with cleft palate producing compensatory articulation errors, resulting in improvement in overall speech intelligibility.

Keywords

PROMPT, compensatory articulation, cleft palate, speech therapy

Received September 19, 2018. Received revised April 16, 2019. Accepted for publication April 16, 2019.

Introduction

In the United States, it is estimated that 7000 infants are born annually with cleft palate, or cleft lip with or without cleft palate.¹ Children who present with a history of cleft palate and/or lip or any other craniofacial anomalies may experience speech, language, and resonance disorders secondary to velopharyngeal insufficiency, malocclusion, and other oral anomalies. Children with cleft palate and/or lip (CCP/L) are likely to undergo several surgical repair procedures depending on the type and severity of cleft. A significant number of CCP/L demonstrate delays in speech sound development, requiring direct speech therapy.² The structural aspects of velopharyngeal anatomy and function, associated hearing loss, dental

difficulties, and malocclusions put children with history of cleft lip/palate at high risk for speech difficulties.³

Among the speech problems observed in children with cleft palate, velopharyngeal inadequacy (VPI), hypernasality, nasal air emissions (audible and inaudible), weak production of pressure consonants, and

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compensatory articulation errors are prevalent.⁴ CCP/L may present with articulation errors categorized as developmental, obligatory, or compensatory. Developmental articulation errors refer to problems producing sounds (articulation) and sound patterns (phonological processes) after the age of expected mastery.^{5,6} Obligatory distortions are produced given abnormal structures, causing the distortion of the sound. Compensatory errors involve changes in placement of a speech sound to offset the abnormal structure, so that these errors can be considered functional.⁷ Traditional articulation methods have been used by speech and language pathologists (SLPs) to address the speech challenges faced by children including CCP/L.

This investigation aims to discuss the speech development of children with cleft palate/lip, describe the errors associated with the disorder, analyze the traditional articulation therapy currently provided to these children, and to introduce a new treatment method that will be investigated to determine its effectiveness with a new treatment population: cleft palate and/or lip. It is the intent of this investigation to review current types of speech therapy treatment currently utilized with CCP/L and discuss an emerging evidence-based technique called Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT). PROMPT has been reportedly successful treating other oral motor speech disorders, but not to address cleft palate speech.

Literature Review

Impact of Cleft Palate/Lip in Speech Production

Bressmann and Sader⁸ indicated that hypernasality resonance is the most usual characteristic of CCP/L speech followed by compensatory articulation errors. Compensatory articulation errors are considered a learned behavior used by CCP/L to adjust for the anatomical irregularities that might continue after primary palatal repair surgery.^{4,9} Magnus et al¹⁰ argued that analysis of phonological deviations could help clarify compensatory articulation, intelligibility, and speech sound pattern in CCP/L.

Several authors have documented misarticulation of speech sounds in CCP/L.^{2,4,8} Some disorders in articulation in this population are associated with VPI or structural anomalies in the oral, nasal, and pharyngeal cavities. Speech sound errors can be classified as obligatory distortions, compensatory errors, articulation errors, and phonological disorders.⁷

Obligatory distortions are produced given abnormal structures, causing the distortion of the sound. Resonance disorders such as hypernasality, hyponasality, and cul-de-sac are considered obligatory errors. Dental malalignment

and occlusion anomalies are also considered obligatory distortions. Obligatory distortions are treated with physical management and speech therapy.^{7,11}

Compensatory errors are produced when the child changes the placement of a speech sound to offset the abnormal oral structure, so that these errors can be considered functional.⁷ CCP/L learn these abnormal sound substitutions during the early developmental stages; they are characterized by changes in the placement of articulation but not in the manner.¹¹ These types of errors are treated via speech therapy. Compensatory articulation errors in CCP/L include glottal stops, pharyngeal fricative, pharyngeal stop, pharyngeal affricative, nasal fricative, velar fricative, palatal fricative, and mid-dorsum palatal stop.⁴

Henningsson et al¹² developed universal parameters to document speech outcomes in CCP/L. The parameter of consonant production errors is divided into 8 categories that represent the errors noted in CCP/L. According to the authors, an error must be present more than once to be documented as an error. The 8 categories are the following: abnormal backing of oral targets to post-uvular place, abnormal backing of oral targets but place remains oral, nasal fricative, nasal consonant for oral pressure consonant, nasalized voiced pressure consonants, weak oral pressures, other oral misarticulations, and developmental articulation/phonological errors.

CCP/L who present with learned misarticulation errors are good candidates for speech therapy. SLPs treat these individuals' articulation errors using different techniques based on traditional articulation therapy in order to obtain correct place and manner of targeted sound productions¹³ and phonological approaches. Kuehn and Moller³ suggested speech therapy treatment for CCP/L that focuses on the modification of the placement of articulation by placing more emphasis on anterior sound productions.

Speech sound production errors have been classified by considering them phonetic or phonologic. Chapman¹⁴ described phonetic errors as associated with the defective learning or faulty oral structure, function, or oral motor skills. On the other hand, phonologic errors are related to the child's complications to arrange, coordinate, and represent the language sound system. CCP/L are at-risk for phonetic and phonological errors.¹⁴ Chapman further explained that sound production errors may start as phonetic errors due to structural anomalies associated with cleft palate; however, these errors evolve into phonological errors as they become part of the child's phonological rule system.

Speech Therapy Approaches

Bessell et al¹⁵ provided a systematic review regarding the type and effectiveness of interventions utilized to treat

CCP/L speech disorders. The authors identified 2 therapeutic methodologies used in speech therapy: (1) traditional articulation approach and (2) linguistic approach.

Traditional articulation therapy is considered a phonetic approach to treat articulation disorders. Although there is no clear definition of traditional articulation therapy, Van Riper is considered the developer of this approach. It consists of 5 steps: discrimination training, stimulability, sound stabilization (isolation, syllables, words, phrases, sentences, and conversation), generalization, and maintenance. This approach targets one phoneme at a time. Once the phoneme is produced, it will be practiced using different syllable structures (ie, consonant [C]-vowel [V], VC, CVC, etc) Traditional articulation therapy mainly utilizes auditory and visual strategies to improve sound production. Visual feedback strategies like electropalatography and nasopharyngoscopy have been utilized to treat CCP/L based on the traditional articulation approach.¹⁵

Phonological therapy targets the phonological system, and its activities have a strong conceptual component that aims to affect the internalization, reorganization, and generalization of the phonological rules and processes of the child's language.¹⁶ Bessell et al¹⁵ in their systematic review of speech and language therapy interventions used with CCP/L found 7 studies involving phonemic-linguistic approaches. Bessell et al¹⁵ classified these approaches into (1) phonological approaches targeting several sound productions so that CCP/L comprehend the rules of the phonological sound system; (2) focused stimulation approaches emphasizing vocabulary that contains a specific sound; and (3) whole-language approaches concentrating on establishing favorable communication experiences.

Bessell et al¹⁵ identified 17 research studies conducted from 1974 to 2009 that aimed to study these 2 approaches when treating compensatory articulation errors in CCP/L. Researchers were unable to provide a definitive conclusion on which methodology obtained better results when treating speech disorders in the CCP/L population.

PROMPT

PROMPT is a motor speech treatment developed in the 1970s by Deborah A. Hayden. PROMPT provides tactile-kinesthetic information to oral musculature (jaw, lips, and tongue) in order to guide the child's movements for speech production. The global conceptual framework of PROMPT has influences from dynamic systems theory (DST) and the neural group selection theory (NGST).¹⁷

Speech production is an elaborate motor skill that requires the coordination, control, and movement across an array of muscles with spatiotemporal needs.¹⁸

Namasivayam et al¹⁹ hypothesized that changes in speech motor control would improve speech articulation, that may result in improvements in speech acoustics, that then influence speech intelligibility. The PROMPT approach is designed to facilitate place, manner, and timing of speech movements by providing precise input and movement transitions using tactile spatial-temporal cues on the child's face.¹⁹

Sensory input is required in the acquisition of motor skills to adjust to the environment and to sustain daily function of motor activities like speaking.²⁰ Studies related to orofacial cutaneous input and its correlation to speech motor learning indicate that somatosensory information applied to facial skin or even perturbation or manipulation to the jaw facilitates speech motor learning.²¹⁻²³ Ito et al concluded in their study that "somatosensory inputs affect the neural processing of speech sounds and show the involvement of the somatosensory system in the perceptual processing of speech."^{24(p1245)} This information suggests that the PROMPT tactile cues applied on the child's face may facilitate the motor learning acquisition of speech production by assisting the child to connect the tactile-kinesthetic input with the auditory outcome during meaningful speech activities.

Effectiveness of PROMPT

Overall, investigations about the effectiveness of PROMPT have concluded positive changes in speech sound production and control when treating speech disorders in children with autism,²⁵ cerebral palsy,²⁶ and speech sound disorders.^{19,27} However, these investigations presented with limitations, such as small sample sizes and no randomized control trial designs. More research has been indicated to examine the effectiveness of PROMPT in a variety of clinical populations.

PROMPT and CCP/L

There are currently no studies evaluating the effect of a treatment utilizing tactile-kinesthetic prompts for sound production, such as PROMPT, in the CCP/L population. The purpose of this research is to investigate sound production in children with history of cleft palate/lip by targeting compensatory articulation errors using the PROMPT method. It aims to improve sound production, and consequently, increase intelligibility. For the purpose of this investigation, intelligibility is defined as the judgment made by a listener on how much of a sound, word, sentence, or speech sample can be understood.

This investigation studies compensatory articulation errors in 4:0- to 12:11-year-old children with cleft palate/lip (unilateral or bilateral). This investigation assessed whether the PROMPT method was an effective

intervention to resolve compensatory articulation patterns and associated reductions in speech intelligibility in children with cleft palate.

Method

Participants

Participants were selected from a cleft palate clinic at a medical center in a large metropolitan city. Participants were excluded from this investigation if (1) results of hearing testing indicated moderate-to-severe hearing loss; (2) scores in standardized testing were 2 or more standard deviations below the mean indicating moderate to severe impairment of receptive or expressive language, or cognition; (c) they presented with signs and symptoms indicating autism spectrum disorder, developmental apraxia of speech, or global motor impairment; (4) they had an unrepaired palate or palatal fistula, (5) they displayed oral-facial defensiveness as determined by an occupational therapist; or (6) parents or children used a language other than English or Spanish.

All participants' legal guardians were informed in their native language about the investigation and provided written consent before participation. Investigation procedures were first approved by 2 institutional review boards prior to contacting potential study participants (Table 1).

Environment

The investigation took place in an outpatient pediatric rehabilitation department at a local hospital in a large metropolitan city. Participants attended speech therapy 3 times a week for 45-minute sessions for 4 weeks, provided individually by the first author.

Listeners

In order to measure participants' speech intelligibility, 3 listeners unfamiliar with cleft palate speech were recruited. All listeners passed an audiological evaluation. These selected listeners listened to audio recordings obtained at session 3, 6, 9, and 12. The stimuli from these recordings consisted of 3 randomly selected targets at the 3 tiers that were played randomly. Listeners graded participants' intelligibility of targeted stimuli (CV syllable structures, words, and phrases) using a 3-point scale (1: poor, 2: fair, 3: good) and they ordered the recording from less intelligible (1), fair (2), good (3), and the most intelligible (4). In addition, listeners were also asked to transcribe the stimuli heard over the audio recording samples into preformatted protocols using the graphemes according to the speech sounds understood by the listeners.

Design Structure

Participants' behavior targets were dependent on individual participant's needs following the PROMPT approach.¹⁷ The behaviors targeted were preselected sound production at 3 tiers: consonant (C)-vowel (V) syllables (eg, CV, VC, VVC, and CVV), words, and phrases (3-5 word phrases).

Participants were exposed to the same therapy session structure during each session. Each session began with data collection of targeted behavior goals and production of targeted stimuli, followed by massed practice. This initial pre-practice aimed to make participants aware of the speech motor movements, oral motor control, and to set the pertinent boundaries associated in the oral muscular movements, as recommended by Hayden.²⁸ The session continued with practice of the individualized selected stimuli probes using a more communicative, natural approach context where the clinician implemented the strategies related to the approach. The sessions ended with a practice of the selected targets (eg, sounds, syllables, words, or phrases) embedded throughout the session. Verbal feedback was utilized to improve desired behavior and to focus attention on movements of the articulators.

Treatment Intervention

In the PROMPT system, the speech motor system consists of respiration, phonation, articulation, and prosody, and it is assessed using the System Analysis Observation (SAO).¹⁷ The results from this nonstandardized assessment about the structure, function, and integration of the speech motor subsystems is transferred to the Motor Speech Hierarchy (MSH).

Selection of the treatment goals and progression were determined following the PROMPT MSH.¹⁷ The MSH is divided into 7 speech subsystems: Stage I: tone; Stage II: phonatory control; Stage III: mandibular control; Stage IV: labial-facial control; Stage V: lingual control; Stage VI: sequence movements; and Stage VII: prosody. The treatment goals for participants were determined by the selection of 3 intervention priorities. The PROMPT approach follows a bottom-up organization system where mandibular control (Stage III) is targeted before labial-facial control (Stage IV) and lingual control (Stage V). In order to improve the acquisition of the words addressed at multiple tiers, stimuli were selected following the PROMPT motor-speech model and determining functionality in communication context. For the purpose of this study, lingual control (Stage V) was one of the priorities due to backing of lingual targets as one of the speech characteristics commonly reported in CCP/L.²⁹

Table 1. Participant Characteristics.

Characteristic	Participant 1	Participant 2	Participant 3
Age (years: months)	4:04	12:08	4:04
Ethnicity	Hispanic	Hispanic	Hispanic
Primary language spoken at home	English	Spanish	Spanish
Languages spoken by participant	English speaker	Bilingual (English/Spanish)	Bilingual (English/Spanish)
Type of cleft	Bilateral cleft lip and palate	Bilateral complete cleft lip and palate	Bilateral complete cleft lip and palate
First lip repair surgery	4 months	3 months	2 months
Cleft palate repair surgery	11 months	11 months	11 months
Alveolar bone graft surgery	No	Left side at 9:7 years	No
	No	Right side at 9:11 years	No
Hearing	Within normal limits	Within normal limits	Within normal limits
Articulation standard score	74 (GFTA-3)	42 (GFTA-3)	62 (GFTA-3)
GFTA-3 percentile ranks	4	<0.1	1
Total speech and language standard score	93 (PLS-5 English Edition)	93 (CELF-5 English)	88 (PLS-5 English Edition)
Early intervention speech and language therapy (before the age of 3)	Yes, Regional Center for 2 years (frequency: twice per week. Duration: 60 minutes each session. Type: individual)	Data not available; family did not recall information	No
School-based speech and language therapy at the time of the investigation	Yes. 1 year (frequency: 1 time per week. Duration: 40 minutes. Type: group)	Yes. 7 years (frequency: 1 time per week. Duration: 30 minutes per session. Type: group)	Yes. 1 year (frequency: 3 times per week. Sessions: 30 minutes. Type: group)
Clinic-based speech and language therapy	Yes. 1.6 years while participant attended preschool (frequency: 1 time per week. Duration: 60 minutes per session. Type: individual)	No	No
Orthodontic treatment	None	Braces	Yes. Palatal expander (Type: Fan Expider)

Abbreviations: GFTA, Goldman-Fristoe Test of Articulation³¹; PLS-5, Preschool Language Scale–Fifth Edition³³; CELF-5, Clinical Evaluation of Language Fundamentals–Fifth Edition.³²

Each participant had individualized priorities following the results from their MSH. A selection of 10 to 11 phonemes were initially designated for each participant. An individualized lexicon and short phrases were first attempted using the 10 to 11 phonemes selected for each participant. However, due to the limited variety of vocabulary initially obtained, it was necessary to utilize more than the recommended number of sounds suggested by the PROMPT approach. Activities were designed based on the lexicon. Lexicon consisted of 10 syllable combinations, 10 words, and 10 phrases.

The data at each session were collected prior to the initial mass practice of the targeted tier (syllable, word, or phrase). Change in tier was determined at 3 consecutive therapy sessions or 80% accuracy, whichever came first. Direct systematic observational recording, manual recording, and video-recording were utilized to collect

data. For manual recording, the participants' responses were coded using + for a correct response and – for an undesired response. During sessions 3, 6, 9, and 12 the data were collected of all stimuli from the 3 tiers. The frequency of PROMPT target stimuli cueing was also tallied per session.

Results

Participant 1

The majority of the articulation errors produced by Participant 1 involved a posterior placement of anterior oral targets to a velar place. The production of the anterior lingual target /t/ was inconsistent at baseline. The anterior lingual target /d/ was selected as this participant's target because this sound was not

present in his phonemic inventory at the beginning of this investigation.

Following the 3 baseline sessions, the intervention began with the first tier, syllables. With tier 1, this participant improved by 8.17% on average across the data points for the intervention phase. An accelerating trend occurred on session 6 (Figure 1), and then stability was reached following this session as the participant reached or surpassed criterion level. Intervention for the second tier began following the 6 baseline sessions. With tier 2, the participant's baseline data showed an accelerating trend in session 4. This participant improved by 2.57% on average across the intervention data points in tier 2 and reached criterion in sessions 8, 10, and 12. Intervention for the third tier began following 9 baseline sessions with an acceleration trend observed in session 5. This participant demonstrated stability in treatment sessions 9, 10, and 11 with 90% accuracy in each session.

The data indicate a change in trend in a positive direction in baseline across the 3 tiers, upward linear trend during the intervention phase for tiers 1 and 2, and flat trend for the last tier. However, the participant reached criterion at 90% and maintained this accuracy for all the intervention data points in this phase.

Participant 1 displayed an accelerating trend at session 6 impacting production of the targeted phoneme at syllable and word level that was reflected in tier 3 at session 7. The same pattern observed on Participant 2 appeared in Participant 1 during session 6 when Participant 2 acquired the speech motor control and production of the anterior lingual target of /d/ and transferred this knowledge and skill from the syllable to the phrase level. In addition, Participant 1 displayed a decrease in the number of tactile and kinesthetic cues per target following the PROMPT method that were provided at the first sessions of the intervention phase, 18.4 times per word to a 3.4 times by the end of the investigation.

Participant 2

The articulation skills of Participant 2 were characterized by backing of anterior targets in the oral cavity resulting in velar placement, nasal fricatives, distortions, and nasalization of sibilants. Among the articulation errors encountered in this participant's speech, the anterior lingual target of /d/ was selected for this investigation.

In tier 1, the participant improved by 7.14% on average across the data points for the intervention phase. An accelerating trend occurred after session 4, and then stability was reached in session 5 as this participant reached

100% mastery level. Intervention for the second tier began following 6 baseline sessions. With tier 2, this participant's baseline data showed an accelerating trend in sessions 5 and 6 (Figure 2). The participant demonstrated stability in treatment sessions 7, 8, and 9 with 100% accuracy in each session. Intervention for the third tier began following 7 baseline sessions. With tier 3, the participant's baseline data showed an accelerating trend after the first 4 baseline sessions. The participant demonstrated stability in treatment sessions 8 and 9 with 100% accuracy in each session. The data indicate a change in trend in a positive direction in baseline across the 3 tiers, an upward linear trend during the intervention phase for tier 1, and a flat trend for tiers 2 and 3 due to participant's mastery of targeted behavior at 100% accuracy.

An acceleration trend was observed for Participant 2 during the baseline phase in tiers 2 and 3 initiated at session 5. The effect could be explained because of having the targeted vocabulary skills built from the previous tiers as well as metacognitive skills necessary for optimal self-monitoring. Once the participant acquired the speech production of the desired target /d/ during the intervention phase in tier 1, the participant was able to transfer the speech production accuracy across the following study tiers. On day 1 of intervention, the participant was provided with an average of 12.5 tactile and kinesthetic cues per target. Cues were provided to the participant's face as needed throughout intervention. On the last day of intervention, needed cues were reduced to an average of 0.1 per target; these data indicate that Participant 2 became more independent for production of targeted stimuli requiring less assistance from the clinician.

Participant 3

Articulation performance of Participant 3 was characterized by compensatory articulation errors, specifically, post-uvular production of oral targets marked by glottal stops. Participant 3 also demonstrated weak oral pressure for oral targets, audible nasal air emissions, moderate-to-severe hypernasal resonance, and suspected VPI.

An improvement by 7.34% on average across the data points for the intervention phase was obtained for tier 1. An accelerating trend was observed in session 7 reaching 60% accuracy by session 10 (Figure 3). After 6 baseline data points for the second tier, intervention was introduced. With tier 2, the participant experienced an accelerating trend in session 7 with an improvement of 6.28% on average across the tier 2 intervention data points reaching 60% accuracy at sessions 10, 11, and 12, but not achieving the 80% criterion. After 9 data points

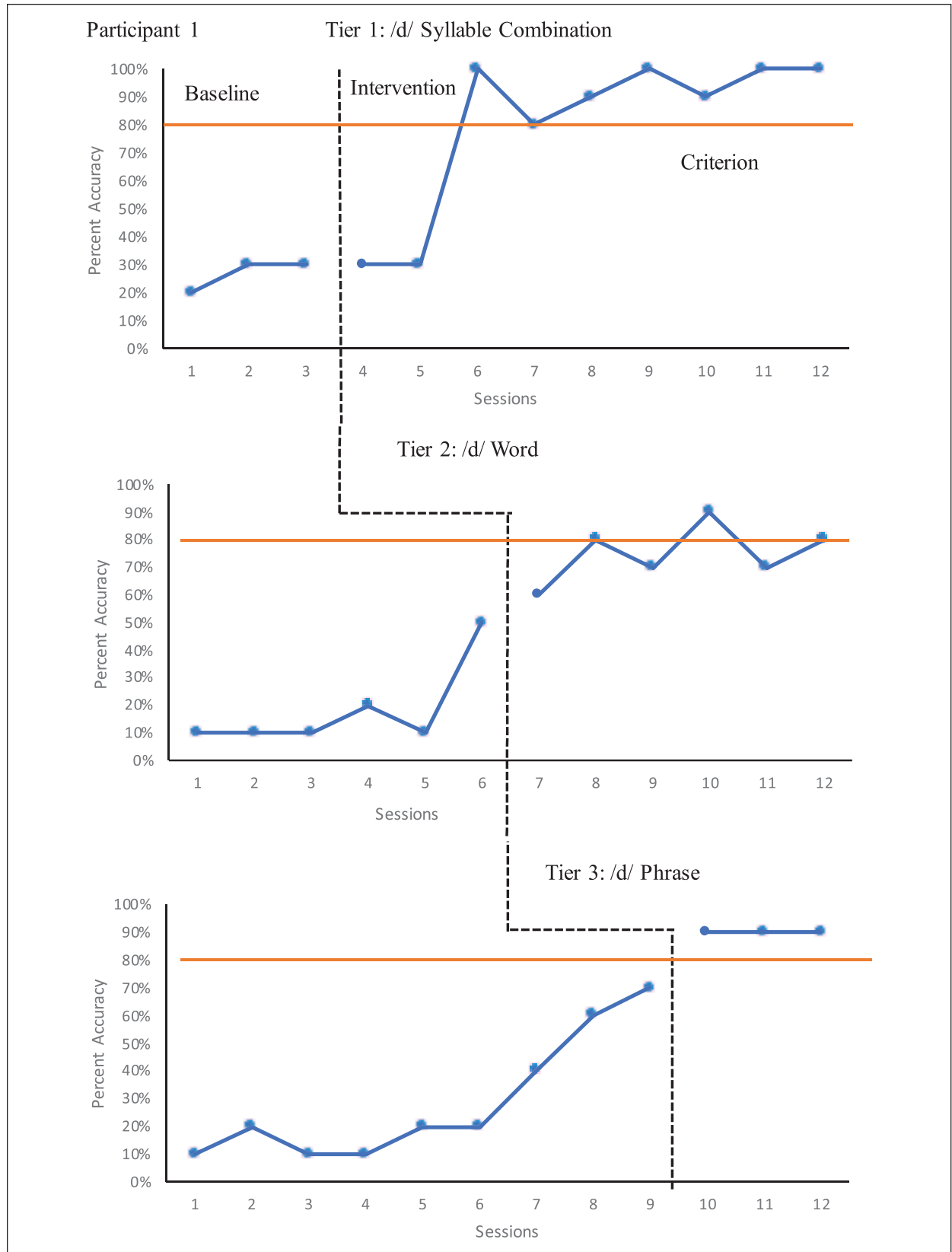


Figure 1. Accuracy of performance on the targeted stimuli across the 3 tiers for Participant 1.

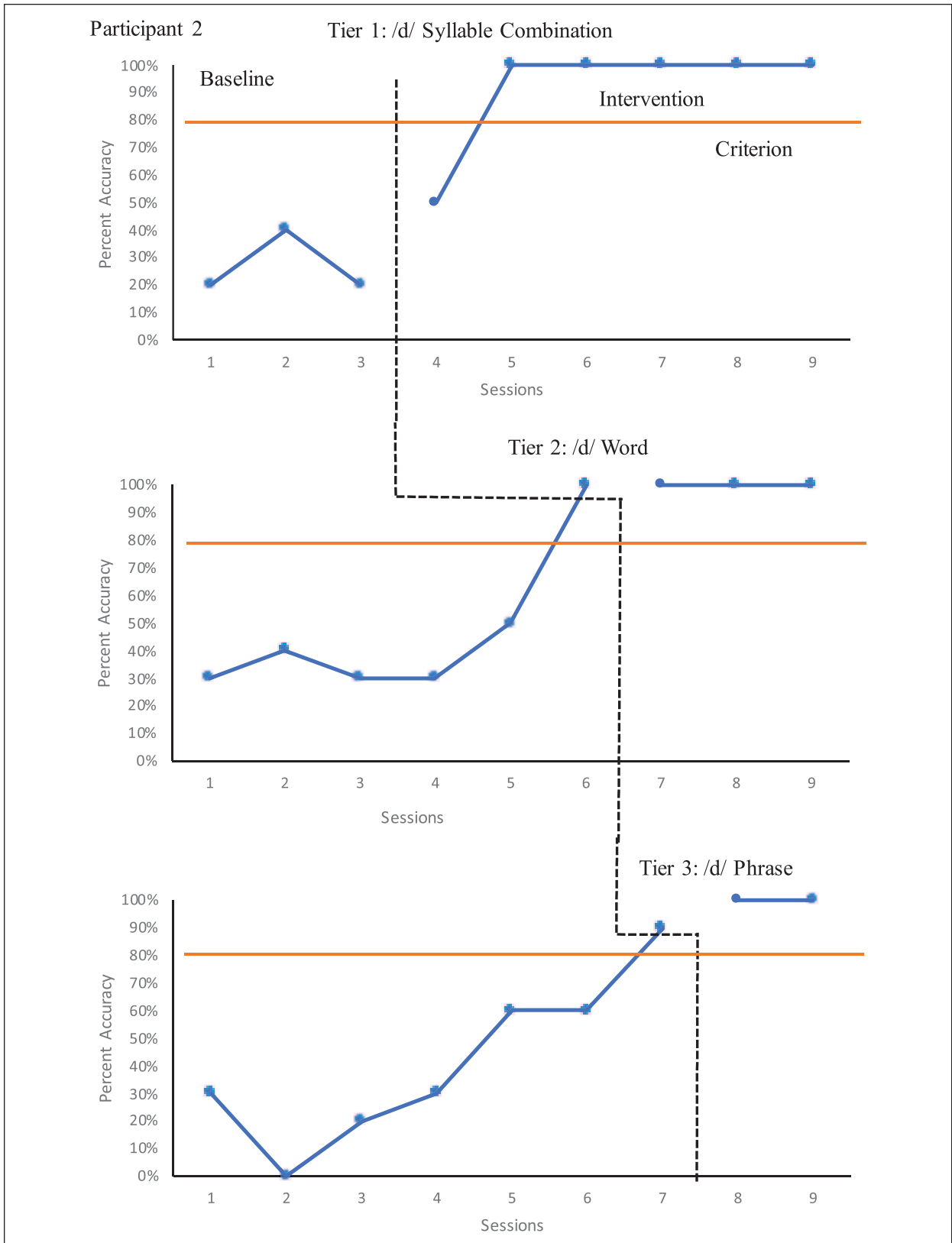


Figure 2. Accuracy of performance on the targeted stimuli across the 3 tiers for Participant 2.

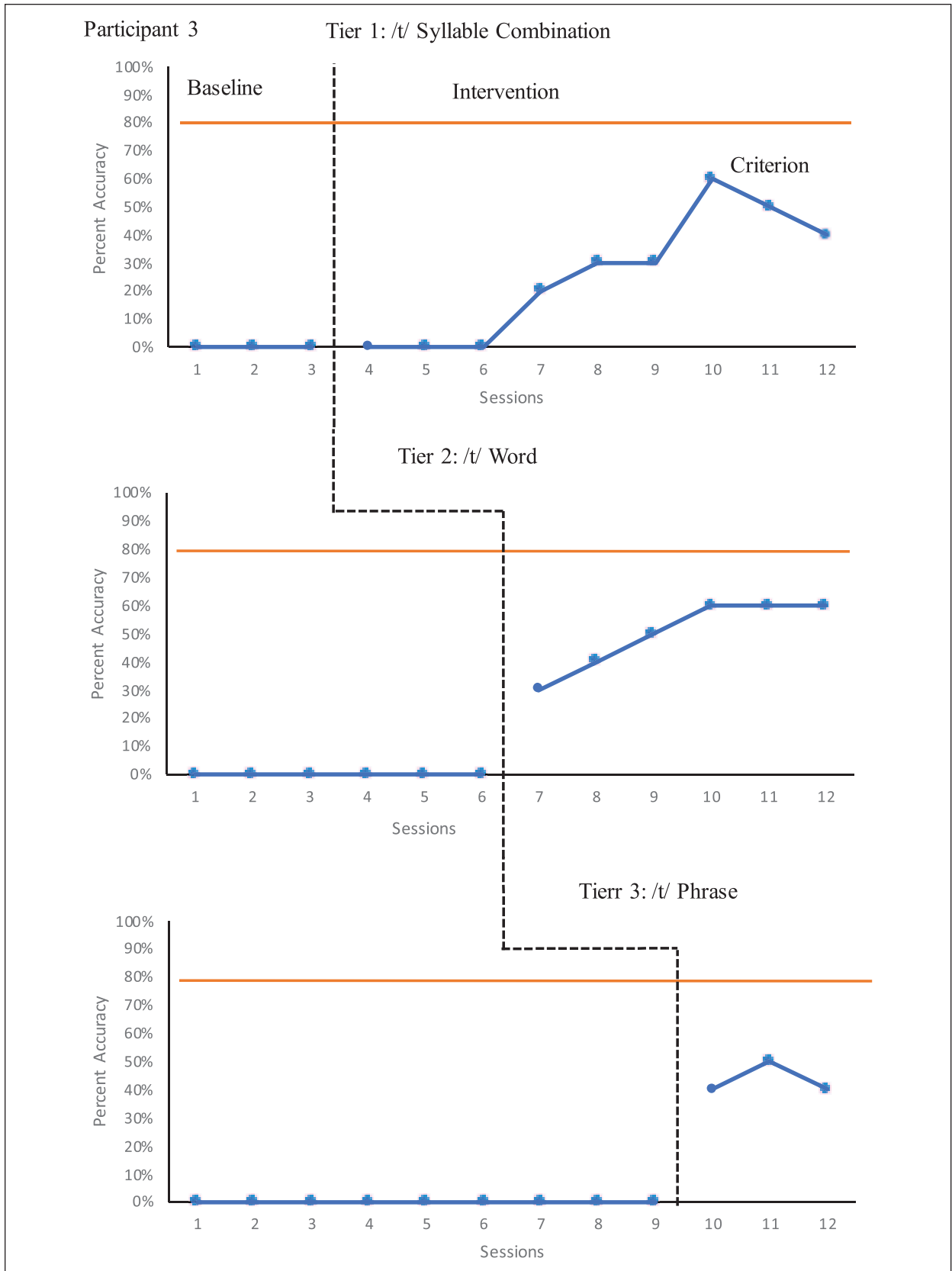


Figure 3. Accuracy of performance on the targeted stimuli across the 3 tiers for Participant 3.

in the baseline phase, intervention was introduced for tier 3. The participant demonstrated stability at 43.34% on average across the data points for the intervention phase. The data distinguished a change in trend in a positive direction in the intervention phases of tier 1 and 2 with an upward linear trend and flat trend for the 3 baseline phases and in the last tier intervention phase.

Participant 3 exhibited a smaller level of improvement in comparison to the other 2 participants. Participant displayed use of maladaptive articulation with post-uvular production, with glottal stops the compensatory articulation error most used by the participant. Participant 3 presented with significant confounding variables that could have been responsible for the inability to attain correct production of the selected speech sound. Participant 3 required occlusion of his nares to improve oral pressure and improve oral airflow for production of the plosive sound of /t/. During nares closure, this participant presented with inconsistent production of the phoneme /t/. During the context of the intervention, this participant produced adequate production of the targeted phoneme within the word level; however, this participant produced a velar placement (/k/) when the principle investigator closed the nares of this participant during the production of targeted stimuli. With regard to the number of PROMPT cues, Participant 3 was provided with more cues when compared with Participants 1 and 2. According to the data collected, Participant 3 also showed a decrease in the average of cues facilitated per intervention session from 27.3 times per word in the first session to 7.1 times per word by the last intervention session.

Another factor negatively affecting targeted speech production for Participant 3 was the palatal expander. This dental appliance occupied this participant's hard palate and covered the alveolar ridge region making it challenging for the participant to place the tongue tip in this area and exercise the upward pressure and release of the tongue for production of /t/. Although accurate production of the targeted phoneme was not achieved, this participant improved placement and the speech motor movement that characterized production of /t/.

For Participant 3, additional cues (eg, closing of the participant's nares) were used to assist with intraoral pressure. The principle investigator pressed an index finger against the participant's philtrum while simultaneously asking the participant to push the tongue toward the clinician's finger, in an effort to teach the participant the concept of *pressure*. This cue was utilized after the clinician noted that Participant 3 was able to place his tongue in the anterior alveolar ridge region, but the participant did not simultaneously produce enough pressure to produce the targeted sound of /t/, nor did the participant release the

tongue from the alveolar ridge region to complete the production of /t/. This cue was also combined with closure of the participant's nares to facilitate oral pressure.

Listeners

Participant 1 demonstrated a significant improvement in the number of consonants correct from sessions 3 and 6 to sessions 9 and 12. This improvement in intelligibility for the recordings in sessions 9 and 12 correlates with the acceleration noted during session 7 for the upper behaviors creating a significant distinction between before and after this mark.

Participant 2 presented a consistent improvement in intelligibility reflected by the percentage of consonants correct from session 3 in comparison to the last session. As with Participant 1, a significant change was observed starting at session 5 that continued to the last session.

All listeners struggled to understand the targeted stimuli of Participant 3. However, overall results suggested an overall improvement in all behaviors in session 9 and a decline in this participant's performance in levels 1 and 3 in session 12 and no change for level 2.

Discussion

The aim of this investigation was to determine the effectiveness of the PROMPT approach to improve speech production of CCL/P with compensatory articulation errors. The results of this study indicate that all participants demonstrated improvements in the speech motor production of the targeted sound at syllable, word, and phrase levels.

The results of this investigation suggest a positive association between the use of the PROMPT method and improvement in speech sound production. Participants 1 and 2 reached criterion at the 3 tiers. Participant 2 made the most significant improvement when compared with the other 2 participants.

This investigation expands on Nagarajan and colleagues'¹¹ work because it supports the idea that adequate feedback of collective modalities, for instance auditory, visual, and tactile, is necessary while managing articulation and resonance disorders in CCP/L. Results of this investigation support Ito and Ostry,²² who indicated that motor learning relies on the kinesthetic input received both from skin and muscle receptors. Ito and Ostry²² concluded that manipulation of an individual's facial skin and lip movements increased motor performance. This investigation also supports the PROMPT hypothesis that the tactile stimuli provided to an individual's face (by gently manipulating facial skin and assisting with the speech motor movements associated

with each phoneme) improves the learning of speech sound production.^{26,30} CCP/L could benefit from the PROMPT method while SLPs employ methods to limit compensatory articulation errors and promote accurate speech productions.

Limitations

Although the PROMPT manual recommends a maximum of 10 to 11 phonemes be used to build the therapy lexicon, this investigation found that 10 to 11 phonemes were insufficient for a therapy lexicon as 10 to 11 phonemes could generate only 10 syllable combination words, 10 words, and 10 phrases; therefore, additional phonemes were used to complete the list of targets. Future investigations in this line of research might result in a more focal speech motor control of the participants' priorities based on their SAO results by reducing the number of vocabulary words per tier and concentrating on a lexicon of 10 to 15 targets that include syllable combination words, words, and simple phrases.

Expansion of this research could investigate (1) the methods and techniques used to teach the concept of pressure as well as the kinesthetic movement required for the production of anterior lingual phonemes in CCP/L who present with suspected VPI, pervasive audible nasal air emissions, and weak consonant pressure; (2) effective speech therapy treatments and strategies that target correct sound production for CCP/L who are too young to yet be referred for a nasopharyngoscopy, or physical management of the VPI; and (3) the impact of various types of palatal expanders utilized with CCP/L and the potential distortion of speech sound productions in the population of cleft palate.

Conclusion

This investigation explored the PROMPT method as an intervention for sound production of the participants' compensatory articulation errors across 3 tiers (syllable, word, and short phrases), as well as participants' overall intelligibility. This investigation indicates a substantial change in speech sound production and intelligibility in at least 2 of the 3 participants. The results obtained in this study suggest that the integration of tactile and kinesthetic cues, in addition to visual and auditory input, could have facilitated acquisition of speech motor movements for production of targeted sounds at syllable, words, and phrase levels resulting in improvements in overall intelligibility. Therefore, the PROMPT method could be an effective approach to improve speech motor control, speech sound production, and intelligibility to treat compensatory articulation errors in CCP/L.

Author Contributions

Raul Herreras Mercado conceived of the presented idea and research and developed the theory and methods of the manuscript. Raul Herreras Mercado carried out the intervention. Kristen Bellom-Rohrbacher provided critical feedback. Keneth Simpson provided critical feedback and helped shape the research, analysis and manuscript. Keneth Simpson verified the analytical methods and supervised the findings of this work. All authors discussed the results. Raul Herreras Mercado wrote the manuscript in consultation with Keneth Simpson and Kristen Bellom-Rohrbacher. All authors agree to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The author has received a financial support from his institution, Adventist Health White Memorial to cover the expenses of this publication.

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References

- Centers for Disease Control and Prevention. Announcements: National cleft and craniofacial awareness and prevention month. *MMWR Morb Mortal Wkly Rep.* 2013;62;543.
- Hardin-Jones MA, Jones DL. Speech production of pre-schoolers with cleft palate. *Cleft Palate Craniofac J.* 2005;42:7-13. doi:10.1597/03-134.1
- Kuehn DP, Moller KT. Speech and language issues in the cleft palate population: the state of the art. *Cleft Palate Craniofac J.* 2000;37:348. doi:10.1597/1545-1569(2000)037<0348:saliit>2.3.co;2
- Peterson-Falzone SJ, Karnell MP, Hardin-Jones MA. *Cleft Palate Speech.* 4th ed. Philadelphia, PA: Elsevier Health Sciences; 2010.
- American Speech-Language-Hearing Association. Speech sound disorders: Articulation and phonological processes. <http://www.asha.org/public/speech/disorders/SpeechSoundDisorders/>. Accessed May 14, 2019.
- American Speech-Language-Hearing Association. Steps in the process of evidence-based practice. Step 3: assessing the evidence. Systematic reviews. <http://www.asha.org/Research/EBP/Assessing-the-Evidence/>. Accessed May 14, 2019.
- Kummer AW. *Cleft Palate and Craniofacial Anomalies: Effects on Speech and Resonance.* 3rd ed. Boston, MA: Cengage Learning; 2014.

8. Bressmann T, Sader R. Speech rate in cleft lip and palate speakers with compensatory articulation. *Clin Linguist Phon.* 2001;15:129-132. doi:10.1080/026992001461442
9. Whitehill TL, Francis AL, Ching CKY. Perception of place of articulation by children with cleft palate and posterior placement. *J Speech Lang Hear Res.* 2003;46:451-461. doi:10.1044/1092-4388(2003/037)
10. Magnus LC, Hodson BW, Schommer-Aikins M. Relationships of speech-related and nonspeech variables to speech intelligibility of children with palatal and lip anomalies. *Can J Speech Lang Pathol Audiol.* 2011;35:32-39.
11. Nagarajan R, Savitha V, Subramaniyan B. Communication disorders in individuals with cleft lip and palate: an overview. *Indian J Plast Surg.* 2009;42(suppl):S137-S142. doi:10.4103/0970-0358.57199
12. Henningson G, Kuehn DP, Sell D, Sweeney T, Trost-Cardamone JE, Whitehill TL. Universal parameters for reporting speech outcomes in individuals with cleft palate. *Cleft Palate Craniofac J.* 2008;45:1-17. doi:10.1597/06-086.1
13. Golding-Kushner KJ. *Therapy Techniques for Cleft Palate Speech and Related Disorders.* Clifton Park, NY: Delmar Cengage Learning; 2001.
14. Chapman KL. Phonologic processes in children with cleft palate. *Cleft Palate Craniofac J.* 1993;30:64-72. doi:10.1597/1545-1569(1993)030<0064:ppicwc>2.3.co;2
15. Bessell A, Sell D, Whiting P, et al. Speech and language therapy interventions for children with cleft palate: a systematic review. *Cleft Palate Craniofac J.* 2013;50:e1-e17. doi:10.1597/11-202
16. Crosbie S, Holm A, Dodd B. Intervention for children with severe speech disorder: a comparison of two approaches. *Int J Lang Commun Disord.* 2005;40:467-491. doi:10.1080/13682820500126049
17. Hayden D. *PROMPT Introduction to Technique Manual (Revised edition).* Santa Fe, New Mexico: PROMPT Institute; 2015.
18. Maas E, Gildersleeve-Neumann CE, Jakielski KJ, Stoeckel R. Motor-based intervention protocols in treatment of childhood apraxia of speech (CAS). *Curr Dev Disord Rep.* 2014;1:197-206. doi:10.1007/s40474-014-0016-4
19. Namasivayam AK, Pukonen M, Goshulak D, et al. Relationship between speech motor control and speech intelligibility in children with speech sound disorders. *J Commun Disord.* 2013;46:264-280. doi:10.1016/j.jcomdis.2013.02.003
20. Feng Y, Gracco VL, Max L. Integration of auditory and somatosensory error signals in the neural control of speech movements. *J Neurophysiol.* 2011;106:667-679. doi:10.1152/jn.00638.2010
21. Ito T, Gomi H. Cutaneous mechanoreceptors contribute to the generation of a cortical reflex in speech. *Neuroreport.* 2007;18:907-910. doi:10.1097/wnr.0b013e32810f2dfb
22. Ito T, Ostry DJ. Somatosensory contribution to motor learning due to facial skin deformation. *J Neurophysiol.* 2010;104:1230-1238. doi:10.1152/jn.00199.2010
23. Tremblay S, Houle G, Ostry DJ. Specificity of speech motor learning. *J Neurosci.* 2008;28:2426-2434. doi:10.1523/jneurosci.4196-07.2008
24. Ito T, Tiede M, Ostry DJ. Somatosensory function in speech perception. *Proc Natl Acad Sci U S A.* 2009;106:1245-1248. doi:10.1073/pnas.0810063106
25. Rogers SJ, Hayden D, Hepburn S, Charlifue-Smith R, Hall T, Hayes A. Teaching young nonverbal children with autism useful speech: a pilot study of the Denver model and PROMPT interventions. *J Autism Dev Disord.* 2006;36:1007-1024.
26. Ward R, Strauss G, Leitão S. Kinematic changes in jaw and lip control of children with cerebral palsy following participation in a motor-speech (PROMPT) intervention. *Int J Speech Lang Pathol.* 2013;15:136-155. doi:10.3109/17549507.2012.713393
27. Grigos MI, Hayden D, Eigen J. Perceptual and articulatory changes in speech production following PROMPT treatment. *J Med Speech Lang Pathol.* 2010;18:46-53.
28. Hayden D. *Bridging PROMPT Technique to Intervention Manual (Revised edition).* Santa Fe, New Mexico: PROMPT Institute; 2016.
29. Gibbon FE, Crampin L. Labial-lingual double articulations in speakers with cleft palate. *Cleft Palate Craniofac J.* 2002;39:40-49. doi:10.1597/1545-1569(2002)039<0040:lldais>2.0.co;2
30. Dale PS, Hayden DA. Treating speech subsystems in childhood apraxia of speech with tactual input: the PROMPT approach. *Am J Speech Lang Pathol.* 2013;22:644-661. doi:10.1044/1058-0360(2013/12-0055)
31. Goldman R, Fristoe M. *Goldman-Fristoe Test of Articulation.* 3rd ed. Bloomington, MN: NCS Pearson; 2015.
32. Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice.* Philadelphia, PA: FA Davis; 2015.
33. Zimmerman IL, Steiner VG, Pond E. *Preschool Language Scales-Fifth Edition (PLS-5).* San Antonio, TX: Pearson; 2011.