Application of oral motor strategies in the treatment of functional speech disorder

A Master's Thesis

Completed by

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Introduction

The child with a functional speech disorder presents with a misarticulation of a speech sound. It is often unknown why the child produces this misarticulation or the best treatment to remediate it, but different treatment approaches are thought to be effective. This thesis explores two current speech therapy methods and their effectiveness for children with functional speech disorders.

There are two classic approaches to speech therapy: phonological and articulatory. In clinical application, these approaches differ in what is viewed as the cause of the speech sound error. A phonological approach views speech errors as having a linguistic base, assuming that the client has not learned language-specific phonological rules that connect speech sounds together into meaningful linguistic units. In therapy, this approach attempts to establish the client's inventory of phonological rules by teaching the rules for correct speech sound production (Bernthal & Bankson, 1998).

The focus of articulatory-based therapy approaches is on how the client's articulators produce speech sounds and the motor processes used to carry out the phonological representation. The goal of this therapy is the development of motor skills needed to produce speech sounds. Articulatory therapy approaches typically work on target sounds in meaningful speech units such as syllables, words, phrases, sentences and conversation, relying on repetition and practice of the correct production of target sounds to train the client's articulatory system.

One of several types of articulatory therapy approaches is oral-motor therapy. Like other articulatory approaches, oral-motor therapy is intended to address a motor disorder that contributes to speech errors. However, the premise of an oral-motor approach differs from other articulatory approaches in that it takes the speech movement out of the context of speech. The speech act is broken down into specific non-speech motor movements. Oral-motor exercises attempt to strengthen the oral musculature and increase stability and gradation of movement in the oral structures to remediate the delayed speech sounds.

Many clinicians utilize oral-motor approaches in therapy, believing that deficits in strength are a central factor in children with phonological disorders. However, there is not conclusive evidence on the link between early oral-motor skills and the development of speech sounds. Additionally, few academic professionals support the use of oral-motor therapy because this therapy takes the articulatory movement required for the target sound out of the context of speech (Forrest, 2002; Lof, 2003). They believe that for articulatory treatment to be effective, the target sound must be addressed in meaningful linguistic units so that transfer and carryover into conversation can eventually be achieved.

Since there is little evidence for or against oral-motor therapy, its use for treating speech disorders needs to be investigated to determine the effectiveness in correcting speech errors. The disagreement between theoretical beliefs and clinical application regarding the use of oral-motor therapy needs to be resolved, and this can only be done through an efficacy study of oral-motor therapy.

The argument for the use of treatment strategies to target functional articulation disorders has risen from knowledge of the development of the speech mechanism. A theoretical framework of the process of speech is important to provide an overall discussion of the speech signal, while neurophysiology and the development of speech provide more specific information that is essential to discussing different approaches to articulation therapy. These topics are discussed below.

Review of the Literature

Theoretical Framework for Speech

Speech is a complex series of events that requires coordination of many systems. A breakdown can occur anywhere in the process, resulting in a speech sound error. The sequence of events necessary to produce speech begins with the message that the speaker intends to communicate. This sequence involves several fundamental processes, including cognitive, linguistic, and motoric. The speaker uses the cognitive process to determine a symbol (i.e., words) that will convey the idea to the listener. The linguistic system maps the idea onto a phonological representation that is conveyed to the listener through words.

To produce a meaningful speech signal, phonological functions must work together with motor processes. The phonological representation must be made at the linguistic level and the articulation is carried out through motor processes. The motor processes that carry out the speech signal include motor planning, motor programming and motor execution. Motor planning determines the movement and spatial characteristics of the target sound and motor programming controls the muscle coordination necessary to carry out an intelligible message. Motor execution of the speech sound includes not only the movement that has been planned and programmed, but the continuous online changes that are made through intrinsic feedback mechanisms (Caruso & Strand, 1999).

This theoretical model of speech production demonstrates the complex interaction of events necessary to produce a speech signal. It also allows for a model to determine where errors in speech occur. In terms of speech sound disorders, errors can occur in the planning, programming or execution of the speech signal. Children with functional articulation disorders may have difficulties in any one of these areas, and research has shown that speech therapy is effective to aid in this remediation.

Neurophysiology of the Speech Mechanism

Speech involves a complex multi-level system, with different areas of the brain contributing to the process. The linguistic information that is conveyed by the speech signal is formulated and interpreted in different regions of the central nervous system. Speech production is controlled by the third convolution of the frontal lobe in the left cerebral hemisphere, or Broca's area, and the understanding of speech has been localized to the posterior portion of the first convolution of the left temporal lobe, or Wernicke's area. The motor impulses necessary to carry out the speech signal originate from the motor cortex in the posterior portion of the frontal lobe. Once the motor signal is initiated at the motor cortex, the impulse continues down the pyramidal tract, mediated by the extrapyramidal system, to the muscles where the motor impulse is carried out (Borden, Harris, & Raphael, 2003).

The pyramidal tract converges with the cranial and spinal nerves to innervate and activate the muscles of speech and respiration. The motor unit is the connection between the nervous system and the muscular system. The movements that combine to make the speech signal are a combination of many muscles that are activated by the motor unit. The motor unit activates the speech musculature by firing electrical signals called an action potential, and thus the signal that originated in the motor cortex is completed (Borden, Harris, & Raphael, 2003).

This complex process requires the integration of many systems. A feedback mechanism is critical in providing a response to the nervous system on how the intended speech signal was carried out (Borden, Harris, & Raphael, 2003). The speech signal is regulated by several different types of feedback mechanisms including auditory, tactile, proprioceptive and central neural. Auditory feedback provides the speaker with air and bone conducted signals of the speech signal emitted, providing the speaker with an auditory signal that attunes them to their speech; however, the downfall is the speed in which this feedback is delivered is not always adequate to regulate speech while it is ongoing. Tactile feedback provides the speaker information about the way their articulators moved and touched one another during the articulation of speech, enabling the speaker to alter his movement patterns for speech. Proprioceptive feedback provides the speaker with information about the way their body moves in space, and how the articulators move in relation to the rest of the body, helping the speaker regulate his speech while it is occurring. Central neural or internal feedback provides the speaker with information about the speech signal before it is fully carried out. Information about the motor signal is constantly being returned to the nervous system and new information is being sent back out to alter the signal, enabling the speaker to continuously monitor and alter his speech signal (Borden, Harris, & Raphael, 2003).

Development of the Speech System

An infant is born with a speech system that is designed for survival, but eventually develops, with exposure and practice to language, into a system that is suited for communication. Development of this system occurs not only as a child gains motor control over the speech mechanism, but also as she learns the phonological rules for production of language. Developing the motor control to produce speech sounds is one of the fundamentals of articulatory development, and oral motor skills are a necessary part of this. Children move through a sequence of development in their speech sounds they are able to produce. The function of the oral motor mechanism is an important factor in the development of speech movements.

It appears that motor control of articulators develops sequentially, with control of the jaw mastered before control of the lips. This developmental order of motor movements appears to affect the sequence of speech sound acquisition in young children (Green, Moore & Reilly, 2002). Speech sound development begins by learning how to use the vocal tract to develop the repertoire of vowel sounds. Consonant development follows, with bilabial, nasal and alveolar sounds appearing earlier, and more complex sounds such as fricatives, liquids and affricates as well as strident, interdental, palatal, and velar sounds appearing later (Creaghead, Newman & Secord 1989; Davis & MacNeilage, 1995). From an articulatory perspective, this developmental progression of speech sound acquisition is explained by growing motor control of the speech mechanism through increased strength, precision and gradation of movement, allowing production of more complex speech sounds.

Treatment of Speech Disorders

In a speech disorder, there is a breakdown of skills. The underlying issues that cause this breakdown may or may not be known, as a breakdown can occur anywhere along the many processes of the speech signal. What is known is that treatment is effective to remediate breakdowns in the speech system, providing the client with skills to correct the errors. Treatment efficacy research is important because clinicians need to know that therapy will be effective in treating their client's speech disorders. The only way to be certain we are doing an efficacious therapy approach is to test it and interpret the data. It is important that clinicians be very cautious in their treatment choices until outcome data have found the treatment to be efficacious (Lof, 2003), thus providing clinicians with information to base appropriate and evidence-based therapy decisions on.

Treatments of articulatory disorders in children have varied greatly, not only in their theoretical constructs but also in the way they target speech sound errors. Linguistically-based approaches view speech sound errors as the result of unlearned knowledge about the language-specific rules that connect speech into meaningful units, and other approaches target the speech act itself. For the purposes of this paper, only the approaches that target the speech act will be discussed. Two approaches that target the speech act that have been very popular among clinicians include articulatory and oral-motor approaches to therapy.

Articulation-Based Therapy

An articulatory approach to therapy comprises exercises that focus on motor movement. Articulatory approaches aim to change disordered movement patterns by instilling new ones, followed by practicing the new skills to generalize to connected speech. Development of the motor skills necessary to produce speech sound movements is the goal of articulatory therapy. Repetition and practice of target sounds is a core part of articulatory therapy, intended to help the client develop new movement patterns.

One specific type of articulatory approach is integral stimulation. Integral stimulation provides multiple cues to the client, including visual, auditory and tactile information about the target sound. In this approach, the principles of cognitive motor learning, such as results of performance, repetitive practice of movement, and self-monitoring of motor movements, are applied to the treatment of motor speech and severe speech sound disorders (Caruso & Strand, 1999; Strand & Debertine, 2000). Cognitive motor learning is an important component of skill development because it encompasses not only knowing what to do, but knowing how to do it correctly (Schmidt & Wrisberg, 2000). Integral stimulation gives the client feedback about how the target sound is produced and allows the client to gain skill in self-awareness and self-monitoring to aid in generalization. In a study by Strand and Debertine (2000), the efficacy of integral stimulation intervention for Childhood Apraxia of Speech, formerly called Developmental Apraxia of Speech, was investigated in a single subject study with one participant. Their findings indicated positive effects of treatment in their participant.

Oral-Motor Therapy

Oral-motor therapy is an articulatory approach in principle. It is motoric in nature and attempts to address speech sound errors by changing movement patterns. But oral motor therapy approaches treatment differently. The principles of oral-motor therapy are based on the belief that children with speech disorders do not have the adequate motoric strength, jaw stability and gradation of movement to produce speech sounds correctly. Therapy activities in an oral-motor approach break down the motor movements of speech into smaller tasks to work on strengthening the oral mechanism. The goal of oral-motor therapy is that these strengthening exercises will lead to more accurate speech production. The difference between an oral-motor therapy approach and articulatory approaches is that oral-motor therapy attempts to change movement patterns by taking the speech sound movements out of the context of speech. Oral-motor therapy is made up of strengthening exercises that do not use speech sounds to do so; instead, the motor movement is the focus.

Supporters of oral-motor approaches say that the developmental progression of the oral mechanism and oral-motor behaviors are related to the development of speech sounds. They believe that therapy targeting oral-motor behaviors will help develop the speech sounds that are being produced in error. Thus, oral-motor therapy tasks that focus on strength, stability and gradation of movement are implemented to facilitate oral-motor behaviors in hopes that doing so will result in greater articulator control and a reduction of speech sound errors (Rosenfeld-Johnson, n.d.; Beckman, n.d.).

In contrast to this view, several researchers have found that the muscle movements required to produce speech are not necessarily the same in type and amount as needed to perform oral-motor exercise tasks. Moore and Ruark (1996) found speech and non-speech activities to be task-specific, and concluded that the relationship of early oral motor activities to early babbling behaviors cannot be assumed. Thus the idea that speech emerges from early appearing oral-motor behaviors is not supported by this research, since speech movements emerge in a way that is distinctly different from non-speech behaviors (Moore & Ruark, 1996; Moore, 1998).

Lof (2003) also discussed task specificity for speech and non-speech activities. He noted the task-specific nature of the oral mechanism structure and its ability to perform both speech and non-speech activities. He cautioned that the function of each of these activities is different, providing examples from cleft palate research. McWilliams and Bradley’s study (as cited in Lof, 2003), where blowing exercises were targeted to facilitate velopharyngeal closure, found that these exercises helped maintain closure during blowing tasks, but the closure was not maintained during speech, indicating velopharyngeal closure is physiologically different during speech than in blowing tasks. Lof concluded that due to the task-specific nature of the oral mechanism, the use of non-speech activities to target speech sound errors is questionable.

Use of oral-motor therapy

The research suggesting that non-speech activities do not facilitate speech sound acquisition is important; however, the oral-motor approach to articulation therapy has risen in its popularity and use recently despite lack of empirical evidence to support its effectiveness. Forrest (2002) discussed the rising popularity of using oral motor exercises in therapy and listed the a few main reasons that clinicians use them, including: using whatever works, not knowing what to do, and because it provides a place to start therapy. Pannbacker and Lass (2002) also noted the use of oral-motor exercises and several reasons for doing so, including the relationship between speech and earlier appearing non-speech behaviors and motor functioning, the wide range of use of oral-motor therapy in articulation and phonological disorders, the promotion of equipment and workshops for oral-motor therapy, and the anecdotal positive outcomes reported by speech pathologists. Despite these reasons, Pannbacker and Lass (2002) noted some disadvantages of oral-motor therapy, including the lack of empirical data on using non-speech activities for treatment of several speech disorders as well as the unclear relationship between speech and early appearing non-speech behaviors as evidenced in research. Evidence to support the use of oral-motor therapy has not been shown, and selecting a therapy without knowing if it is efficacious can be detrimental. Clinicians should select therapy based on proven therapeutic methods, instead of choosing just any therapy for a lack of knowing where to start with the client (Forrest, 2002).

The principles that drive an oral-motor approach assume that the speech system of children with phonological disorders is not a strong as it should be motorically. It is assumed that increasing oral-motor strength should increase the intelligibility of speech. But the question remains, how much strength is needed for speech? Forrest (2002) found that actually, very little strength is needed for speech when compared to the amount of available strength in the oral mechanism. In reviewing the literature on oral-motor therapy and its relationship to strengthening weakened muscles, Lof (2003) concluded that oral-motor exercises probably do not strengthen the articulators much due to task specificity and the resistance that is lacking during strengthening exercises used in oral-motor therapy. Even if articulators are strengthened, speech production would probably be unaffected because of the lack of emphasis these exercises place on producing specific change for speech (Lof, 2003).

Speech is a series of very complex motor movements, and principles of motor learning tell us that motor movements are best learned when these complex movements are broken down into smaller tasks. The basis of oral-motor therapy for articulation purposes is taking speech sound movements and breaking them down into isolated motor movements. This breakdown and practice approach is expected to facilitate speech sound remediation at the speech level because the muscles will have been strengthened and range of motion and stability will have been established, making the oral-musculature ready to produce speech. The question that arises is whether taking speech movements out of the context of speech and breaking them down into smaller tasks actually facilitates better sound production in the context of speech. Therefore the concept of part-whole training, whether practicing part of a larger task leads to efficiency on the larger task, still needs to be addressed. The way a behavior is decomposed determines the efficiency of training of those individual parts (Forrest, 2002). Forrest discussed part-whole training further and stated " only segmentation of the whole task into temporally or spatially independent components provides an advantage to part training compared with teaching of the behavioral whole, and this is true only if the parts represent independent components of the behavior" (Forrest, 2002, pg 19). From this, Forrest concluded that part-training is not an effective treatment unless the task "has been determined to meet the demands of part-whole training" (Forrest, 2002, pg 19)

Based on the research discussed earlier about development of oral motor skills in relation to speech, there is little theoretical support for oral-motor therapy. However, there are little data that give conclusive evidence to either side of the argument. In an ASHA poster session, Fields and Polmanteer (2002) examined the effectiveness of oral motor therapy in increasing correct phoneme production in preschool kindergarten children in a six week period. Their findings indicated that the group of students that received oral-motor therapy had fewer articulatory errors than the group who received articulation or phonological therapy at the end of intervention. Contrastingly, in a review of oral-motor treatment outcomes, Lof (2003) reported on several studies where oral-motor therapy was found to be unsuccessful in producing positive treatment outcomes. Colone and Forrest's study (as cited in Lof, 2003), a single subject design, tested the efficacy of oral-motor therapy on monozygotic twin boys by providing oral-motor therapy to one child and phonological therapy to the other child. The study concluded that the oral-motor approach was not effective in creating positive changes in target error production. Occhino and McCann's study (as cited in Lof, 2003), evaluated the effectiveness of oral-motor therapy by systematically alternating oral-motor therapy and articulation therapy sessions with a 5-year-old boy. This study concluded that neither speech production nor oral motor skills were positively affected by the oral-motor therapy.

The research regarding the connection between motor development and speech sounds is inconclusive, and little conclusive research exists on the effectiveness of oral-motor exercises in the treatment of speech sound disorders. The idea that a weakened motor system plays a part in speech disorders seen in children has been questioned by saying that these children do not fit in the category of phonologically impaired because their primary deficit is a motor one. Speech disorders lie in deficient use of connected speech, thus oral-motor exercises may not be effective in treatment of speech disorders because they do not even work on speech movements in speech, the movements are broken down and taken out of context of linguistically meaningful units (Forrest, 2002). Yet, many clinicians continue to use an oral-motor approach to therapy and feel they have success with it, despite the lack of research to support its use in therapy.

A bridge must be made from the empirical evidence about the relationship between oral-motor behaviors and speech sound acquisition and the therapy approaches used to target these speech sound errors. The theoretical assumptions about oral-motor behaviors and their effect on the acquisition of speech are not testing therapy approaches, they are only providing speculation about why certain therapy approaches may or may not be effective. An efficacy study of oral-motor therapy can be the bridge between these assumptions and the correct clinical implementation of therapy approaches.

The research showing an unclear relationship between the development of oral motor control and the speech mechanism leads us to ask the question, is there a need for oral motor exercises in the treatment of speech disorders, and would another type of therapy be better? There is clearly a need for more controlled studies addressing the issue of effectiveness of oral motor activities in treatment of children with phonological disorders. The current study addresses the effectiveness of an oral-motor therapy approach as compared to an articulatory approach to therapy, with the main research question being: Are oral-motor exercises effective in the treatment of children with speech sound disorders, and are oral-motor exercises as effective as an articulatory approach when looking at speech errors within a speech framework?

Method

A single subject, multiple-baseline across subjects design was used in this study. Baseline information was obtained, and then two treatments were applied sequentially to the experimental variables, which were each child's target sounds. Two error patterns were chosen for each child, and each error was targeted by both treatment conditions.

In this study the two treatment conditions were oral-motor therapy and articulation therapy using integral stimulation. This design was appropriate because effects of oral-motor exercises are not specific to target sounds, thus a design that ensures that therapy for one sound will not affect the other was necessary. Additionally, the treatment conditions were independent from each other in their implementation so that if one condition showed no improvement, another condition could be implemented and differences in performance between phases could be observed. Because the different treatment conditions were applied sequentially, the possibility of multiple treatment interferences was minimal.

During baseline**,** no intervention was applied. The participant's performance on target speech sounds was tracked and any changes were noted during a minimum of three sessions. The first treatment, oral-motor therapy, was begun following consistent baseline performance. The second treatment, articulatory therapy, was applied after a minimum of eight sessions, and when there was stability seen in the first treatment condition. The different phases of the treatment sequence each provided baselines from which to measure change against and to make decisions about timing of application of treatment conditions to the experimental variables. Change in production of target sounds was tracked over time and compared between the two different treatment conditions (Barlow & Hersen, 1984).

Participants

For this single-subject multiple baseline design study, three children with moderate to severe phonological disorders were recruited from referrals to the Portland State University Speech-Language and Hearing Clinic. These children were 53 months (4;5), 55 months (4;7), and 62 months (5;2) of age at the onset of the study. Several assessment tools were used to select appropriate participants: a conversational speech and language sample was taken from each child, hearing screenings were conducted by the examiner, and formal and informal measures were administered that examined several aspects of speech and language, including receptive and expressive language, articulation, and oral-motor skills.

Participants were native monolingual English speakers. Each child demonstrated a moderate to severe functional phonological disorder, defined as multiple speech sound errors and poor intelligibility ratings (the percent that the child is understood by an unknown listener) with at least two phonetically unrelated errors (i.e., differing in manner, place and/or voicing characteristics). This information was obtained via spontaneous language sample and articulation errors present during the administration of the Goldman Fristoe Test of Articulation 2nd Edition. Additionally, each child chosen had normal receptive language, measured by performance considered within normal limits on the Preschool Language Scale, 4th edition (mean=100, SD= +/- 15). Each child's cognitive abilities were inferred from performance on receptive language measures, as well as measured by the Wechsler

Preschool and Primary Scale for Intelligence-Revised (Block Design Subtest) (mean=10, SD= +/- 1.5). All children selected for this study demonstrated normal cognitive abilities. Finally, each child had normal hearing abilities based on a hearing screening conducted by the researcher. For those children that met criteria for the study, consent was obtained via a signed consent form from the parents and verbally from the children (See Appendix A).

Description of Participants

Participant A: AP

AP was a 53 month old (4;5) male who evidenced incorrect production of velars, fricatives, interdentals, bilabials, and liquids. A summary of AP's speech sound errors is listed in Table 1. AP's language and cognitive skills were found to be within normal limits when compared to his same-age peers, with functional language skills supporting these findings. AP used sentences that were age appropriate in length and complexity. He also used a variety of word shapes. A summary of tests administered and AP's performance on these measures is listed in Table 2. The Goldman Fristoe Test of Articulation was not administered to AP because he had been given that testing measure approximately one month prior to the initial evaluation. A report showing his error sounds was provided by AP's family and that information as well as errors present in a spontaneous speech sample was used to determine appropriate target sounds.

Table 1. Summary of AP's speech sound errors

TARGET		**ERRORS**	
Consonants	Initial	Medial	Final
Stops			
/p/	/m/		
/b/	/b, m/		
/t/	/n/		
/k/	/n/	/n/	/ʔ/
/g/	/d/	/ʔ,d/	/ʔ, d/
Fricatives			
/f/	/m/		
/θ/	/t/		deleted
/ð/	/t/		deleted
/ʃ/	/n/	/s/	
/tʃ/	/n/		
/s/	/n/	/n/	
Liquids			
/l/	/j/		
/r/	/w/		
Consonant Clusters			
/fl/	/ml/		
/gr/	/dr/		
/kl/	/n/		
/kr/	/n/		
/kw/	/w/		
/pl/	/ml/		
/pr/	/mr/		
/sl/	/n/		
/st/	/n/		
/sp/	/m/		
/tr/	/n/		
Vowels	All vowels produced correctly		

Table 2. Summary of AP's test scores

Test administered	**Test score**
Preschool Language Scale 4th Edition	Auditory Comprehension Subtest Standard Score: 118 Percentile Rank: 88% Expressive Communication Subtest Standard Score: 105 Percentile Rank: 63%
Wechsler Preschool and Primary Scale for Intelligence-Revised, Block Design Subtest	Scaled Score: 13

There was a detectable amount of nasality present in AP's speech at the time of evaluation, and the concern of velopharyngeal incompetence was monitored over the course of intervention. AP was typically very consistent in his speech sound errors. His typical error patterns were substitutions and the types of substitutions depended on the phonetic context of the sound. The most common error pattern observed was nasal assimilation.

Participant 2: JR

JR was a 55 month old (4;7) male who evidenced incorrect production of velars, fricatives, liquids and consonant clusters. A summary of JR's errors is listed in Table 3. JR's language and cognitive skills were found to be within normal limits when compared to his same-age peers, with functional language skills supporting these findings. JR used sentences that were age appropriate in length and complexity. He also used a variety of word shapes. A summary of tests administered and JR's performance on these measures is listed in Table 4.

Table 3. Summary of JR's speech sound errors

TARGET		**ERRORS**	
Consonants	Initial	Medial	Final
Stops			
/g/	/d/	/d/	/d/
/k/	/t/	/t/	/t/
Fricatives			
/f/	/s/	/s/	/s/
/v/	/b/	/b/	/b/
/θ/	/s/	/s/	/s/
/ð/	/d/	/d/	
Liquids			
/l/	/w/	/w/	
/r/	/w/	/w/	
Consonant Clusters			
/bl/	/bw/		
/br/	/br/		
/dr/	/dw/		
/fl/	/sw/		
/fr/	/sw/		
/gl/	/dw/		
/gr/	/dw/		
/kl/	/tw/		
/kr/	/kw/		
/pl/	/pw/		
/sl/	/sw/		
/tr/	/tw/		
Vowels	All vowels produced correctly		

Table 4. Summary of JR's test scores

Test administered	**Test Score**
Preschool Language Scale 4th Edition	Auditory Comprehension Subtest Standard Score: 104 Percentile Rank: 61% Expressive Communication Subtest Standard Score: 85 Percentile Rank: 16%
Goldman Fristoe Test of Articulation 2nd Edition	Standard Score: 84 Percentile Rank: 15%
Wechsler Preschool and Primary Scale for Intelligence-Revised, Block Design Subtest	Scaled Score: 12

JR was very consistent in his speech sound errors. His typical error patterns were substitutions. He was consistent in all phonetic contexts.

Participant 3: MD

MD was a 62 month old (5;2) male with a severe speech sound disorder who evidenced incorrect productions of most sounds. A summary of MD's speech sound errors is listed in Table 5. MD's receptive language and cognitive skills were within normal limits when compared to his same-age peers. A formal expressive language measure was not obtained due to MD's poor intelligibility, and functional expressive language skills could not be determined. MD produced very simple sentences and his word shapes were very limited in scope. His speech consisted primarily of consonant-vowel (CV) and CVCV word shapes. A summary of tests administered and MD's performance on these measures is listed in Table 6.

Table 5. Summary of MD's speech sound errors

TARGET		**ERRORS**	
Consonants	Initial	Medial	Final
Glides			
/w/	/j/		
Nasals			
/m/		/h/	
/n/			deleted
/ŋ/		deleted	
Stops			
/p/		/j/	deleted
/b/		/j/	deleted
/t/	/d/		deleted
/d/		deleted	deleted
/g/	/d/	/j/	deleted
/k/	/t/	/h/	deleted
Fricatives			
/f/	/j/	/w/	deleted
/v/	deleted	deleted	deleted
/θ/	/j/	deleted	deleted
/ð/	deleted	/j/	deleted
/ʃ/	/j/	/h/	deleted
/tʃ/	/d/	deleted	deleted
/dʒ/	deleted	/j/	deleted
/s/	/j/	/j/	deleted
/z/	/j/	/j/	deleted
Liquids			
/l/	/j/	deleted	deleted
/r/	/j/	/j/	deleted
Consonant Clusters			
/bl/	/b/		
/br/	/b/		
/dr/	/d/		
/fl/	/j/		
/fr/	/j/		
/gl/	/d/		
/gr/	/d/		
/kl/	/t/		
/kr/	/t/		
/kw/	/t/		
/pl/	/p/		
/sl/	/j/		
/sp/	/j/		
/st/	/j/		
/sw/	/j/		
/tr/	/d/		
Vowels	MD's vowels productions were inconsistent, errors included: /ɑɪ/ produced as /æ/, /ɑɪ/ and /o/; /ɪ/ produced as /æ/, /ɔ/, /i/ and /ə/; /æ/ produced as /ɔ/ and /æ/.		

Table 6. Summary of MD's test scores

Test administered	**Test Score**
Preschool Language Scale 4th Edition	Auditory Comprehension subtest Standard Score: 85 Percentile Rank: 16% Expressive Communication subtest *no score obtained*
Goldman Fristoe Test of Articulation 2nd Edition	Standard Score: <40 Percentile Rank: <1%
Wechsler Preschool and Primary Scale for Intelligence-Revised Block Design Subtest	Scaled Score:9

MD's speech sound errors were inconsistent. Errors depended on many things, including phonetic context, word shape, word length and phonetic complexity of the word. His typical errors were substitutions, omissions and distortions. He typically produced /d/ for /t/ in the initial position of words. He typically used correct production of /d/ in the initial position of words with some incorrect productions such as producing a nasal for /d/ if there was a nasal later on in the word. He consistently deleted all sounds in the final position of words, accounting for the simple syllable shapes observed. MD appeared to have favorite sounds that he produced, particularly /j/; he typically used /j/ as a substitution in a difficult word or for a difficult sound.

MD presented with characteristics that support a diagnosis of Childhood Apraxia of Speech (CAS). There are several differential diagnosis markers for CAS (Davis, Jakielski & Marquardt, 1998). The characteristics that MD exhibited were as follows:

1. *Limited phonemic inventory.* The client produced limited production of the sounds of English. As seen in MD's summary of speech sound errors, he had a very limited inventory of speech.

2. *Presence of vowel errors.* Correct production of vowels were inconsistent, despite observation of available vowels. MD showed inconsistent performance in his vowel production and no clear error pattern was observed.

3. *Inconsistent articulatory productions.* The client did not produce consistent error patterns, and the production was not necessarily dependent on the phonetic context. MD showed some correct productions, but they were inconsistent and his error patterns did not follow a clear pattern.

4. *Simple syllable shapes.* The client used predominantly simple syllable shapes such as V and CV, and VCV. The syllable shapes observed in MD's were limited to CV and CVCV word shapes.

Materials

To document data collection sessions a Sony DCR PC-101 digital camera was used. The sessions were taped on Sony Mini Digital Video Cassettes, 60 minutes in length.

Procedures

Identification of treatment targets

Treatment targets were determined based on analysis of initial assessment materials. Criteria for selecting targets included stimulability of sounds and developmental norms for speech sound acquisition. Two error patterns were targeted for intervention in each child. The error patterns that were chosen for intervention differed in place, manner, and/or voicing to control for the event that treatment of one sound would affect outcome measures of another similar sound. For each error pattern targeted for therapy, both voiced and voiceless cognates were chosen as therapy goals, because by targeting one cognate, change was expected in the other cognate. If a participant showed correct productions of either cognate during baseline, it was still included as a therapy goal to keep consistency between participants within the single subject design. For each child, both error patterns were targeted with an oral-motor approach and an integral stimulation approach to articulation therapy. A summary of each participant's target sounds can be found in Tables 7-9.

Table 7. AP's target sounds and word positions

Target Sound	**Word Positions**
/p/	Initial
/b/	Initial
/k/	Initial & Final
/g/	Initial & Final

Table 8. JR's target sounds and word positions

Target sound	**Word Positions**
/k/	Initial & Final
/g/	Initial & Final
/f/	Initial & Final
/v/	Initial & Final

Table 9. MD's target sounds and word positions

Target Sound	**Position**
/t/	Initial & Final
/d/	Initial & Final
/s/	Initial & Final
/z/	Initial & Final

Clinician training

Clinical preparation for this study included training in Sara Rosenfeld-Johnson oral-motor treatment methodology (Rosenfeld-Johnson, 2003). This approach was used for all oral-motor therapy and an oral motor therapy protocol based on this methodology was developed. Information showing the oral-motor exercises targeting specific sounds for each child is located in Appendix B. Development of therapy activities was dependent on each child's individual target error patterns. In addition, an individual articulatory treatment plan was developed for each child based on their individual target errors.

Intervention

Intervention was conducted over 9 weeks with the participants attending individual clinic sessions three times a week for 30 minute sessions. Each session consisted of 25 minutes of therapy (i.e., oral-motor or articulatory) and 5 minutes of data collection. While oral-motor techniques and articulatory treatment techniques varied depending on each child's individual speech errors, a general description of each is below. All intervention was conducted at the Portland State University Speech-Language and Hearing Clinic. The researcher was observed by a licensed Speech-Language Pathologist during both treatment phases to ensure that the treatment being implemented was valid.

Oral Motor Therapy

The objectives of oral-motor therapy sessions included strengthening exercises, jaw stability exercises, and grading exercises of the oral musculature. Oral-motor therapy activities are built into hierarchies of production criteria. An individual participant's target sounds determined which oral-motor exercises were chosen for therapy. Specific oral motor treatment activities included horn blowing, tongue exercises, bubble blowing, straw drinking and jaw stability exercises using bite blocks.

The horn blowing hierarchy is broken into 13 horns that increase in the amount of breath flow required to produce the horn's sound. The criterion for success on each horn is 25 successive blows. The length of time needed to successfully blow each horn increases as the hierarchical level increases (Rosenfeld-Johnson, 2001).

The bubble blowing hierarchy is broken into hierarchical goals. The client begins the hierarchy by developing awareness by popping bubbles on his lips. Then the client begins to blow bubbles independently, receiving tactile, visual and verbal feedback from the clinician. The client blows bubbles at different distances and the criterion for success is ten successive blows. The end of the hierarchy is bubble blowing independently to a distance of four feet (Rosenfeld-Johnson, 2001).

The straw hierarchy is broken into eight straws, each of which increase in difficulty of liquid intake through increasing twists in the straws. The client is first instructed in correct straw drinking, requiring the client to suck the straw with only ¼ inch in his mouth. The criterion for success for each straw is the ability to drink two ounces of liquid in less than two minutes (Rosenfeld-Johnson, 2001).

The jaw stability hierarchy uses bite blocks of different sizes to strengthen the jaw musculature. The client is instructed to bite on the bite block, first once on each side, second once with one bite block on each side, and third with one bite block in between and in line with the front teeth. The client is instructed to bite down on the block and the clinician performs an isometric pull. The criterion for success for each bite block is 15 seconds of hold for each of the three exercises performed with each bite block (Rosenfeld-Johnson, 2001).

Finally, several tongue exercises are part of oral-motor therapy. One such exercise includes holding cheerios at different points in the mouth to build awareness and strength. Places include the alveolar ridge, behind the bottom teeth, and the lower lip. The client is instructed to hold the cheerio there for five seconds and then eat it. The criterion for success for this activity is 50 cheerios. After building strength and awareness with cheerios, the client is instructed to maintain tongue placement without cheerios (Rosenfeld-Johnson, 2001).

Articulatory Therapy

The second approach was an articulatory approach to treatment, integral stimulation. This approach uses visual, tactile and auditory modalities to give cues and feedback to the client. The clinician models target sounds and the client imitates, paying close attention to the clinician's face and auditory model. The client is instructed to "watch me and listen to me," providing full visual and auditory information about the target sound (Caruso & Strand, 1999). The target sound is addressed in meaningful speech units (i.e., syllables, words, phrases, sentences and conversation). Further implementation of this approach includes repetition and practice of the correct production of target sounds to develop articulatory skill. The goal is for the client to replace his speech error with the correct target sound using imitation, sound approximation, and placement instructions.

Integral stimulation is based on several known precursors to motor learning: (a) knowledge of results, (b) knowledge of performance, (c) repetitive practice of movement, and (d) self-monitoring of motor speech movements. Clinical application of integral stimulation often includes distributing practice time into short, frequent sessions to allow for cognitive motor learning to take place. The clinical practice time should focus on repetitive practice. Two types of repetitive practice are used, blocked and random. Blocked practice is practice of target sounds in one phonetic context, and it is useful for developing proficiency in the target. Random practice targets sounds in multiple phonetic contexts and is key to cognitive motor learning and generalization of target sounds (Caruso & Strand, 1999).

A key component of integral stimulation is extrinsic feedback provided by the clinician. Initially, the client receives information from the clinician's model, and during practice, the clinician provides extrinsic feedback about the client's performance. The clinician must give the client feedback on whether the produced sound is right or wrong (i.e., knowledge of results) as well as what was done to make the sound correct or incorrect (i.e. knowledge of performance). The clinician provides information about a few variables at once, so not to overwhelm the client. The goal of providing this extrinsic feedback is to train the client to move towards intrinsic feedback so the client can self-monitor his own performance (Caruso & Strand, 1999).

Data Collection

Upon completion of each treatment session a speech sample was gathered during a 5-minute play session. This play session was videotaped and analyzed for each participant's target sounds. Additionally, word lists were developed that contained each child's target sounds. The pool of words used to randomly select the word lists is located in Appendices C - M. For each session, a randomized word list of 20 words was selected using Microsoft Excel (2002). The client was instructed to repeat the word lists after the researcher in an imitation task. The clinician noted the number of opportunities the target occurred during both the spontaneous language sample and the word lists and then the number of times the target was correctly produced, calculating a percent correct score for each target for each session throughout the project duration. Change was noted by charting the percent correct scores and then determining if there was an increase over time.

In addition to quantitative information gained from the data collection sessions, qualitative information was obtained both by the researcher at the end of each session, and by interviewing the participant's families. Following each treatment session the researcher reviewed the treatment session and documented any challenges to the treatments during that session as well as activities or clinician prompts that appeared to assist in increased productions. The researcher also noted if correct productions were present during the treatment sessions that were not represented in the data collection portion. Both during and following the project duration, the participant's families were asked to comment on the different treatments implemented. This information was documented via anecdotal report by the researcher.

Therapy approaches were switched when no change had occurred in the percent correct scores of the target speech sounds. Due to time constraints, oral-motor therapy was implemented a minimum of 8 sessions, and was terminated if no change was seen no change for which time frame.

Validity and Reliability

During the duration of this study, the researcher was observed by a licensed speech-language pathologist during both treatment phases to ensure that the treatment being implemented was valid.

Upon completion of this experiment, reliability testing was completed on 10% of the video recordings. Interrater reliability was assessed by having a certified speech-language pathologist listen to the video recordings and transcribe the data sessions phonetically, given the orthographic transcription from the researcher's transcription. The percent target sounds correct was calculated and compared to the researcher's calculations. Interrater reliability on single words was 98%, and on spontaneous speech was 99%.

Results

This study investigated the effectiveness of oral-motor exercises in the treatment of children with speech sound disorders, comparing it to an articulatory approach. The study design consisted of a single subject, multiple-baseline across subjects design. There were three phases of data collection, a baseline phase and two sequential treatment phases. Data were collected at the end of each baseline and treatment session during play session probes and a percent correct score was determined for each participant's target sounds. These scores were charted into data tables to observe patterns over the course of the treatment phases.

Each participant completed baseline sessions, oral-motor treatment sessions, and articulatory treatment sessions using integral stimulation. AP completed three baseline sessions, ten oral-motor therapy treatment sessions, and eleven integral stimulation therapy treatment sessions. JR completed three baseline sessions, twelve oral-motor treatment sessions and eleven integral stimulation treatment sessions. MD completed seven baseline sessions, eight oral-motor treatment sessions and six integral stimulation treatment sessions.

At the end of each session there was a short play session during which a spontaneous speech sample was obtained. The speech sample was analyzed for target sounds, and a percent correct score was determined by dividing the number of target sounds correct by the total number of target sounds. Additionally, a word list selected from the randomized list for each child's target sound was presented to the participant in an imitation task that contained the target sounds and this information was analyzed for a percent correct score (see Appendices C – M).

In addition to percent correct, placement, voicing and manner characteristics were analyzed for each target sound. These characteristics allowed the researcher to see slight increases of correctness in the subjects' target productions. The results for each participant are discussed below.

AP

AP's speech was analyzed for correct production of initial /p/ and /b/ and initial and final /k/ and /g/. These targets were chosen based on developmental norms and an initial spontaneous speech analysis. Voiced and voiceless cognates were chosen because by targeting one cognate, change can be expected on the other.

Target sounds /p/ and /b/

Production of the targets initial /p/ and /b/ remained stable during baseline session. AP's production of initial /b/ stabilized at 100% correct; it was still tracked throughout the study duration to maintain consistency between participants. No change was noted during the oral-motor treatment course. During the integral stimulation treatment course preliminary ascending trends were observed in the data as the frequency of correct productions of initial /p/ increased in both spontaneous speech and single words, but remained variable. Outcome measures for targets initial /p/ and /b/ can be seen in Figures 1 and 2.

Figure 1. AP’s percent correct for initial /p/ and /b/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

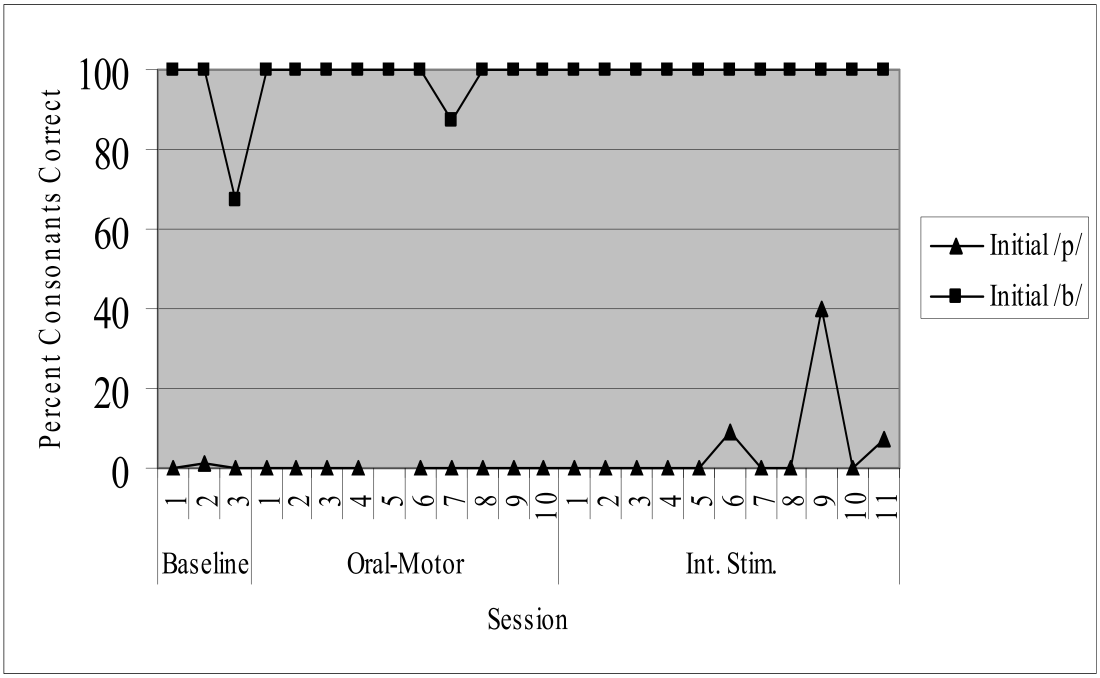
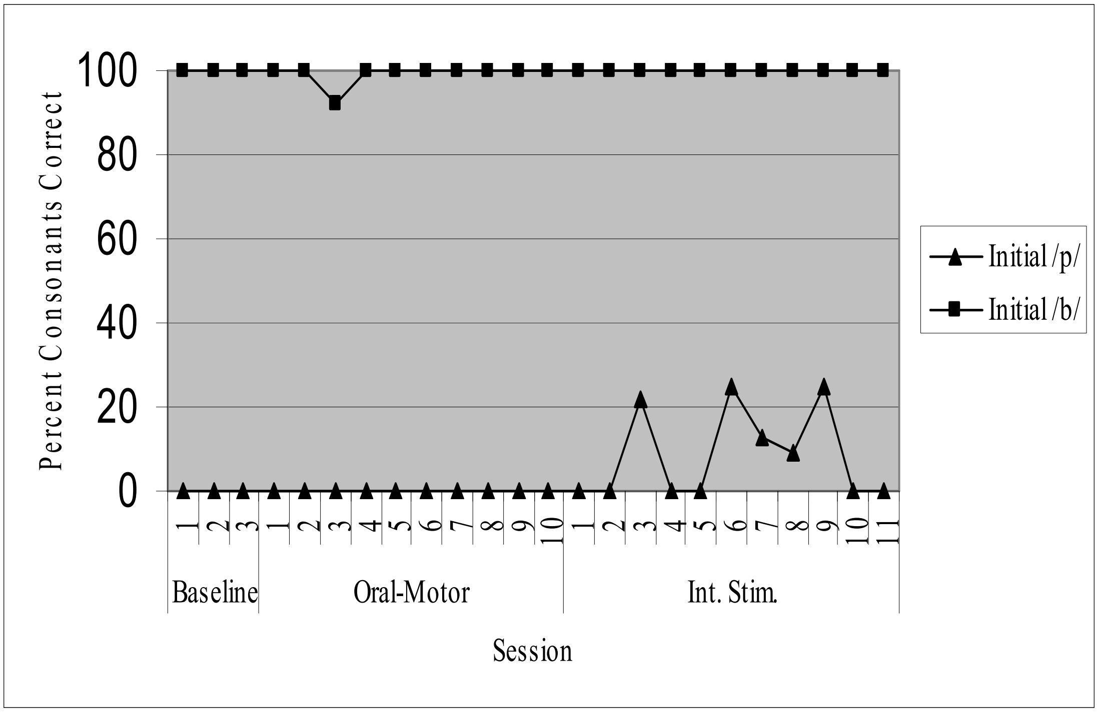


Figure 2. AP’s percent correct for initial /p/ and /b/ in single words during baseline, oral motor, and integral stimulation sessions.



While an increase in the correct productions of target sounds was noted during integral stimulation in AP’s data collection sessions, the number of correct productions seen during integral stimulation treatment sessions was even greater. AP produced initial /p/ with 80-100% accuracy in integral stimulation treatment sessions given cues and instruction. Additionally, he began to use speech sound manner characteristics that were closer to the target sound. Initial data collection found that AP substituted /m/ for /p/ and later data collection found a much higher incidence of /b/ substituted for /p/.

Target sounds /k/ and /g/

Production of the targets initial and final /k/ and /g/ remained stable during baseline session. No change was noted during the oral-motor treatment course. During the integral stimulation treatment course preliminary ascending trends were observed in the data as the frequency of correct productions of initial /k/ and final /g/ increased in spontaneous speech and single words. The frequency of correct productions also increased for initial /g/ and final /k/ in spontaneous speech and single words. Outcome measures for targets initial and final /k/ and /g/ can be seen in Figures 3 and 4.

Figure 3. AP's percent correct for initial and final /k/ and /g/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

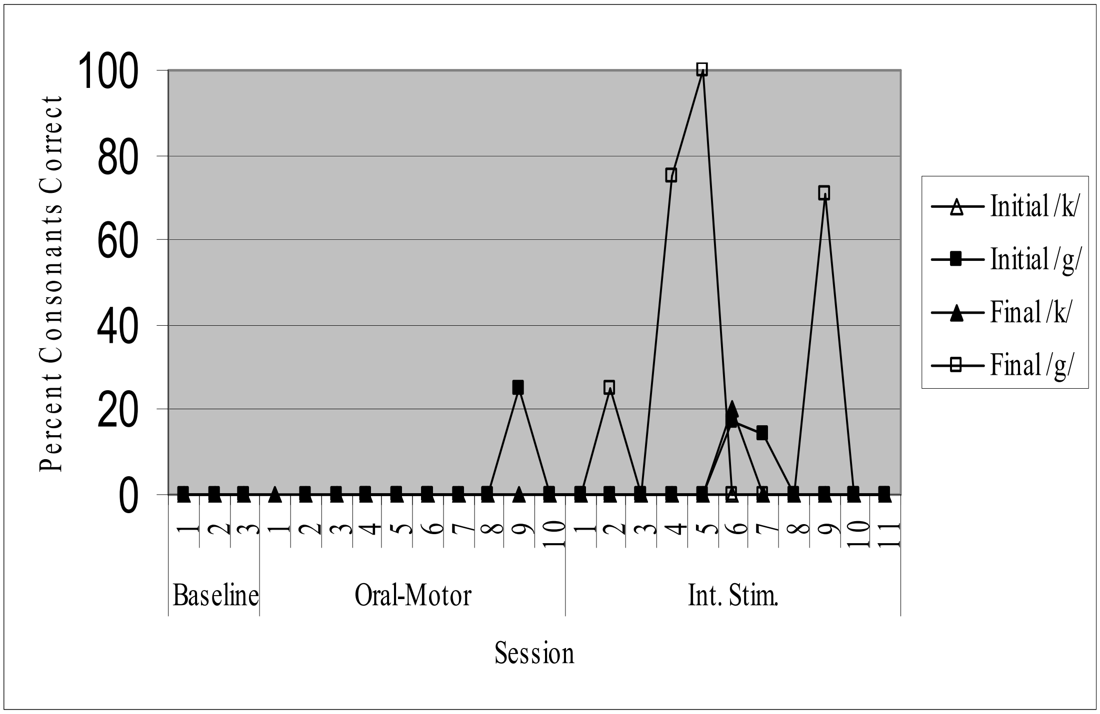
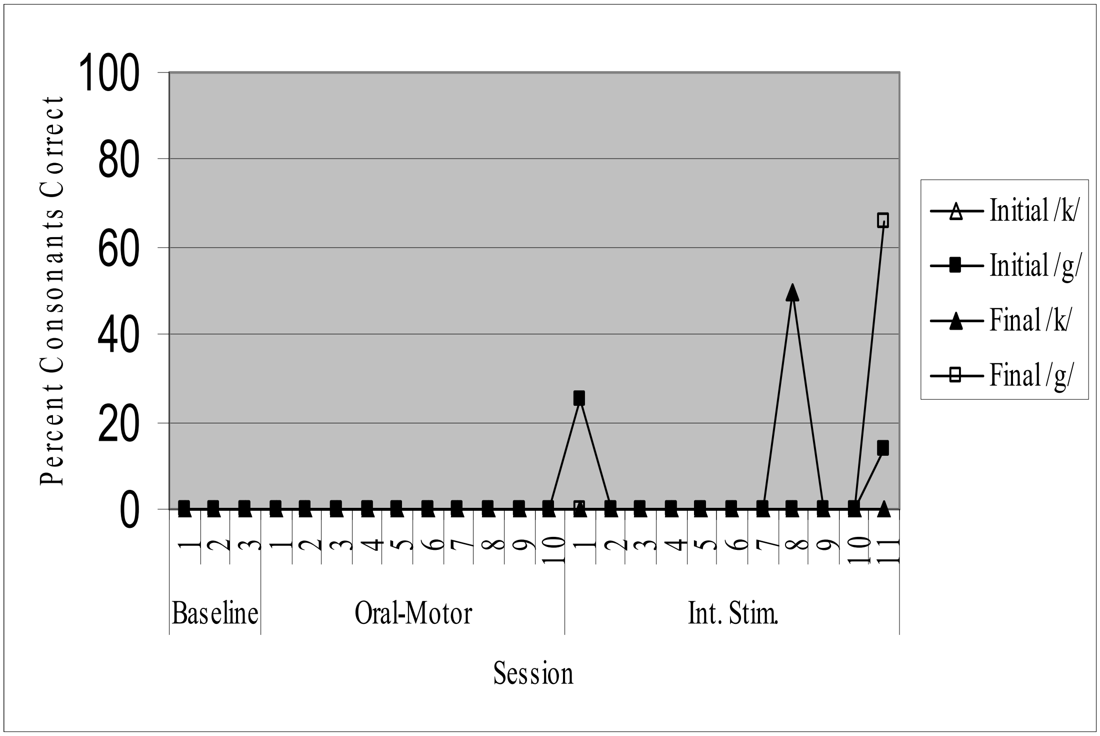


Figure 4. AP's percent correct for initial and final /k/ and /g/ in single words during baseline, oral motor, and integral stimulation sessions.



Overall an increase in correct productions of target sounds occurred during integral stimulation as measured in AP's data collection sessions. However, the amount of correct productions seen during integral stimulation treatment sessions was even greater. AP produced final /k/ with 80-100% accuracy during integral stimulation treatment sessions given cues and instruction. The target sound final /k/ was addressed most often in therapeutic sessions. Correct production of final /g/ and initial /k/ and /g/ was seen less frequently, as these target sounds were not addressed much in therapeutic sessions due to time constraints and client responsiveness.

Correct productions during oral-motor treatment sessions could not be noted due to the lack of opportunities for productions of target sounds.

AP's mother was asked to comment on AP's response to the different treatment approaches. It appeared that she favored integral stimulation: she noticed a change in AP's speech once the integral stimulation treatment was introduced and said that the oral-motor part of treatment did not work and they didn't see any progress. AP's mother reported that AP started to use more sounds during integral stimulation, and following treatment, this trend continued. She said that AP seemed to respond to the "feeling" of the sounds during integral stimulation and that he started to self-monitor as soon as the feedback was introduced and continued to do so after the treatment ended.

JR

JR's speech was analyzed for correct production of initial and final /f/ and /v/ and initial and final /k/ and /g/.

Target sounds /f/ and /v/

Production of the targets initial and final /f/ and /v/ remained stable during baseline session. No change was noted during the oral-motor treatment course. During the integral stimulation treatment course preliminary trends in data were observed as the frequency of correct productions of final /f/ increased in single words. Outcome measures for targets initial and final /f/ and /v/ are seen in Figures 5 and 6.

Figure 5. JR's percent correct for initial and final /f/ and /v/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

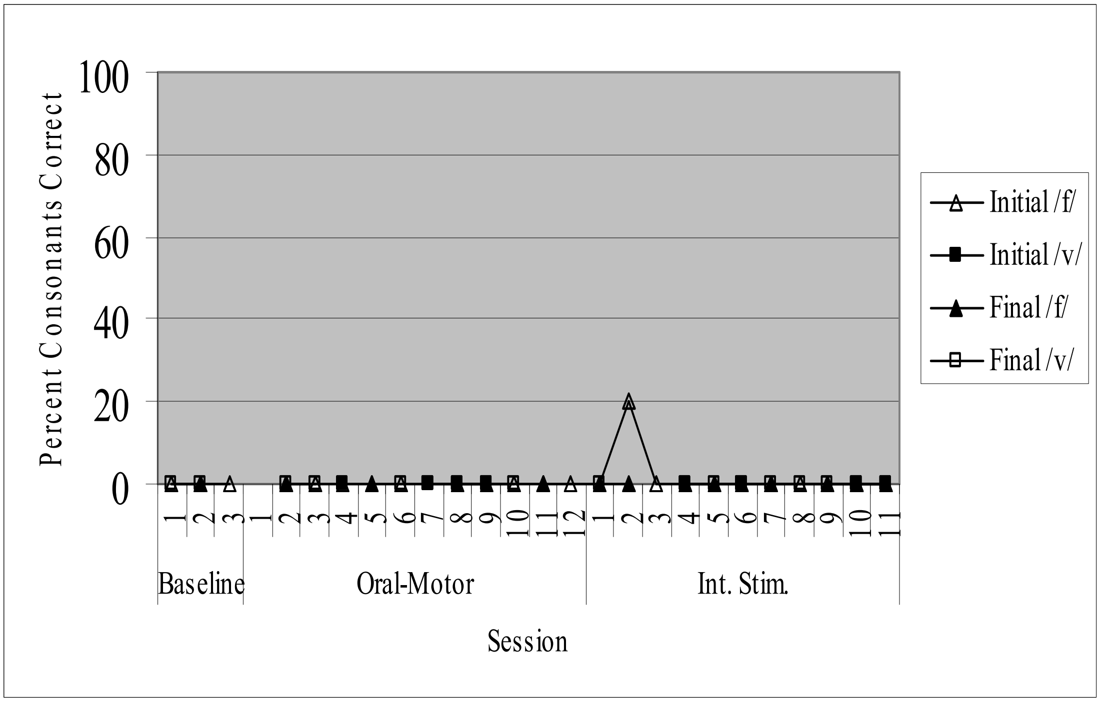
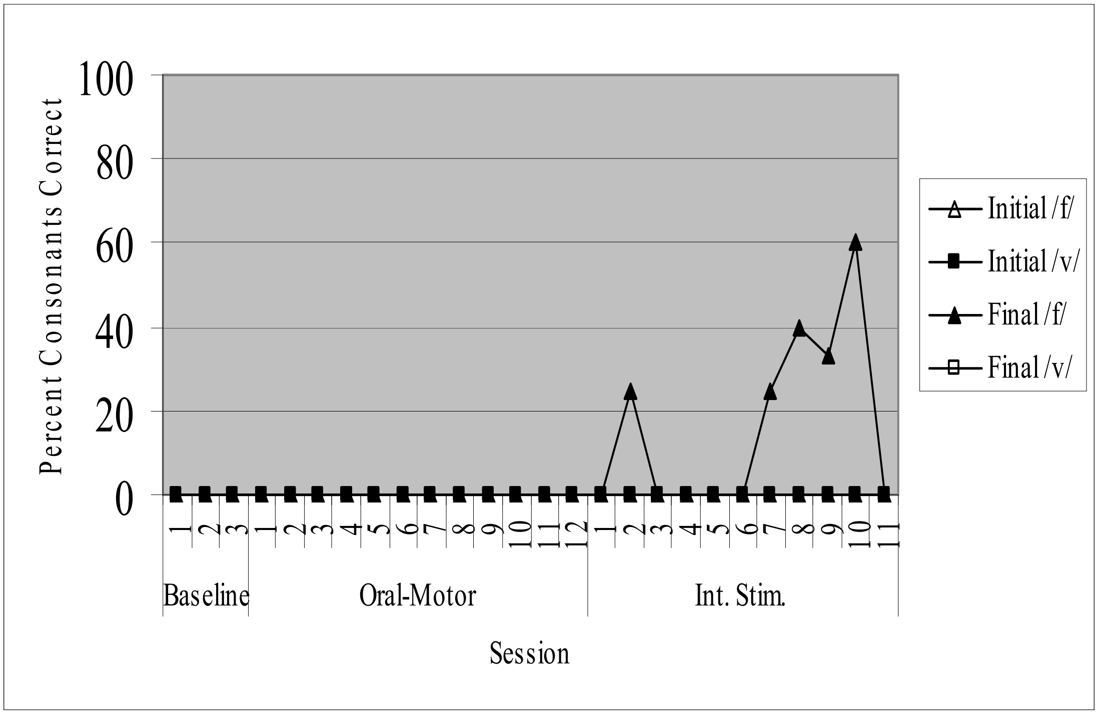


Figure 6. JR's percent correct for initial and final /f/ and /v/ in single word samples during baseline, oral motor, and integral stimulation sessions.



JR demonstrated increased accuracy in production during the integral stimulation phase data collection periods. The number of correct productions seen during integral stimulation treatment sessions was even greater. JR produced final /f/ with 60-100% accuracy in integral stimulation treatment sessions. The target sound final /f/ was addressed most often in therapeutic sessions. Correct production of final /v/ and initial /f/ and /v/ was seen less frequently, as these target sounds were not addressed much in therapeutic sessions, due to time constraints and client responsiveness

Target sounds /k/ and /g/

Production of the targets initial and final /k/ and /g/ remained stable during baseline session. No change was noted during the oral-motor treatment course. It appeared that the target sound final /k/ began to emerge during the integral stimulation treatment course, but no firm conclusions could be drawn due the short duration of the increase in correct productions. Outcome measures for targets initial and final /k/ and /g/ can be seen in Figures 7 and 8.

Figure 7. JR's percent correct for initial and final /k/ and /g/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

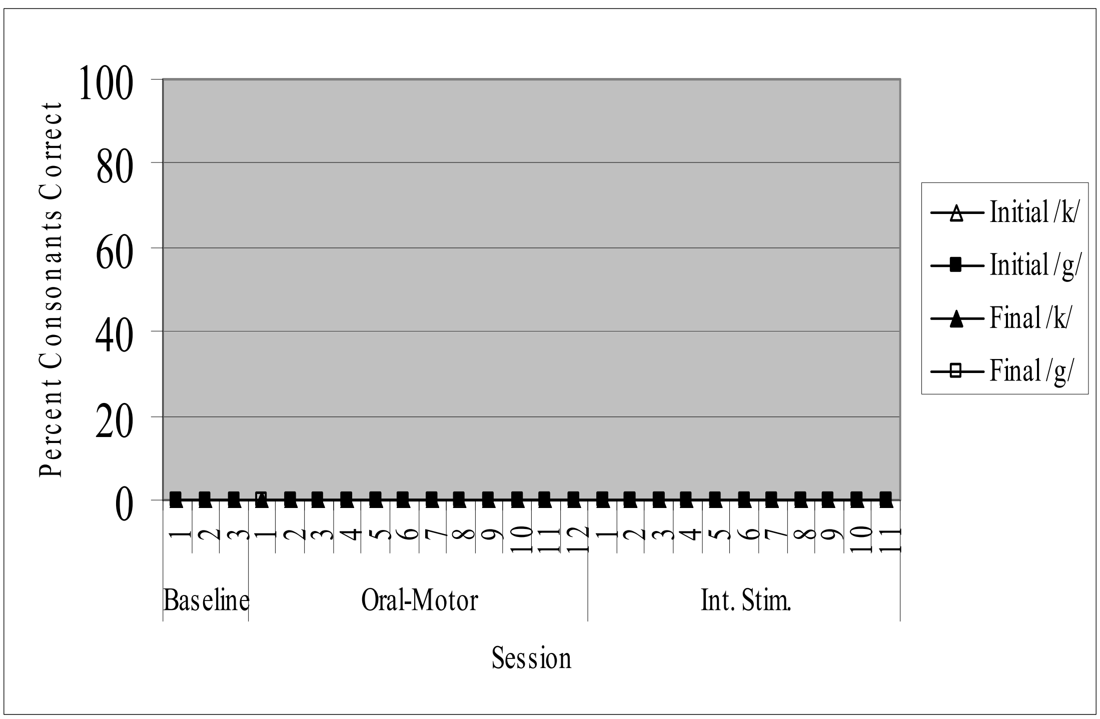
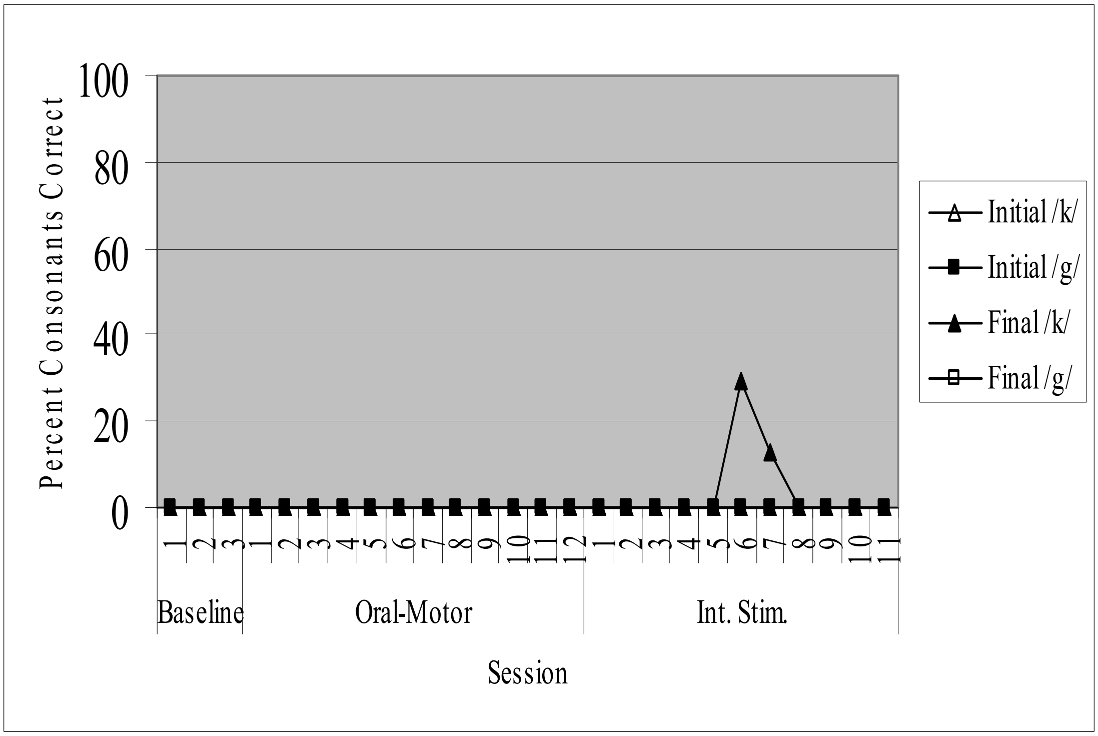


Figure 8. JR's percent correct for initial and final /k/ and /g/ in single word samples during baseline, oral motor, and integral stimulation sessions.



No overall change of target productions as measured in data collection was seen; however, an increase in correct productions was noted in treatment sessions. JR produced final /k/ with 40-70% accuracy during integral stimulation treatment sessions. The target sound final /k/ was addressed most often in therapeutic sessions. Correct production of final /g/ and initial /k/ and /g/ was seen less frequently, as these target sounds were addressed infrequently in therapeutic sessions due to time constraints and client responsiveness.

JR's mother was asked to comment on the different therapy approaches. In her opinion, JR enjoyed treatment and gained more from the integral stimulation phase of therapy. She said that soon after the switch in treatment phases, she noticed a difference in JR's speech. JR's mother compared the oral-motor phase and integral stimulation phase. She noted that the oral motor therapy did not produce positive results when compared to integral stimulation, and indicated that they would not choose to use a treatment approach that included oral-motor activities in the future.

MD

MD's speech was analyzed for correct production of initial and final /t/ and /d/ and initial and final /s/ and /z/.

Target sounds /t/ and /d/

Production of the targets initial and final /t/ and /d/ was quite variable throughout the study duration. No change was noted during the oral-motor treatment course. Nor was change noted during the integral stimulation treatment course. Outcome measures for targets initial and final /t/ and /d/ can be seen in Figures 9 and 10.

Figure 9. MD's percent correct for initial and final /t/ and /d/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

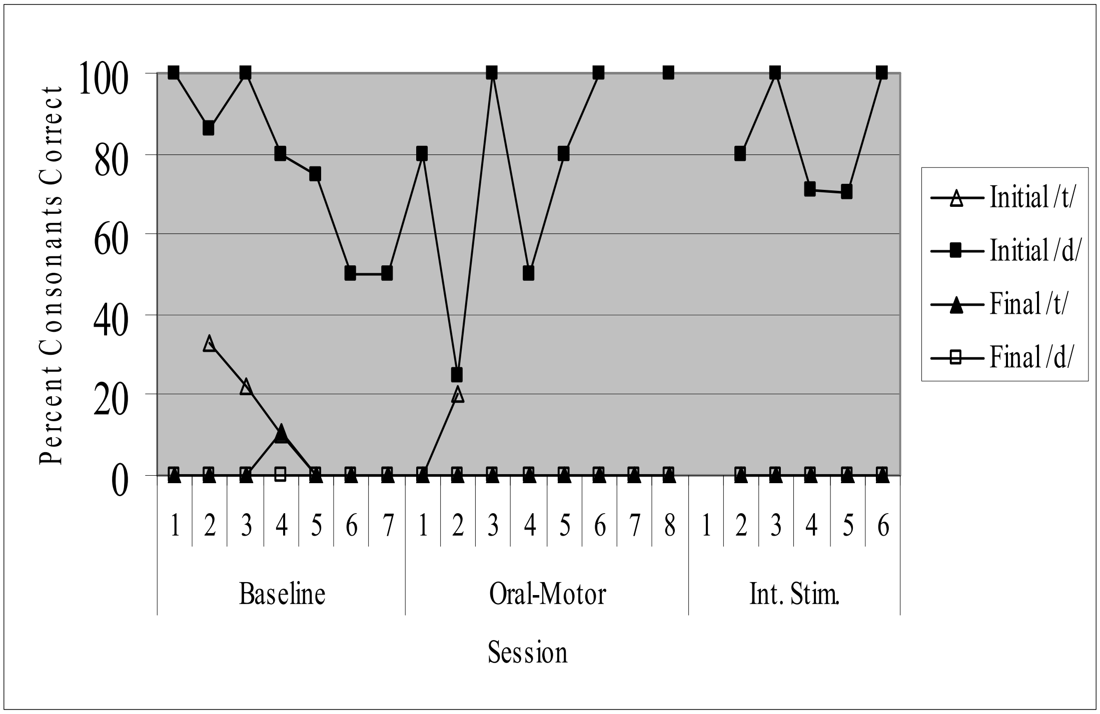
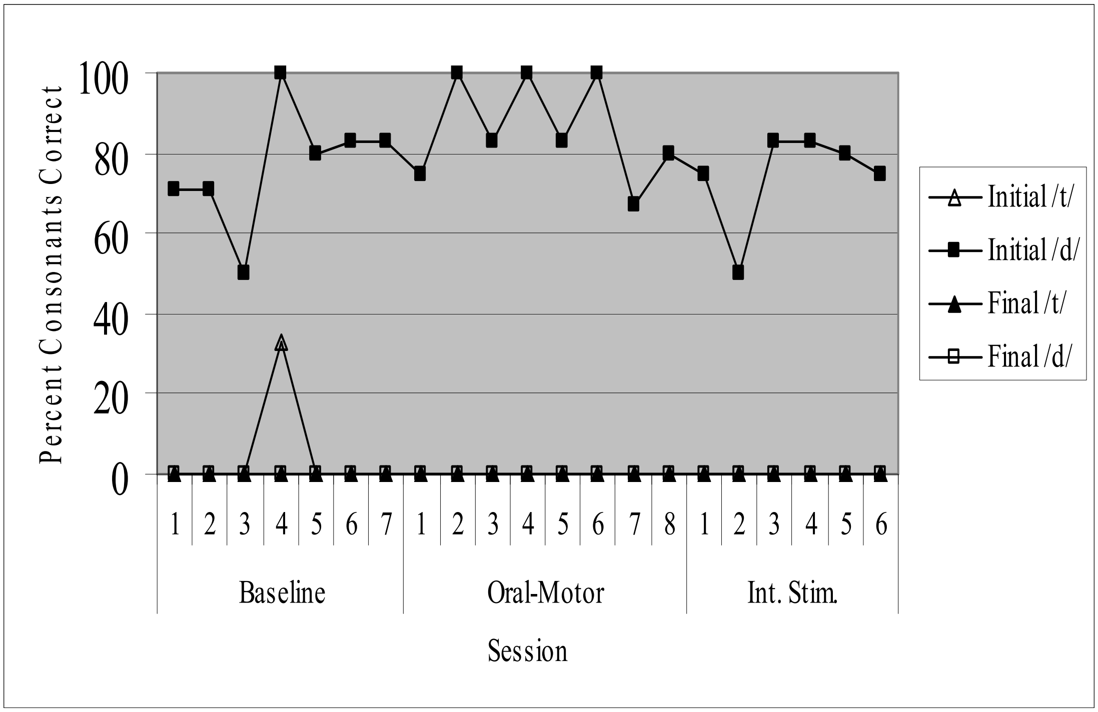


Figure 10. MD's percent correct for initial and final /t/ and /d/ in single word samples during baseline, oral motor, and integral stimulation sessions.



No overall improvement as measured in data collection was seen. Few accurate productions were seen in integral simulation treatment sessions as well. The target sound /t/ was addressed most often in therapy, but target levels began at the sound in isolation level. MD produced /t/ in isolation with 40-50% accuracy, given cues and instruction. Once the target sound was introduced in a syllable, such as /tu/ or /ti/, MD returned to his initial productions of /d/ for /t/. He produced the /t/ sound in isolation and then produced a vowel following it as long as the vowel was separated out from the target sound. The target sounds final /t/ and /d/ were addressed less in therapeutic sessions due to time constraints and client responsiveness. MD showed few correct productions of final /t/ and /d/ in treatment sessions.

Target sounds /s/ and /z/

Production of the targets initial and final /s/ and /z/ remained relatively stable during baseline sessions. No change was noted during the oral-motor treatment course. No change was noted during the integral stimulation treatment course. Outcome measures for targets initial and final /s/ and /z/ can be seen in Figures 11 and 12.

Figure 11. MD's percent correct for initial and final /s/ and /z/ in spontaneous speech samples during baseline, oral motor, and integral stimulation sessions.

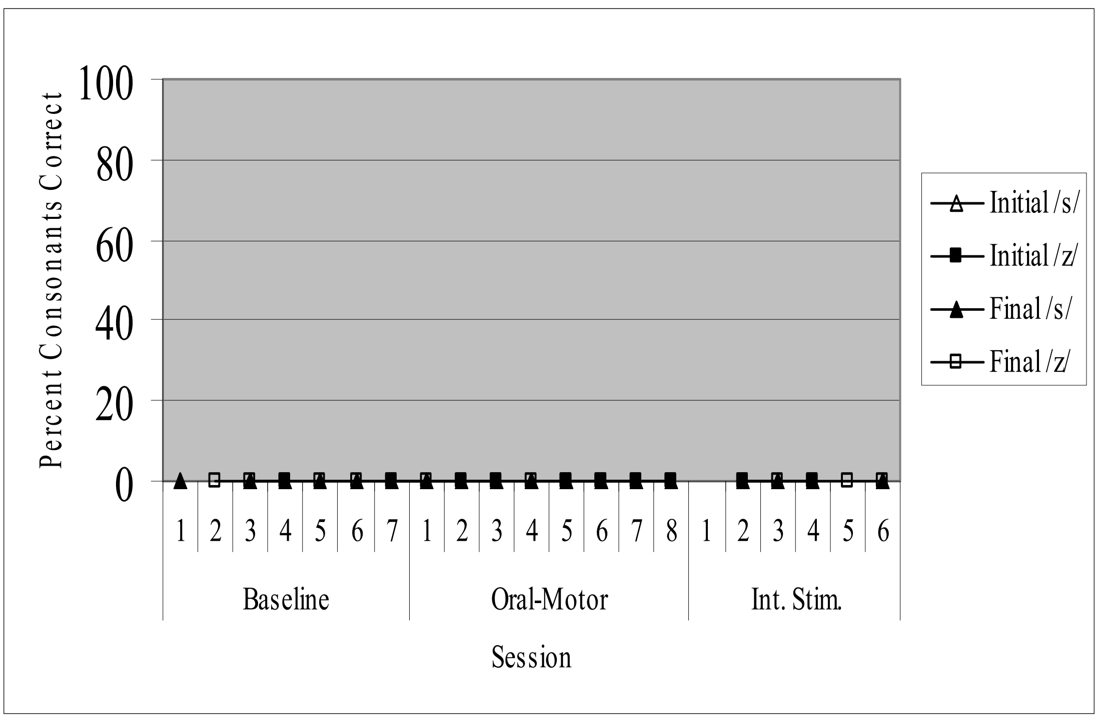
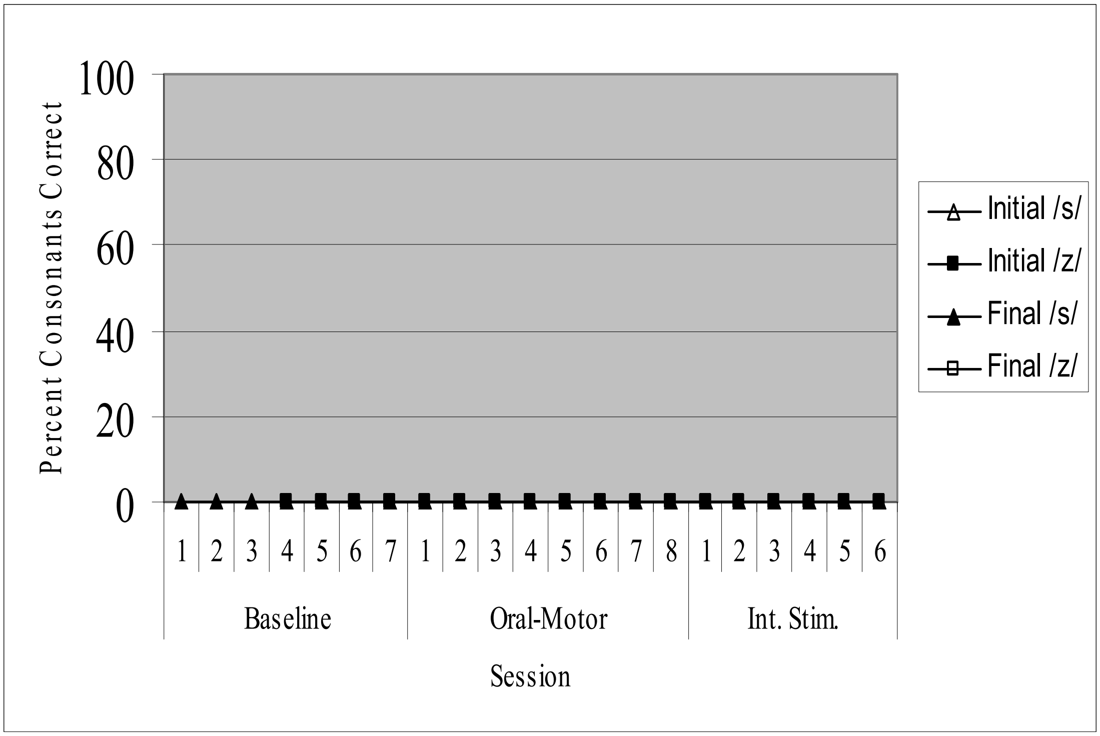


Figure 12. MD's percent correct for initial and final /s/ and /z/ in single word samples during baseline, oral motor, and integral stimulation sessions.



No overall improvement for /s/ and /z/ as measured in data collection was seen. Very few accurate productions were seen in integral simulation treatment sessions as well. The target sound /s/ was addressed most often in therapy, and target levels started at the isolation level. MD was unable to produce /s/ in isolation, but given cues and instruction, he produced /ʃ/ in isolation, showing he was producing a manner and voicing characteristic that was much closer to his initial production of /j/ for /s/. He also produced the phoneme /ʃ/ in the final position of vowel-consonant words when the vowel was separated from the target sound. In one data collection session during the term, MD spontaneously used /ʃ/ in the final position of words. This pattern is seen as progress as MD typically used no fricatives in his speech and typically deleted all final consonants. The target sound /z/ was addressed less in therapeutic sessions due to time constraints and client responsiveness.

MD's parents were asked to comment on both treatments. They said that both therapy phases were beneficial. They felt that the oral-motor phase of therapy helped MD to use his oral structures more and get his mouth ready for speech by strengthening the oral musculature. They said that they felt the oral-motor phase prepared his muscles, and once the integral stimulation phase was introduced MD started to use more words and sounds.

Discussion

The purpose of this study was to investigate whether oral-motor exercises were effective in the treatment of children with speech sound disorders, and whether oral-motor exercises were as effective as an articulatory approach in correcting speech errors.

In all three study participants, little progress was seen in the targets measured using either an oral-motor or articulatory approach to therapy. No accurate productions of the speech sound targets were observed during the oral-motor phase of therapy. During the articulatory phase of therapy, where an integral stimulation approach was used, varying results were found between participants, and the patterns of accurate productions seen in the data differed between spontaneous speech and single words. Results do not provide a conclusive answer to the comparative component of the research question, as there were varied results seen in the integral stimulation phase of therapy. The results of the analyses performed on the participants' target sounds will be discussed as well as information obtained through observation of treatment sessions.

During the oral-motor phase of therapy all participants showed no progress on their target speech sounds. These findings suggest that oral-motor therapy is not an effective intervention technique for targeting speech sounds in children with articulation disorders. Thus far there has been little empirical research on the effectiveness of oral-motor therapy in the treatment of articulation disorders in children. Forrest (2002) discussed this issue and concluded that because of this lack of evidence, it cannot be said that oral-motor exercises are an effective treatment strategy.

The main issue that arises when clinicians discuss oral motor therapy is it's usefulness in remediation of errors in connected speech. Since oral-motor exercises break down speech movements into single units, there is the question of whether this break down is more efficient than working on speech errors in speech. The results of this study show varied results regarding this issue. The outcome measures for two participants suggest that oral-motor exercises are not as effective as an articulatory approach to therapy, shown by the lack of improvement in speech sound targets during the oral-motor phase of intervention. In both participants, no progress was seen during the oral-motor phase, but preliminary trends in data were noted during the articulatory phase, where increased accuracy of target word productions was seen in the data and in treatment session activities. The results, both quantitative and qualitative, for the third participant were inconclusive regarding the usefulness of oral-motor therapy for targeting speech sounds.

Despite the lack of improvement evidenced by data in this single subject design, qualitative observations were made in therapy sessions between the treatment phases. The design variables that were used prevented this information from being considered in outcome measures. Correct productions were seen in all participants during the integral treatment sessions although this was not the case during the oral-motor phase of treatment. All three participants' families noted improved productions outside the treatment room once integral stimulation was introduced, but their opinion of the effectiveness of either treatment appeared inconclusive.

This discrepancy between what was observed during the treatment sessions and what the outcome measures show suggest that the data collection measures used did not adequately capture the participants' true abilities. Targeting the newly learned speech sounds in spontaneous speech may have been too difficult a task for children who exhibit complex articulation disorders. and targeting only the repetition task may have been a more sensitive measure. The data collection sessions consisted of play sessions and word lists that were presented in that order. Since the oral-motor phase of therapy was the first treatment introduced, the data collection sessions were introduced to the participants as play sessions that included time to say their words. The objectives of oral-motor treatment do not include targeting the speech sound directly, thus the data collection strategies employed were not necessarily appropriate for the oral-motor treatment phase. The data collection strategies did not change once oral-motor therapy was terminated and integral stimulation therapy began. A large component of integral stimulation includes awareness training and self-monitoring, which the participants did not appear to utilize in the data collections sessions during the integral stimulation phase. These concepts were not introduced to the participants during the oral-motor phase; therefore, they could not be utilized during the data collection sessions for the integral stimulation phase because data collection had to be consistent over the course of the study. Thus, the data collection tools proved to be a very non-functional task for the participants during the integral stimulation phase and did not capture the effect of treatment that was seen during the integral stimulation treatment sessions.

There were several issues that were encountered during this study that merit discussion because of the impact they had on the data and on the therapy itself. The methodology used in the oral-motor phase of therapy presented some challenges, including the timing of introduction of the target speech sound and that the relationship to linguistic aspects of speech is not accounted for. Additionally, the issue of cognitive motor learning in relation to the hierarchies of performance in oral-motor therapy proved to be challenging.

In the Sarah Rosenfeld-Johnson methodology, the target speech sound is not introduced until the child has reached criteria for productions within the oral-motor exercise hierarchy. This method suggests that the child's strength, grading of movement, and range of motion are increased during oral-motor exercises and these enable the client to produce the speech sound correctly. In this study, all participants in this study showed adequate muscular abilities to perform speech acts prior to the beginning of this study. They moved easily through the hierarchies of the oral-motor exercises, and overall strength did not appear to be an issue.

The production of the speech signal consists not only of the motor movements that the signal is composed of, but also of the linguistic information that is conveyed to the listener. The linguistic information that is shared by the speaker is done through the speech motor output (Kent, 2000). Oral-motor therapy attempts to separate the motor movements from the linguistic information. This differentiation of tasks does not appear to be an effective intervention tool. As shown in the outcome data, the participants showed improvement in their target sounds only after linguistic information was attached to the motor movement. This indicates that a cognitive motor component is crucial for learning to take place. The child must learn about the speech target through repetitive practice and motor learning, as well as through feedback mechanisms that make use of cognitive motor learning strategies. Feedback mechanisms such as audition and proprioception give the speaker information about what motor movement was produced, as well as what linguistic information was conveyed, such as rate, timing and correctness of the target (Borden, Harris, & Raphael, 2003). The clinician can subsequently use these channels to give additional external feedback to the client about how to remediate errors. Once a client is given feedback about their speech signal, they are able to use this feedback to make changes and self monitor, as clearly evidenced in this study by the positive results seen once the intervention strategies included both repetition of motor movements, as well as cognitive motor learning components.

Another factor that this methodology does not factor in is the task specifications necessary for success at a specific hierarchy level. The criteria that are suggested to move clients up in the hierarchies are not clearly delineated and the oral-motor tools do not support the criteria suggested. For example, to achieve success on each level of the horn hierarchy the client is required to blow each horn for longer amounts of time, but the horn itself does not require that amount of time for the horn to produce the blow. It was very challenging to explain to the client that they must blow the horn for a longer amount of time, especially for twenty-five times in a row. This is a cognitively demanding concept for young children to understand; a response that was seen was that once the client got the feedback of the horn blowing they stopped blowing because they got the reinforcement they needed. Thus the client could blow horns for twenty-five times in a row, showing that strength and breath support were not an issue, but not get criteria for the level due to the time requirement of the horn. This resulted in additional time spent on possibly unnecessary tasks.

Another example of difficult criteria to implement seen in oral-motor treatment sessions was during the use of bubbles for air-flow support. The nature of blowing bubbles did not lend itself to the tasks designed for the hierarchy. The clients were required to blow bubbles successively longer distances, but the bubbles would often pop or float away before the designated distance was obtained. For example a client blew 9 blows of bubbles the designated distance, but then on the 10th blow (the criteria for success for this task) the bubble popped or floated away. Thus, criteria for success were not obtained due to the nature of bubbles, not the ability of the clients to blow bubbles. The clients were observed multiple times performing the tasks required in the hierarchies, but specific criteria were not always obtained preventing them from achieving success**.** The oral-motor methodology suggests that if a client does not obtain criteria for success is it due to insufficient motor skill or breath support. The above observations appear to show that this was not the case, suggesting that the therapy tools were not representative of what the clients could actually do.

The problems discussed above suggest that there were many factors unrelated to cognitive motor learning that may have impeded improvements in the participants target sounds during the oral-motor phase, but this was not the case during the integral stimulation phase. Integral stimulation employs several principles of cognitive motor learning, such as repetitive practice, feedback about performance and results, and self-monitoring strategies (Caruso & Strand, 1999; Strand & Debertine, 2000). Built into the therapy, these principles provide a solid foundation for speech sound acquisition. Once the speech sound was introduced into therapy and the participants were aware of the goal of therapy, they started to utilize feedback from the clinician and self-monitoring strategies to change their behaviors. These strategies coupled with repetitive practice produced improvement and skill in the participants target sounds during the integral stimulation phase.

Despite the positive outcomes seen using integral stimulation, there are several weaknesses of this approach that should be noted. An approach such as integral stimulation that uses cognitive motor learning is much more demanding on the therapist. It requires an in-depth knowledge of the articulatory system and the ability to adapt treatment strategies to each individual child. In addition, it is typically a more drill-based approach that can be unexciting for both the client and clinician.

Individual differences

Due to the variety of the participant's skills and articulatory disorders, a discussion of individual differences is appropriate. The difficulties that AP and JR exhibited during the study duration have been discussed in general above, but MD showed more difficulty than the other subjects with many of the tasks, likely due the type of his speech disorder, Childhood Apraxia of Speech (CAS). During the oral-motor phase MD had incredible difficulty with performance on horn blowing, bubble blowing and tongue exercises, all tasks that require volitional motor movements**.** As discussed earlier, the diagnosis of CAS includes several speech characteristics, but non-speech characteristics such as impaired volitional motor abilities are included in differential diagnosis of CAS (Davis, Jakielski & Marquardt, 1998). MD also evidenced sensory defensiveness that made application of several oral-motor techniques difficult. The basis of oral-motor therapy is built on volitional motor movements and the issues that MD displayed indicate that oral-motor therapy would not be an appropriate choice for a child with CAS because the tasks required of the clients are ones that are most affected by their disorder, such as skilled motor movements requiring motor planning. This claim is supported by the information gained from MD's outcome measures, as improvement in target speech sounds were not seen until the speech target was introduced into therapy and it was only seen during treatment sessions, not in data collection. This indicates that not only is the motor plan important for correct speech sound production, but the context of speech is an important factor in gaining skill and proficiency in target sounds.

Conclusion

Summary

Three preschool-aged males who presented with severe speech sound disorders participated in a study to determine the effectiveness of oral-motor therapy as compared to articulatory therapy. A single subject, multiple-baseline across subjects design was used to investigate this topic and the treatment conditions were applied sequentially. The Sarah Rosenfeld-Johnson oral-motor methodology was used in this study and an articulatory plan using integral stimulation was developed for each child depending on their errors (Rosenfeld-Johnson, 2001).

Data were obtained after each treatment session in spontaneous speech samples and word lists. Data were analyzed for patterns in behavior over the treatment phases. The data showed little improvement in the participants' target sounds during both treatment phases, but preliminary trends in data were observed. Additionally, behaviors observed during integral stimulation treatment sessions and qualitative information gained from the participant's families suggest that progress was made during this phase. The findings from this study suggest that an oral-motor approach to therapy does not produce an increase of correct production of target sounds when compared to an articulatory approach to therapy. It did not appear that oral-motor therapy was as effective an intervention strategy as other therapy approaches when targeting articulatory errors. In addition to this, there were several issues regarding oral-motor therapy and its use that suggested that it is not an effective intervention strategy.

Limitations

As discussed earlier, the current data collection methods were not necessarily representative of the child's performance in treatment sessions. To keep consistency among intervention phases, cues that facilitated awareness of performance and self-monitoring could not be given during the integral stimulation data collection sessions. This was an important factor that proved to effect change in the participants' productions, and future researchers should account for this and design their data collection measures so that these feedback mechanisms can be incorporated into data collection.

Another limitation of this study was the implementation of the oral-motor protocol. The Sarah Rosenfeld-Johnson protocol that was used suggests that the client is seen for therapy for 30-45 minutes sessions for a period of several months (Rosenfeld-Johnson, 2001; Rosenfeld-Johnson, 2003). Due to time constraints, this study was implemented for a period of 9 weeks, with approximately half that time devoted to oral-motor therapy. Based on this study, the effects of oral-motor therapy given several months of implementation are not known.

Clinical Implications

There are several clinical implications that can be inferred from the findings of this study. The order in which the data collection stimuli were presented may have affected outcome measures. The data were collected by eliciting spontaneous language samples from the participants with a word list probe presented following the language sample. The spontaneous language sample was introduced to the participant's as "play time," and the word list was introduced to the participants as "saying our words." The play time really appeared to affect the participants' performance. They would get caught up in playing, and it was evident that the speech sound targets had not generalized to this level of production yet. It appears that the transition from therapy to the play session may have reduced their level of awareness about their target sounds and affected the outcome measures on the word lists. Perhaps organizing the data collection session so that the word list was presented first would have generated more correct responses, because the participants appeared to understand that the word lists contained their target sounds once they were introduced.

When discussing therapy time the issue regarding the number of therapy targets surfaces. This study targeted four separate speech sounds, when the voiced and voiceless cognates are considered. The concept was that targeting the voiced and voiceless cognates would promote carryover between sounds and levels of correctness could be awarded if a child produced a /b/ for a /p/. However, the study duration was too short an amount of time to target all four sounds especially since the children were not producing the sounds to begin with. The actual data suggest very little progress was made on target sounds; however, this appeared to be due to lack of time and client responsiveness to target those sounds.

Research Implications

This study was performed using a single subject design over a 9-week period. Performing a study with a longer duration for each protocol in order to better assess the benefits of each intervention would allow more information to be gained on this topic. As shown by the participants' performance during the play sessions, treatment targets had not generalized past a structured therapy setting and this time frame did not allow enough time to address all the targets effectively and give the participants enough practice time. Alternatively, individual studies could be conducted to examine the benefit of each individual treatment approach.

Finally, this topic would be of interest to investigate on a larger scale. A single subject design is a beginning. It provides information on patterns seen in a small subset of children, but larger scale studies could substantiate these findings by providing statistical information regarding effectiveness of these intervention strategies.

This study was done to further the existing research regarding the use of oral-motor activities in the remediation of children with severe speech sound disorders. The findings support previous claims that oral-motor exercises are not effective or efficient in the treatment of children with speech sound problems (Forrest, 2002; Lof, 2003). The research is still very limited and focused on particular communities. Further research is needed to support or reject these findings and to more fully understand the usefulness of oral-motor exercises.

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Appendix A

Informed Consent

Consent Form

Dear Parents/Guardians,

I am contacting you to invite you to participate in a project about speech therapy with young children. My name is Dr. Christina Gildersleeve-Neumann. I am a certified speech-language pathologist and a faculty member at Portland State University in the Department of Communication. I have contacted you because you are pursuing assessment to determine if your child has a speech delay, or you believe your child has a speech delay and you are pursuing speech therapy for that delay. This project will involve assessment to determine whether your child does have a speech delay (if you have not recently had an assessment for that purpose) and therapy for your child's speech delay using and comparing two currently acceptable treatment approaches.

The assessment procedures and therapy approaches we use do not present major risks to you or your child. They are therapy approaches currently used by licensed speech-language pathologists in treating speech delays and disorders. One potential known risk of any speech therapy is drawing attention to a person's speech delay, which could result in negative feelings for that individual. This is not a frequent result of speech therapy. In addition, research and clinical practice have shown that this potential risk is outweighed by the benefit of improved speech resulting from speech therapy.

Completing research helps us understand the difficulties some children experience with language and communication and to determine the best ways to treat these difficulties. The purpose of the current project is to understand the most effective type of therapy for children with delays in speech development. In this project, we will assess the effectiveness of two therapy strategies: 1) the use of non-speech "oral-motor" exercises, such as the use of whistles and horns for strengthening mouth muscles, and 2) speech therapy that takes a speech sound approach, conducting treatment through words containing sounds not produced correctly by the participant.

If you are interested in participating, we will initially provide a thorough communication assessment of your child, unless your child has had this completed in the previous three months. We will then determine the appropriateness of your child's communication needs, if any, and the proposed therapy regime of this research program. If the two match well and you agree, we will then provide your child with speech therapy services three times a week for 30 minute sessions. The sessions will take place at the Speech and Hearing Clinic as Portland State and will be provided free of charge. Free parking will also be provided.

The proposed assessment of communication will include probes of your child's language, hearing and speech levels. Tasks include activities such as pointing to pictures, playing with toys, responding to questions, and talking with me. A hearing screening will also be completed (if your child does not pass the hearing screening, we will contact you). You will receive a full report documenting the results of our assessment that you may keep for your records or take to any agency providing speech and language services, including PSU.

If your child meets the criteria for our study, and you choose to be a participant, we will begin therapy three times a week at PSU where you will receive therapy free of charge. We will initially treat the two most prominent error patterns in your child's speech. Each session will be 30 minutes long and will consist of 12 minutes of oral motor therapy activities, 12 minutes of speech-based therapy, and 6 minutes of free play related to your child session. We will audio tape and video tape your child during the free play data collection period. Before we begin, we will explain the activities to your child and ask him/her if they would like to participate. All tasks have been designed for use with young children, and activities that children typically enjoy. We will also ask you to complete a questionnaire related to developmental history for your child. At the end of the project, your child/family will be placed at the top of the waiting list have the option to continue at PSU clinic

Following completion of the project, we will give you a progress report that outlines the results of the two therapy types of your child's speech errors. Additionally, with your permission we will share the results of the language assessment with your child's speech-language specialists. We will keep confidential both your and your child's name and all information gathered during this project by using identification numbers on all materials used in the project. All materials will be kept in a locked cabinet in the Speech and Hearing Department at PSU. These tapes will be used for analyses only.

You may withdraw from the project at any point in time if you do not want to continue in the project, and this will not affect your relationship with PSU. If you so choose, you can receive additional speech therapy services at the PSU Speech and Hearing Clinic, and your child will receive speech therapy services immediately, if possible, or placed on the waiting list to receive speech therapy services in the near future. If you choose to continue to receive speech therapy services elsewhere, we will supply you with a copy of your child's therapy goals and the progress they have achieved towards those goals to give to the speech therapist of your choice.

Participation in this project will not be harmful in any way to your child. Also, we will not interfere with what is happening in your child's classroom. We would be happy to schedule the visits for before or after school if this is a possibility for you and your family.

We want you to understand that participation in this study is *completely voluntary*, and that you are free to choose not to have your child participate. If you do decide to have your child participate, you may withdraw him/her at any time during the study (if, for instance, your child becomes unhappy). Your decision whether or not to participate will not affect your relationship with Portland State University. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The videotapes gathered in this study will only ever be referred to by your child's age, sex, and some random, identification number (e.g., 1, 2, 3). The tapes will eventually be destroyed.

If you are willing to participate, please sign one copy of the attached consent form and return it to me in the enclosed envelope. Your signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that your child is willing to participate, that you may withdraw your consent at any time and discontinue participation without penalty, and that you are not waiving any legal claims, rights or remedies. You may keep a copy of this form, if you wish.

Please let me know if you have any questions now, and we will be happy to address them. If you have any questions at any time in the future, you can contact Dr. Christina Gildersleeve Neumann at cegn@pdx.edu or by phone at (503) 725-3230. If you ever have questions regarding your rights as a research subject or at any point have any concerns regarding this study, please contact me, or the Human Subjects Review Committee, Office of Research and Sponsored Projects, 111 Cramer Hall, Portland State University, 725-4288.

Sincerely,

Christina Gildersleeve-Neumann, Ph.D., Assistant Professor
Speech and Hearing Program

I give my permission for my child, ______________________________________, to participate in the speech therapy project at Portland State University.

Parent/Guardian's Name	Signature
Address	City / Zip Code
Home Number	Work Number
Child's Name	Date of Birth
School Name	Teacher's Name

The project was explained to _____________________________ and he/she was willing to participate.

Child's signature (if appropriate) (parent/teacher/researcher)	Witness to child's agreement

If you have concerns or problems about your participation in this study, please contact either Human Subjects Review Committee, Office of Research and Sponsored Projects, 111 Cramer Hall, Portland State University, 725-8182, or Christina Gildersleeve Neumann at 725-3230.

Script for Obtaining Consent from the Children:

My name is ____________ and I am a teacher, too! But I don't work at your school. I work at a different school. I am really glad to meet you. Your mom and dad said it would be okay if I spent some time with you. I have some different pictures I want you to look at, and some books I want to show you. After we're done today you might come back again and we would spend time a couple of days a week working and playing together. Does that sound okay? When we are finished looking at books and pictures, I have something special for you that you can take home and keep. If you don't want to come, you don't have to. But I hope you will want to come and see some of the different things I have to show you.

(Child consents or does not consent to participate).

Appendix B

Oral-Motor Therapy Protocol

AP-Oral-Motor Protocol

Target sound	Oral-motor exercises used
Initial /p/ and /b/	Bite Blocks for Jaw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Tongue Depressor for Lip Closure
Initial /k/ and /g/	Bite Blocks for Jaw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Depression
Final /k/ and /g/	Bite Blocks for Jaw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Depression

JR-Oral-Motor Protocol

Target sound	Oral-motor exercises used
Initial /f/ and /v/	Bite Blocks for Haw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Tongue Depressor for Lip Closure Cheerio for Lower Lip Retraction
Final /f/ and /v/	Bite Blocks for Haw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Tongue Depressor for Lip Closure Cheerio for Lower Lip Retraction
Initial /k/ and /g/	Bite Blocks for Jaw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Depression
Final /k/ and /g/	Bite Blocks for Jaw Stability Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Depression

MD-Oral-Motor Protocol

Target sound	**Oral-motor exercises used**
Initial /t/ and /d/	Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Elevation
Final /t/ and /d/	Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Elevation
Initial /s/ and /z/	Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Elevation
Final /s/ and /z/	Bubble Blowing Hierarchy Horn Blowing Hierarchy Straw Drinking Hierarchy Cheerio for Tongue-Tip Elevation

(Rosenfeld-Jonhson, 2001)

Appendix C

AP: Single word test stimuli for /p/ and /b/ in initial word position

baba
babe
baboon
Babs
baby
baby doll
back
bacon
bad
badge
bag
bait
bait
bake
bake
baked
bakes
bale
bales
ball
ballet
balls
baloon
ban
ban
banana
bane
bang
banjo
banned
bans
bar
barb
bare
bare
barge
bark
barked
barks
barn
bars
base
based
bash
bask
bass
bat
batch
batched
bath
bathe
bathes
baths
bay
bay
beach
beach
bead
beak
bean
bear
bear
bears
beau
bed
beds
bee
bee
beef
been
beer
bees
beet
beg
begged
begs
beige
bell
bell
bells
Ben
Bess
bet
bets
bib
bibbed
bibs
bicycle
bid
bids
big
big bird
bike
biked
bikes
bill
bills
bin
bind
bins
birch
bird
birds
birth
bit
bite
bites
bits
boa
boast
boat
boats
Bob
bobby
Bob's
bog
bogs
bogus
boil
boils
bold
bologna
bomb
bond
bone
bones
boo
boom
boost
boot
booth
booths
bore
bored
born
boss
both
bough
bought
bound
bout
bouts
bow
bowl

bowls
boy
boys
buck
bucks
bud
buddy
budge
buds
buff
buffalo
bug
bugged
bugs
built
bully
bum
bumped
bumps
bums
bun
bunny
buns
buoy
burn
burned
burns
burr
burst
bus
bussed
busy
but
butter
buttercup
buzz
buzzer
by
pa
pace
paced
pack
packed
packs
pad
pads
page
paged
paid
pail
pails
pain
pained
pains
pairs
pajamas
pal
pale
pales
palm
pam
pan
panda
pane
panes
panic
panned
pap
papaya
pares
park
part
pass
pass
passed
pat
path
paths
pats
Paul
pave
paved
paw
pawn
pawns
pay
pays
pea
peak
peal
peals
peanut
pear
pearl
pears
peas
peat
peck
pecked
pecks
peeked
peeks
peel
peeled
peels
peep
peeps
peer
peers
peewee
peg
pegged
pegs
pen
penned
pens
people
perk
pet
Pete
peter
piano
pick
picked
picks
pie
pier
pies
pig
piggy
pigs
pike
pile
piles
pill
pillow
pills
pilot
pin
pine
pineapple
pined
pines
pinned
pins
pipe
piped
pipes
pirate
pit

pitcher
pits
pity
pizza
pocket
pod
pods
poise
poised
poke
poked
poker
pokes
pole
poles
policeman
polliwog
pond
pony
pooch
pool
pools
poor
pop
popped
poppy
pops
pop-up
pork
pose
posed
pot
potato
pots
pouch
pound
pour
poured
pours
pout
pouts
pub
puck
pucks
puff
puffed
puffs
pug
pull
pulls
pump
pun
puns
purr
purse
pussy cat
put
putt
puzzle

Appendix D

AP: Single word test stimuli for /k/ and /g/ in initial word position

cab
cabin
cabs
cad
cads
cage
caged
cake
caked
cakes
calf
calico
call
called
calls
calm
calves
came
camel
camp
camped
camp-
out
can
candy
cane
canes
canned
cans
cap
caped
capes
capped
caps
car
caramel
card
cards
care
cared
cares
cars
case
cased
cash
cashed
cast
cat
catch
cats
caught
cause
cave
caved
caves
chord
chords
coach
coached
coal
coarse
coat
coats
cob
cobs
cocoa
cod
code
codes
coil
coiled
coils
coin
coined
coins
coke
cokes
cola
cold
colt
comb
combed
combs
come
comes
comic
comp
con
cone
cones
conned
cons
coo
cooed
cook
cooks
cool
cooled
cools
coop
coops
coos
cop
cope
coped
copes
cops
cord
cords
core
cork
corks
corn
cost
cot
cots
couch
cough
coughed
coughs
could
course
cove
cow
cows
coy
coyote
cub
cubs
cud
cuff
cuffs
cup
cups
curb
curbs
curl
curls
curse
cursed
curves
cut
cuts
gab
Gabe
Gabe's
gabs

gag
gal
gala
gale
gales
game
games
gang
gangs
gap
gape
gaped
gapes
garb
gas
gash
gassed
gate
gates
gauge
gauged
gave
gavel
gay
gaze
gazebo
gear
get
getaway
gets
ghee
ghosts
gift
gill
gills
girl
girls
give
gives
go
goal
goalie
goals
goat
goats
gob
gobs
God
goes
going
gold
goldfish
gone
goo
good
goods
goof
goofs
goon
goop
goose
goosed
gore
gorilla
gosh
got
governor
gown
guess
guessed
guide
guides
guinea
pig
gull
gum
gums
gun
guns
guppy
Gus
gush
guy
guys
Kai
kale
Kate
Kate's
Kay
Kay's
keel
keen
keep
keeps
Keith
kept
kermit
key
keyed
keys
kick
kicked
kicks
kid
kids
kilt
Kim
kin
kind
king
kiss
kissed
kit
kite
kites
kitsch
kitsch
kook
Kyle
quiche

Appendix E

AP: Single word test stimuli for /k/ and /g/ in final word position

ache
alike
antic
atomic
awake
baby
duck
back
bag
bake
bark
basic
beak
bean-
bag
Beck
beg
bic
big
bike
black
bleak
block
bloke
bog
book
bowleg
brag
brake
break
brick
broke
brook
buck
bug
bulldog
cake
catalog
chalk
check
cheek
chic
chick
chilidog
choke
chuck
chug
clack
Clark
clerk

click
cloak
clock
clog
cluck
coke
cook
crack
crag
creek
croak
dark
deck
dig
dike
dock
dog
dog tag
drag
drake
drug
duck
dug
duke
eek
egg
fake
fig
flag
flake
fleck
flick
flock
fog
fork
funny
book
gag
gawk
gig
hack
hag
hawk
hotdog
hug
ick
Ike
Jack
jag

Jake
jerk
jog
joke
jug
kayak
keg
kick
Kirk
knack
knock
lack
ladybug
lag
lake
lark
leak
leg
lick
like
lock
log
look
luck
lug
lurk
Mac
magic
make
mark
meek
Meg
Mike
muck
mug
nag
neck
nick
nook
oak
pack
paper
bag
park
peak
peck
peg
perk
pick

pig
pike
pluck
plug
poke
polliwog
pork
puck
pug
quack
quake
quick
rack
rag
rake
Rick
rig
rock
rug
sag
sake
seek
shack
shag
shake
shark
sheik
shirk
shock
shook
shriek
shuck
sick
slack
sleek
slick
slug
snack
snake
sneak
snuck
snug
soak
sock
stack
stag
stake
stalk
stark
steak
stick
stock
stoke
stork
stuck
suck
tack
tag
take
talk
tea bag
teak
thick
thug
tic
tick
tock
took
track
trek
trick
trike
truck
tuck
tug
Turk
tweak
twig
tyke
vague
Vic
wag
wake
walk
weak
whack
wick
wig
work
wreck
yak
yike
yoke
yolk
yuck
Zack

Appendix F

JR: Single word test stimuli for /f/ and /v/ in initial word position

face
fad
fail
failed
fails
fair
fairy
faith
faiths
fake
fall
fans
far
fare
fared
farm
fast
fate
father
fats
fawn
Fay
faze
fear
feat
feeds
feel
feels
feet
feigned
feigns
fell
felt
fern
ferns
fib
fibbed
fibs
fig
fight
fights
file
fill
filled
fills
fin
final
find
fines
finger
fins
fire
fired
fires
firm
first
fish
fished
fit
fits
fizz
foal
foam
foams
fob
foe
fog
foil
foiled
fond
fool
fooled
fools
foot
football
for
ford
fore
fork
forks
forms
fought
foul
fourth
fudge
full
fum
fun
funny
funs
fur
fussed
fuzz
phase
phoned
phones
photo
vacation
vague
vain
vans
vapor
vase
vat
vat
veal
veal
vent
venus
vet
vic
victory
video
vie
vine
vines
violin
viper
visa
visit
vitamin
voice
volleyball
vote
vow
vow
vowed

Appendix G

JR: Single word test stimuli for /f/ and /v/ in final word position

above
alive
beef
beehive
believe
brave
calf
calve
cave
chafe
chef
chive
christmas
eve
clef
cliff
cough
cove
cuff
curve
cutoff
Dave
deaf
dive
dove
drive
eave
enough
eve
fire chief
five
fluff
gave
giraffe
give
glove
goof

grieve
grove
gruff
half
halve
heave
hive
hoof
huff
if
I've
Jeff
Jif
jive
kerchief
kickoff
knave
laugh
leaf
leave
live
loaf
love
move
muff
native
nerve
of
off
olive
pave
peeve
photograph
poof
puff
rave
relative

relive
roof
rough
safe
save
scuff
serve
shave
sheriff
shove
show-off
sieve
skiff
skydive
sleeve
sniff
staff
Steve
stiff
stove
stuff
surf
swerve
thief
thieve
thrive
tough
turf
waif
waterproof
wave
weave
whiff
wife
woof
wove

Appendix H

JR: Single word test stimuli for /k/ and /g/ in initial word position

cab
cabin
cabs
cad
cads
cage
caged
cake
caked
cakes
calf
calico
call
called
calls
calm
calves
came
camel
camp
camped
camp-
out
can
candy
cane
canes
canned
cans
cap
caped
capes
capped
caps
car
caramel
card
cards
care
cared
cares
cars
case
cased
cash
cashed
cast
cat
catch
cats
caught
cause
cave
caved
caves
chord
chords
coach
coached
coal
coarse
coat
coats
cob
cobs
cocoa
cod
code
codes
coil
coiled
coils
coin
coined
coins
coke
cokes
cola
cold
colt
comb
combed
combs
come
comes
comic
comp
con
cone
cones
conned
cons
coo
cooed
cook
cooks
cool
cooled
cools
coop
coops
coos
cop
cope
coped
copes
cops
cord
cords
core
cork
corks
corn
cost
cot
cots
couch
cough
coughed
coughs
could
course
cove
cow
cows
coy
coyote
cub
cubs
cud
cuff
cuffs
cup
cups
curb
curbs
curl
curls
curse
cursed
curves
cut
cuts
gab
Gabe
Gabe's
gabs

gag
gal
gala
gale
gales
game
games
gang
gangs
gap
gape
gaped
gapes
garb
gas
gash
gassed
gate
gates
gauge
gauged
gave
gavel
gay
gaze
gazebo
gear
get
getaway
gets
ghee
ghosts
gift
gill
gills
girl
girls
give
gives
go
goal
goalie
goals
goat
goats
gob
gobs
God
goes
going
gold
goldfish
gone
goo
good
goods
goof
goofs
goon
goop
goose
goosed
gore
gorilla
gosh
got
governor
gown
guess
guessed
guide
guides
guinea
pig
gull
gum
gums
gun
guns
guppy
Gus
gush
guy
guys
Kai
kale
Kate
Kate's
Kay
Kay's
keel
keen
keep
keeps
Keith
kept
kermit
key
keyed
keys
kick
kicked
kicks
kid
kids
kilt
Kim
kin
kind
king
kiss
kissed
kit
kite
kites
kitsch
kitsch
kook
Kyle
quiche

Appendix I

JR: Single word test stimuli for /k/ and /g/ in final word position

ache
alike
antic
atomic
awake
baby
duck
back
bag
bake
bark
basic
beak
bean-
bag
Beck
beg
bic
big
bike
black
bleak
block
bloke
bog
book
bowleg
brag
brake
break
brick
broke
brook
buck
bug
bulldog
cake
catalog
chalk
check
cheek
chic
chick
chilidog
choke
chuck
chug
clack
Clark
clerk
click
cloak
clock
clog
cluck
coke
cook
crack
crag
creek
croak
dark
deck
dig
dike
dock
dog
dog tag
drag
drake
drug
duck
dug
duke
eek
egg
fake
fig
flag
flake
fleck
flick
flock
fog
fork
funny
book
gag
gawk
gig
hack
hag
hawk
hotdog
hug
ick
Ike
Jack
jag
Jake
jerk
jog
joke
jug
kayak
keg
kick
Kirk
knack
knock
lack
ladybug
lag
lake
lark
leak
leg
lick
like
lock
log
look
luck
lug
lurk
Mac
magic
make
mark
meek
Meg
Mike
muck
mug
nag
neck
nick
nook
oak
pack
paper
bag
park
peak
peck
peg
perk
pick

pig
pike
pluck
plug
poke
polliwog
pork
puck
pug
quack
quake
quick
rack
rag
rake
Rick
rig
rock
rug
sag
sake
seek
shack
shag
shake
shark
sheik
shirk
shock
shook
shriek
shuck
sick
slack
sleek
slick
slug
snack
snake
sneak
snuck
snug
soak
sock
stack
stag
stake
stalk
stark
steak
stick
stock
stoke
stork
stuck
suck
tack
tag
take
talk
tea bag
teak
thick
thug
tic
tick
tock
took
track
trek
trick
trike
truck
tuck
tug
Turk
tweak
twig
tyke
vague
Vic
wag
wake
walk
weak
whack
wick
wig
work
wreck
yak
yike
yoke
yolk
yuck
Zack

Appendix J

MD: Single word test stimuli for /t/ and /d/ in initial word position

dab	dot	tee
dad	doug	teen
dam	dough	ten
dan	dove	tick
date	doze	tie
day	duck	tiff
deaf	dud	till
deal	dude	tin
deb	dues	tip
deck	dug	to
dee	duke	toad
deep	dull	toe
dell	dump	toll
den	dune	tom
dice	dutch	ton
did	dye	tone
dig	tab	too
dill	tack	tool
dim	tad	tooth
dime	tag	top
dine	tail	tore
dip	take	toss
diss	tall	tot
do	tame	touch
doe	tan	tow
dog	tap	toy
doll	tart	tub
dome	taught	tuck
done	tax	tug
door	tea	tune
dope	tear	turn
dose	ted	two

Appendix K

MD: Single word test stimuli for /t/ and /d/ in final word position

ad
at
ate
bad
bead
bed
bid
bit
bite
bode
boot
bud
cad
cat
coat
cod
code
dad
deed
did
dot
dud
eat
ed
fad
fade
fat
fed
feed
feet
foot
gad
gate
goat
good
got
guide
had
hat
heat
hide
hood
hot
jade
jet
kate
kid
kite
knit
lad
laid
late
lead
lid
lied
light
lit
load
loot
mad
mat
meet
met
moat
mod
nead
net
nod
nut
oat
pad
pet
pod
rat
red
rid
rod
sad
seed
side
sit
soot
suit
tight
toad
toot
tot
tote
vat
vet
vote
weed
wet
wheat
wide
wood
yacht
yet

Appendix L

MD: Single word test stimuli for /s/ in initial and final word positions

ace
base
bess
boss
bus
case
cell
cite
dice
dose
face
fuss
gas
geese
goose
guess
gus
hiss
house
ice
juice
kiss
lace
lass
lease
less
loose
mass
mess
mice
miss
moose
moss
mouse
nice
niece
noose
pace
pass
peace
race
rice
ross
sad
safe
sag
sail
sake
salt
sam
same
sane
sap
sat
save
saw
say
seam
seat
see
seed
seem
seen
seep
sell
set
sid
side
sigh
sign
sill
sin
sing
sip
sit
so
soak
soap
sob
sod
sole
soo
soon
soot
sop
soul
soup
soy
sub
suck
thus
toss
us
vase
vase
vice
voice
yes

Appendix M

MD: Single word test stimuli for /z/ in initial and final word positions

bees
boos
boys
buys
buzz
clause
cloze
clues
cruise
czar
days
dies
doze
draws
dries
dues
fees
fizz
flaws
fleas
flees
flies
foes
fuzz
gauze
glows
his
hoes
jaws
jays
knees
lays
pause
pays
peas
pies
she's
shies
shoes
shows
sieze
sighs
tease
ties
toes
vies
vows
ways
weighs

whizz
whose
zack
zag
zag
zane
zany
zap
zapped
zeb
zebra
zebu
zed
zee
zek
zeke
zelda
zeng
zenith
zero
zeros
zest
zest
zeta
zeus
ziff
zinc
zion
zip
zipper
zippy
zips
zircon
zither
zits
zoe
zombie
zonal
zone
zone
zoned
zoom
zoom
zoom
zoomed
zooms
zoot
Zorro
Zounds