ABSTRACT

An abstract of the thesis of Anita Kay Jensen for the Master of Science in Speech and Hearing Sciences presented June 1, 2005.

Title: Effects of Integral Stimulation Therapy on Speech Intelligibility of a Child Diagnosed with Childhood Apraxia of Speech.

CAS is considered a neurological motor speech disorder based in a deficit of programming and planning of speech movements, and is not attributed to any physical limitations of the speech musculature. Its presence is suggested when 8 out of 11 speech and non-speech characteristics are observed during speech production, and is marked by poor progress in therapy. Given the limited number of efficacy studies on the treatment of CAS, clinicians face the enormous challenge of implementing efficacious treatment. Movement researchers emphasize the importance of addressing the cognitive motor learning of specific muscle movements for motor disorders. Of the various treatment approaches used to treat CAS, the Integral Stimulation approach is grounded in the cognitive motor learning principles, and accounts for the learning of speech movements.

It is critical that speech language pathologists use effective and evidence-based therapy approaches when treating motor speech disorders such as CAS. To
date, efficacy data on motor planning deficits in children and efficacy studies on
treatment of CAS are limited.

The purpose of the present study was to examine the effectiveness of
Integral Stimulation approach as a treatment for CAS. It examined changes in
speech intelligibility over the course of each treatment session through calculation
of percent accuracy of total phonemes produced, total vowels produced, and total
consonants produced.

One 10-year-old boy previously diagnosed with CAS and met speech
behavior criteria for CAS received parental permission to participate in this study.
He attended therapy sessions twice weekly for 50-minutes sessions. Speech targets
/s, z, ʃ/ were selected as speech targets for intervention. Data was obtained through
speech probes administered each session for 30 sessions.

Changes in speech intelligibility were noted as an increase in accuracy of
consonants, vowels, and total phonemes. Progress and charted over time. An
increase was observed in accuracy of /s, z/. Inconsistent accuracy was observed in
production of /ʃ/. Overall intelligibility increased by 5% across total phonemes,
vowels, and consonants between analyses of pre- and post-treatment speech
samples. These results suggest that cognitive motor learning occurred, and that
Integral Stimulation is an effective treatment approach to use in treatment of CAS.
EFFECTS OF INTEGRAL STIMULATION THERAPY ON SPEECH

INTELLIGIBILITY OF A CHILD DIAGNOSED WITH

CHILDHOOD APRAXIA OF SPEECH

by

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INTRODUCTION

Childhood apraxia of speech (CAS) is considered a lifelong communication disorder. With therapy, the individual with CAS will strive to achieve a higher level of intelligibility, although persisting errors in speech, language or prosody are likely. It is not thought to be a disorder from which one recovers – rather, it may be minimized to a limited extent, but not altogether eliminated (Hall, 2000). Generally considered a motor speech disorder of neurologic origin, CAS is characterized by difficulty in planning and programming voluntary speech movement sequences that result in speech production. In other words, children with CAS have difficulty “telling” their articulators where to move to produce speech.

Several defining characteristics of CAS are shared by other speech disorders such as phonological disorders. These include high frequency of substitutions and omissions, inconsistent errors of articulation, difficulty sequencing sounds, However, CAS is suspected when several “cluster symptoms” present in the articulation, phonation and prosody of speech, such as difficulty executing volitional oral movements, inconsistent consonantal and vowel errors, or distorted prosody. Hallmarks of CAS also include slow response to therapy over time and slow generalization of improvements made in therapy to conversational speech (Davis, Jakielski, & Marquardt, 1998), which help differentiate it from other severe speech disorders.
While the etiology of CAS is undetermined, research has suggested that the disorder’s origins lie within neurological functions and result from “impairment at one or more of the levels of motor processing” (Caruso & Strand, 1999, p. 17). Cognitive impairment or physical limitations of the articulatory, phonatory, or resonatory systems are not contributing factors of apraxic speech. As with other articulation disorders, several factors contribute to the prognosis for individuals with CAS: a) the severity of impact on their speech intelligibility, b) the age at which intervention is begun, and c) the effectiveness of the treatment applied.

What is effective, appropriate treatment for CAS? Those who define CAS as a motor speech disorder suggest that cognitive motor learning principles should lay the foundation for treatment to increase motor learning skills through repetitive practice of speech movements. Individuals with CAS have been noted to achieve greater automaticity of speech movement sequences when provided with multiple opportunities to practice processing the articulatory movements found to be most difficult. According to Strand and Skinder (1999), the principal objective of treatment for CAS is to provide multiple opportunities for the child to practice specific speech movement sequences that are difficult to produce voluntarily. Practice of these movement patterns should be systematic, hierarchical and repetitive. Following this design, the nervous system has the opportunity to practice sensorimotor speech processing, and ultimately bring about permanent changes in cognitive motor skills. It is thought that this type of methodical practice in repetition will lead to automaticity of motor processing skills (Strand, 1995).
Integral stimulation is one approach used to treatment motor speech disorders such as limb apraxia, acquired apraxia of speech in adults, severe speech disorders and CAS. It is grounded in the four principles of cognitive motor learning: precursors to motor learning, conditions of practice, knowledge of results, and the influence of rate in speech. Strand and Skinder (1999) maintain the overall goal of integral stimulation is to approximate or correct target utterances by providing numerous opportunities to practice specific speech movement gestures. It is a hierarchical, “bottom up” treatment approach that initially targets the simplest syllable shapes and gradually works through more complex forms which increase in length and linguistic complexity. Integral stimulation also maximizes the modalities used in treatment. A distinctive feature to integral stimulation is the use of a “watch me and listen to me” strategy, in which the client imitates the clinician after attending to auditory and visual models of the targeted production. These cues are provided maximally at the beginning of treatment, and are gradually faded during treatment as the client successfully produces target utterances.

To date, efficacy data on motor planning deficits in children and efficacy studies on treatment of CAS are very limited (Caruso & Strand, 1999; Marquardt & Sussman, 1991; Pannbacker, 1988; Strand & Debertine, 2000; Strand & Skinder, 1999). The majority of the studies examining treatment efficacy are case studies, and cannot claim with confidence that changes in the children’s speech production were attributable to the treatment approach employed (Strand & Skinder, 1999). Within the body of existing literature that examines treatment approaches used in
treatment of CAS, differences in subject selection criteria have made it difficult to determine exactly why a specific treatment approach was employed (Marquardt & Sussman, 1991). More scientific evidence is needed in this area to determine which treatment approaches best meet the needs of motor planning and processing deficits such as CAS.

The present study examined the efficacy of CAS in light of its etiology, defining characteristics, and various treatment approaches used in speech therapy for children with CAS.
LITERATURE REVIEW

The determination of an effective treatment approach for CAS first requires an understanding of the nature of the disorder. As with treating any communication disorder, it is crucial that the clinician has a firm grasp on the etiology and behavioral characteristics of the disorder, along with an understanding of the theoretical underpinnings that drive the various treatment procedures proposed. This literature review will discuss the etiology of CAS – and its ambiguity – its speech characteristics, and the principles of cognitive motor learning which support the use of integral stimulation as an appropriate articulatory treatment for children with CAS.

CAS is considered a neurologically motor-based speech disorder (Crary, 1993), resulting in the difficulty of producing volitional oral movements for speech which is not attributable to weakness or paralysis of speech musculature. Controversy has surrounded the specific neurological processes involved – is CAS due to impairment at the level of motor processing, or is it linguistic in nature? Researchers and clinicians such as Crary (1993), Hall, Jordan and Robin (1993), and Caruso and Strand (1999) hypothesize that CAS is due to an impairment at one of more levels of motor processing. Others maintain that CAS is a disorder phonological in nature, and results from the inability to create and access abstract representations of the individual phonemes, syllables and segments which comprise words (Gierut, 1998). As children with CAS demonstrate language deficits and many speech characteristics consistent with phonological disorders, many
researchers believe CAS stems from phonological impairment and is linguistic in nature (Aram & Nation, 1982; Ekelman & Aram, 1983).

Caruso and Strand (1999) emphasize the importance of clinicians’ etiologic considerations when making treatment decisions involving suspected CAS. The clinician’s view of the nature of a disorder largely determines the stimuli selected, the approach taken, and outcomes of treatment. The great difficulty in making a distinction between the two proposed underlying etiologies of CAS is that the inner workings for speech involved are immeasurable and unobservable; consequently, it is “difficult to isolate linguistic from motoric contributions to articulation difficulties in children” with suspected CAS (Forrest & Morissette, 1999, p. 188). Adding to this is yet another dimension, the age of onset. CAS occurs while the individual is still acquiring language skills. Crary (1993) suggests that due to the interaction between the impaired motor processes and phonological processes during this developmental period, the phonological processes may be affected; thus, a child with CAS may have characteristics that overlap with phonological disorders.

Researchers have sought to isolate specific definitive speech errors that would differentiate CAS from phonologically-based articulation disorders. Thoonen, Maassen, Gabreëls and Shreuder (1994) examined consonant errors of children with suspected CAS and children with typically developing articulation skills. By conducting a feature analysis across voice, place and manner of articulation of substitution errors within both groups, their findings indicated that
place of articulation was the feature least frequently retained in substitutions made by the CAS group, which presumably differentiated it from the control group. Thoonen et al. (1994) concluded these errors were associated with phonological encoding, as cited in Levelt (1989), and thus were diagnostically significant; the errors were not attributed to a deficit in phonological representation. These findings would be of diagnostic significance if they were replicable, but a following study conducted by Forrest & Morissette (1999) led to contrary findings. Children with phonological disorders were also found to retain place of articulation least frequently in substitution errors. Discrepancies within subject selection and research methodology and the ambiguous nature of the disorder contribute to the inability to replicate such results (Forrest & Morissette, 1999).

Due to the lack of consensus on differential diagnostic characteristics and lack of convergence on theoretical perspective, differential diagnosis of CAS is considered difficult at best (Davis et al., 1998). Because of this ambiguity, the prevalence of the disorder remains unknown (Forrest, 2003; Pannbacker, 1988), though it is estimated that 5% of the population receiving speech therapy services for speech disorders are affected by CAS (Shriberg, 1994). The ensuing issue, that children are diagnosed with CAS and treated by speech-language pathologists (SLPs), in spite of diagnostic ambiguity, was explored by Forrest (2003). In her study, Forrest examined 50 total characteristics indicated by 75 practicing SLPs as diagnostic criteria used in establishing diagnosis of CAS. The results of the study concluded that there was “little congruence across SLPs in the characteristics that
they use to diagnose (CAS)” (p. 378). Though many participants indicated that inconsistency in speech productions was one of the more salient characteristic of CAS, the variety of responses and the occasional contradictions were reflective of the ambiguous nature of the disorder. Results of Forrest and Morrisette’s study are characterized as “purely descriptive” (p. 379), due to the delivery of instructions, variability of knowledge and experience of participants in working with CAS, and subject selection methods. However, valuable insight was gained regarding how current SLPs view and diagnose the disorder. Replication of this research is needed to explore the diagnostic criteria for CAS.

Though controversy surrounds CAS regarding diagnostic markers that could determine differential diagnoses, clinicians frequently classify and measure characteristics of CAS along the following general parameters: a) speech characteristics, b) non-speech characteristics, and c) prosodic characteristics. Speech characteristics may include a limited phonemic repertoire; frequent omissions; frequent consonant and vowel errors; difficulty sequencing sounds and syllables in words; incorrect voicing of speech sounds; and use of simple syllable shapes, to name a few (Caruso & Strand, 1999; Davis et al., 1998; Davis & Velleman, 2000). Non-speech symptoms may include poor diadochokinetic rates; general awkwardness; low performance on oral sensory tests; difficulty with volitional or imitative oral movement; and limited awareness of speech deficits (Robin, 1992; Yorkston, Beukelman, & Strand, 1999). Receptive language in children with suspected CAS has been observed to be within normal limits, but
their expressive language falls far behind due to the uncoordinated fine motor movements of the articulators and variable articulatory performance inherent in CAS (Hall, 2000). Prosodic deficits in children’s speech are identified as inappropriate stress in sounds, syllables and segments; inappropriate inflection of speech; variable rate which is typically fast; lack of variation in vocal pitch; limited range of intensity of speech; and variation of resonatory qualities of speech (Yorkston et al., 1999).

CAS is suggested when children present 8 out of 11 speech and non-speech characteristics in the absence of paralysis or weakness of the speech musculature (Davis et al., 1998). The speech characteristics these authors identify include reduced phonemic repertoire; frequent omission errors; frequent vowel errors; inconsistent speech errors; increased errors in longer utterances; difficulty in imitating words and phrases; excessive use of simple syllable shapes; and distorted suprasegmentals. Non-speech characteristics include difficulty with volitional oral movements; lower performance in expressive language as compared to receptive language; and reduced diadochokinetic rates (Caruso & Strand, 1999). It is essential to note that although deficits in speech and non-speech characteristics may overlap for children with suspected CAS and children with other speech disorders, prosodic deficits and slow progress in therapy are key among the most distinctive characteristics that aid in identification of suspected CAS.

The question remains, how do clinicians make treatment decisions when etiology is still undetermined? Clinicians may base their etiological perspective on
two considerations: the similarities in observable characteristics between CAS and its symptomatic cousin, acquired apraxia of speech, or AOS; and clinical observations of the interaction between suspected CAS and varying treatment approaches. For decades, AOS has been believed to be caused by “disruption in the planning and programming of voluntary, complex motor activity for speech production” (Caruso & Strand, 1999, p. 14), which results from neurologic damage brought on by stroke, tumors, or trauma to the head. Like CAS, AOS has been termed a motor speech disorder, and is defined by many as difficulty in the planning or programming of movement for speech, although movement of the same musculature for non-speech tasks is normal (Yorkston et al., 1999). Also akin to CAS, acquired apraxia is observed as disturbances in articulation and prosody of speech, with many of the same speech errors: (a) inconsistent speech errors, (b) difficulty with longer utterances, (c) vocalic errors, (d) difficulty with executing articulatory sequences, and (e) groping behaviors, to name a few (Caruso & Strand, 1999). Though the age of and circumstances surrounding onset of both CAS and acquired apraxia differs, these similarities cannot be dismissed.

Clinicians may also gain perspective on etiology of CAS in light of how suspected CAS interacts with approaches already documented in its treatment. Several treatment approaches used with CAS were based on the clinical work and positive treatment results in AOS in adults. Rosenbeck (1978) maintained that “the best rule is to use what works most efficiently.” The following therapy approaches
utilized in the treatment of AOS have also been found by many researchers to be of value in treating CAS include the use of (a) simple syllable shapes, (b) slow rate, (c) concentration on movement performance drill, (d) hierarchical cues that are faded over time, (e) multiple modalities, such as auditory, visual and tactile cues, (f) self-monitoring skills, (g) practice of speech sound combinations instead of isolated phonemes, (h) intonation and prosody, and (i) emphasis on opportunity for much practice (Pannbacker, 1988; Strand, 1995). Following Rosenbeck’s rule of thumb, rule-based phonology or auditorily-based therapy approaches have not been recommended as effective treatment techniques, as they have yielded little results in treatment of suspected CAS by numerous researchers (Darley, Aronson, & Brown, 1975; Pannbacker, 1988; Powell, 1996; Rosenbeck, Hansen, Baughman, & Lemme, 1974).

It has also been suggested that therapy approaches used for AOS follow treatment principles applied in the field of limb motor control and learning, as related to the reacquisition, retention, and generalization of speech skills. Citing Schmidt and Lee (1999), Ballard (2001) examined the principles of practice and feedback, and reiterated their influence in the successful acquisition and retention of speech motor tasks. She concluded that repetitive practice of isolated motor skills results in better acquisition, and randomized practice of several motor targets result in better retention and transfer of motor skills. A higher number of practice repetitions during treatment sessions, ideally 50 or more, facilitates greater learning of speech motor and limb motor movements. Types of feedback are also influential
in successfully relearning and retaining motor skills. Specific feedback that
describes what was done in the execution of a motor task is helpful when delivery
occurs during the early stages of learning motor skills. Feedback that informs an
individual of the accuracy of his motor skills promotes long-term retention of the
skill. However, the feedback schedule may inhibit motor learning if given
immediately following execution of a motor skill, as it may interrupt the self-
evaluation process and preclude motor learning. It was emphasized that these
principles serve as a guide when planning treatment, and “do not dictate the
treatment protocol applied, but rather how the protocol is applied” (p. 13).

These principles are evident in one approach applied in treatment of AOS,
which utilizes multiple modalities to elicit target sounds. The Sound Production
Treatment approach (Wambaugh, 2001), or SPT, was devised to address speech
ersors in individuals with AOS. Hierarchical in design, this technique utilizes
sequential steps to follow when speech errors occur. It elicits maximum number of
repetitions, delivers specific types of feedback, and facilitates articulatory
placement cueing, integral stimulation practices (“Watch me, listen to me”), and
minimal pairs contrast during treatment sessions. Results yielded with SPT in
treatment of apraxic adults have been positive, and indicate that SPT may facilitate
acquisition, retention and generalization of treatment targets to untreated speech
sounds.

It has been noted that treatment approaches utilizing multiple input
modalities are more effective in treating CAS (Marquardt & Sussman, 1991;
Pierce, 1991). Numerous treatment techniques developed with the intent to give the child a variety of avenues by which to process stimuli have been utilized for decades. Young and Hawk’s Motokinesthetic Approach (1955) focused on improving articulation through the use of clinician-provided tactile and auditory cues and actual manipulation of the articulators to achieve accurate placement and movement of the articulators. Similarly, McDonald’s Sensorimotor Approach (1964) utilized proprioceptive feedback in addition to auditory and tactile cues. Tactile and auditory cues, in the form of rhythmic tapping and prosodic changes are utilized in Melodic Intonation Therapy (Helfrich-Miller, 1984). Prompts for Restructuring Oral Muscular Phonetic Targets, or PROMPT (Chumpelik, 1984) focuses on increasing motor control in production of individual phonemes by delivering external, tactile prompts to the face and lower chin.

While these techniques may have achieved some degree of success in the remediation of speech errors in CAS, they lack the fundamental premise considered paramount in treating motor speech disorders: they may emphasize the practice of isolated phonemes or movement patterns, but do not account for the learning of these movement patterns. A primary goal for treatment of CAS is to improve the motor learning that lends automaticity to speech motor performance, which occurs through systematic, repetitive practice of transitioning between difficult articulatory configurations, not through treatment in production of isolated phonemes (Caruso & Strand, 1999; Strand, 1995). This type of motor learning is considered crucial to
the treatment of motor speech disorders, and occurs when treatment adheres to
the principles of cognitive motor learning.

For clinicians who treat motor speech disorders, it is necessary to review the
principles of cognitive motor learning to gain insight before making treatment
decisions. As defined by Schmidt (1988), cognitive motor learning is “a set of
processes associated with the practice or experience leading to relatively permanent
changes in the capability for responding” (p. 346). In other words, it is the process
of acquiring the capability for performing skilled behaviors or actions. Cognitive
motor learning results from direct practice or experience, and does not occur
through typical developmental maturation, inspiration or instruction. The process
of cognitive motor learning is not observable; therefore, it is inferred that the
learning has taken place through repeated observation and documentation of
changes. Relatively permanent changes in an individual’s potential to produce
skilled actions are also a result of cognitive motor learning (Magill, 1998; Rose,
1997; Schmidt, 1988).

Cognitive motor learning is influenced by several factors: precursors to
motor learning; conditions of practice; knowledge of results; and influence or rate
on speech. In treating motor speech disorders, it is important to bear in mind these
four principles as they lay the foundation for increasing one’s potential for
cognitive motor learning, and provide the clinician with direction when making
decisions about treatment procedures (Caruso & Strand, 1999).
Precursors to cognitive motor learning, the first principle of motor learning, encompass what the child brings to treatment before therapy has begun. This includes the child’s own level of motivation to work on speech and his or her trust in the clinician. Also important is the child’s ability to maintain focused attention on speech tasks. Children with CAS experience greater difficulty in allocating the resources necessary to successfully produce difficult speech movements (Caruso & Strand, 1999). If the processing demands of treatment stimuli exceed a child’s processing capacity, failure is imminent and the child’s motivation level may be diminished. Therefore, it is crucial for clinicians to be cognizant of a child’s processing capacity when selecting the type and number of treatment stimuli for therapy (Strand, 1995).

The second principle of motor learning, conditions of practice, guides the clinician in treatment design. Conditions of practice include several factors. One factor, prepractice, involves informing the child of what is to be done in treatment and why it is important. Another factor, repetitive practice, occurs through the child’s imitation of clinician-provided models and instruction of selected speech tasks. Repetition is one key aspect to treatment of CAS, as with other motor-based disorders, in that motor learning occurs through experience, or practice, of the targeted motor tasks. The key to repetitive practice is that the learner gains practice retrieving the information necessary to execute a specific motor task (Schmidt & Wrisberg, 2004). For motor speech disorders such as CAS, the foci of treatment are combinations of speech sounds that are difficult for the child to produce.
accurately and consistently. Thus, it is essential that the child be provided with numerous opportunities for practice of these movement patterns in the context of speech.

The third condition of practice is the issue of blocked versus random practice. Blocked practice involves concentrated practice of speech movements in a specific phonetic context in which a specific movement is practiced in uninterrupted repetition in one session or block of time. For instance, a child who has difficulty producing initial /s/ in c-v-c words might practice saying the word "sat," for an unbroken stretch of time before moving on to the word "said." Practice of each word is uninterrupted and concentrated solely on the production of that word in the controlled phonetic context of each word. Random practice involves the practice of a variety of speech movements that are practiced within the same block of time, and the order in which they are practiced is varied. In the case of this example, a child who has difficulty with initial /s/ in c-v-c words might randomly rotate practice between multiple c-v-c words that begin with /s/. The child is challenged to focus on producing the correct sound in a variety of phonetic contexts.

It has been commonly accepted that in the improvement or refinement of a specific motor task, it is necessary to maintain a concentrated, uninterrupted and repetitive practice of the targeted skill, without variation in the skills being practiced or in the practice environment altogether. This is seen in non-speech tasks in the practice of sports, dance and instrumental music. For instance, in
basketball, a player may practice a free-throw repeatedly until the player is able
to execute the free-throw with consistency, making the basket each time the ball is
thrown. The theory of this type of practice leads one to believe that the player will
be prepared to make a free-throw shot during an actual game. Against conventional
thought is that blocked practice will lead to improved performance during an actual
game; in fact, it does not.

Although a random practice schedule yields lesser performance on targeted
motor tasks in the initial stages of practice, it actually leads to greater motor
learning than a blocked practice schedule (Schmidt & Wrisberg, 2004; Strand &
Skinder, 1999). It is believed that the contextual nature of a random practice
schedule – unvaried and controlled versus varied at random – enables the
individual to practice retrieving the information necessary to complete the motor
tasks; thusly, the individual has the ability to perform better under varying
conditions. In the instance of a basketball player practicing free-throws in a
concentrated manner, a player may be able to make several shots when performing
in that context only; conversely, during a game, the player may not seem as adept at
making the shot because the practice environment was not congruent with the game
environment. This suggests that in relation to treatment of CAS, the cognitive
motor learning of targeted speech movements may be better facilitated by
practicing those movements in a varied phonetic context. For instance, a child who
is targeting the articulatory movements necessary to produce initial /st/ clusters in
words such as “stop” or “stay” may yield greater cognitive motor learning by practicing those sounds in sentences, rather than practicing them in isolated words.

Movement researchers have determined that although blocked practice of motor tasks will result in better initial motor performance, it does not result in greater motor learning of the skill (Schmidt & Wrisberg, 2004). In a landmark study on motor learning and performance, Shea and Morgan (1979) reported that when individuals practiced three specific hand and arm movements in a blocked manner, they showed greater performance of the motor skills compared to the group who practiced the hand and arm movements at random. However, the group who practiced the movements at random showed greater retention of and better motor learning of the specific movements. Such findings have been replicated in similar studies in a variety of settings (Ballard, 2001; Lee & Magill, 1983; Schmidt & Wrisberg, 2004). In relation to treatment of CAS, this may suggest that speech treatment targets may be better practiced in a randomized fashion rather than in blocks of uninterrupted repetitions. Clinicians might not see the increased performance on treatment targets when approached in this manner, but the level of retention of the target skills and level of cognitive motor learning is increased when targets are randomized throughout the session.

These findings generate profound implications in the treatment of CAS for they help determine both treatment stimuli and how treatment is implemented in therapy. Blocked practice results in faster acquisition and improved performance initially of a speech movement in specific phonetic contexts, and is useful in
facilitating performance of newly acquired skills (Schmidt & Wrisberg, 2004). It is more congruent with traditional articulation therapy practice and may yield better performance on targeted sounds or words in sounds during a treatment session, but may not be facilitative of target sounds in a client’s natural speech once he exits the treatment environment. Generalization of the speech movement does not occur with blocked practice because motor learning has not been achieved. Random practice yields the opposite results: motor learning occurs at a slower rate and shows improved generalization effects. The challenge to clinicians is to determine what practice schedule best suits a client’s level of acquisition, and to appropriately plan treatment according to that schedule.

Rather than assuming a traditional approach to treating disordered sounds and practicing isolated sounds or specific words contiguously, treatment of CAS should focus on practicing specific speech movements in varied phonetic contexts, which more closely resembles speech in a natural context. This will help to better facilitate the motor learning of that specific speech movement or movement combinations, and may lead to generalization of the skill into other speech contexts (Strand & Skinder, 1999).

Movement researchers have also studied is the effects of duration and frequency of practice sessions on cognitive motor learning and performance (Magill, 1998; Rose, 1997; Schmidt, 1988; Schmidt & Wrisberg, 2004). Two practice schedules have been examined: mass practice and distributed practice. Mass practice entails the prolonged practice sessions with fewer opportunities for
rest between the practices of targeted movements. A mass practice schedule might appear as one 60-minute practice session per week. Distributed practice involves shorter practice sessions with more opportunities for rest between the practices of targeted movements. In comparison to mass practice, a distributed practice schedule might appear as two 30-minute practice sessions per week (Magill, 1998; Schmidt & Wrisberg, 2004). Research has shown that when learning a continuous motor task, one that may involve physical fatigue after prolonged repetitions, a distributed practice schedule results in increased cognitive motor learning. Two possible reasons for this difference in learning is that when an individual has more rest time in between practice sessions, the practice is less tedious and they attend more to their motor learning. Also, by distributing their practice sessions so there is less time between sessions, the individual has the opportunity to relearn the skill more often, thus increasing the amount of cognitive motor learning (Schmidt & Wrisberg, 2004). Speech, as a continuous motor task, is better approached in therapy in a distributed practice schedule. Researchers of CAS (Strand & Skinder, 1999) and other speech disorders (Ruscello, 1993) discuss that in terms of retention of speech motor skills, a distributed practice schedule allows a child more opportunities to practice drawing the speech motor skills learned from memory, thus increasing their cognitive motor learning.

Another factor essential to conditions of practice is the variability of practice conditions. Varied practice involves alteration of practice conditions such as environment and rate. It has been shown to increase motor learning and
generalizability, the ability to apply the motor learning to new situations or new environments (Schmidt, 1988). In relation to treatment of CAS, the alteration of prosody, stress, and volume of treatment stimuli during practice increases one’s experience in applying the motor learning of specific articulatory gestures in a variety of conditions and contexts. Varied practice of this type is critical when considering the variable nature of the communication environment, as change in communication partners, emotional states, and environmental conditions may necessitate a variation of prosody, rate and volume (Strand & Skinder, 1999).

The third principle of motor learning concerns the extrinsic feedback a person receives when learning a motor skill. Extrinsic feedback is important for individuals who are gaining cognitive motor learning skills, especially if their ability to supply intrinsic feedback is impaired. According to Magill (1998), extrinsic feedback serves two purposes in cognitive motor learning: to help the individual achieve his or her goal and determine what made them successful, and to inspire the learner to continue working towards his or her goal. The specific types of feedback referred to in cognitive motor learning literature are knowledge of results versus knowledge of performance. Knowledge of results is feedback on the accuracy of an intended movement, without comment on the quality of the movement. In contrast, knowledge of performance describes how one performed the movement and provides specific information on the quality of the movement (Magill, 1998; Rose, 1997; Schmidt & Wrisberg, 2004). Feedback of both types is useful, but the challenge is to achieve a balance between too much and not enough.
feedback for the learner to maintain motivation to continue striving towards his or her goal (Schmidt & Wrisberg, 2000). A learner may intrinsically know he performed a task incorrectly; however, telling him so will not necessarily add to their learning of the targeted movement. Too little feedback may hinder one’s ability to successfully achieve a motor task; and too much feedback could contribute to a diminished motivation to continue work on the skill (Schmidt & Wrisberg, 2004).

Extrinsic feedback is central to the correction of speech production of children with CAS, as it has been shown to be an integral aspect of motor learning (Strand, 1995). More so, the type of extrinsic feedback used in treatment of CAS has a direct impact on the performance and repairs of targeted speech tasks. If a child is told, “That was not right,” after he incorrectly produced a final /k/ in “duck,” he is given information on the accuracy of his speech production. When giving this type of feedback – identification of correct and incorrect productions – it should immediately follow the utterance to benefit motor learning. In contrast, if the clinician states “You made the end-sound /k/ in the front of your mouth,” the child is given qualitative information on the articulatory movements to produce the final /k/ sound in the word “duck.” The specificity of this type of response is useful to clients in therapy to understand how their speech errors are made and generate greater awareness of their speech production (Yorkston et al., 1999).

Both knowledge of results and knowledge of performance are important, in that they can be motivating and instructive when implemented appropriately.
Feedback of both types is important in treating CAS, but timing and balance between the two types of feedback is equally important. Knowledge of performance has been shown to be most effective when delivered during the acquisition phase of cognitive motor learning (Ballard, 2001), due to its specific nature. Knowledge of results is not as instructional as knowledge of performance, and may be redundant or not beneficial due to its lack of specificity. It has been shown to be ineffective in increasing motor learning when it is given too frequently, such as after every trial; therefore it should be given intermittently (Strand, 1995; Strand & Skinder, 1999; Yorkston et al., 1999). Though too much qualitative feedback can also be overwhelming, knowledge of performance has been shown to increase cognitive motor learning, and is found to be more useful in natural environments (Schmidt & Wrisberg, 2004).

The influence of rate is the fourth principle of motor learning. The reduction in rate of speech has been observed to affect several parameters of speech production. In cases of CAS, slower speech allows the speaker more time to program and perform speech movements, receive greater proprioceptive feedback, and achieve greater precision of speech movements executed. The negative result of reducing rate of speech is the potential loss of natural speech regarding rate and prosody.

Treatment of motor speech disorders must satisfy the tenets of cognitive motor learning (Caruso & Strand, 1999; Strand, 1995; Strand & Skinder, 1999; Yorkston et al., 1999). Integral stimulation is one such treatment approach that is
based on these principles and grounded in the theory of cognitive motor learning (Strand & Skinder, 1999). It is perhaps one of the most widely-used approaches in treating speech disorders in children (Strand & Skinder, 1999). A multi-modal approach, integral stimulation utilizes auditory, visual and tactile cues that are presented maximally and faded over time to foster greater independence and automaticity of speech motor skills. The practice of speech sounds and behaviors occurs at the syllable, word segment, word, phrase and sentence-level. It incorporates elements of rate and prosody, and aims to build self-monitoring skills of speech production.

The issues of practice, mass versus distributed practice schedules, knowledge of performance and issues of rate, all principles of cognitive motor learning, are specifically addressed by the approach’s design. Repetitive practice is key to integral stimulation (Strand & Skinder, 1999); the clinician provides maximum opportunities for the child to practice the articulatory gestures that are problematic, which facilitates greater cognitive motor learning. The clinician is encouraged to design distributed practice within treatment sessions, as scheduling shorter and multiple sessions per week is generally challenging. In this manner, short breaks are interspersed throughout treatment sessions as the client progresses in increasing his or her ability to accurately produce the target movements (Strand & Skinder, 1999). Depending on the disorder’s severity of impact on the child’s speech, speech tasks are also practiced under varied conditions during each session so generalization of motor learning occurs across phonetic contexts and speech
environments. Knowledge of performance is the recommended type of feedback used in integral stimulation. However, the clinician must also use his or her best clinical judgment regarding the type, frequency and timing of feedback he or she gives during a treatment session. These will often depend on the clients’ age and severity of impact on their speech intelligibility. Issues of rate are also explored in integral stimulation, as a decrease in speech rate has been known to increase speech intelligibility. However, as rate is decreased, the naturalness of speech production is compromised; thus the clinician is again prompted to use her best clinical judgment in straddling the rate trade-off (Caruso & Strand, 1999). Self-monitoring is also addressed early on in Integral Stimulation, as self-correction is one of the treatment’s ultimate goals (Strand & Debertine, 2000).

Though a significant amount of movement research has been dedicated to the effects of cognitive motor learning on limb motor skill, there are very few scientific studies that examine the effects of cognitive motor learning in relation to the motor skills for speech. It is crucial to learn if cognitive motor learning plays a role in speech motor skills as it does with limb motor skills. If it does, cognitive motor learning and its principles may have a profound impact on the manner in which clinicians direct their treatment of motor speech disorders.

Even more limited, however, is the amount of research on the efficacy of integral stimulation as a treatment approach applied to CAS. To date, only two efficacy studies exist that examine the effects of the integral stimulation approach as a treatment for apraxic speech (Rosenbeck et al., 1974; Strand & Debertine,
2000) and only one directly concerns the treatment of CAS. Rosenbeck et al. (1974) utilized an integral stimulation approach in the form of an 8-step task continuum in treatment of 3 adults with acquired apraxia. Their findings indicated that treatment of this kind could, “if intelligently employed, help to restore some communicative ability to some severely apraxic patients” (p. 471). Nearly two decades later, Strand and Debertine (2000) examined the effects of integral stimulation when it was used in treatment with a young child with CAS, and concluded that “a treatment approach maximizing the principles of motor learning may facilitate the treatment of severe developmental apraxia of speech” (p. 299).

The authors noted the importance of continuing research of the individual parameters of cognitive motor learning and their effects on speech motor skills. The more we understand cognitive motor learning and its impact on speech motor skills, the better understanding clinicians will have on how to direct their treatment of motor speech disorders such as CAS.

The purpose of this study was to assess the effectiveness of Integral Stimulation when used as an articulation treatment in speech therapy for one school-aged child diagnosed with Childhood Apraxia of Speech, or CAS. The participant was audio recorded while reading or repeating targeted phrases or sentences. Recordings occurred towards the middle of each treatment session. The clinician phonetically transcribed each data session using broad transcription and compared the child’s productions to transcriptions of the target. A second listener
phonetically transcribed 5% of the recordings to ensure accuracy of the clinician’s transcriptions.

The primary goal was to evaluate the efficacy of Integral Stimulation as a treatment approach for CAS through the improvements made, if any, in speech intelligibility as demonstrated by an increase in the percentage of the total phonemes produced. It was hypothesized that as a result of participation in treatment based on the Integral Stimulation approach, increases would occur in overall speech intelligibility; the frequency of self-correction of speech errors; and the number of correctly produced target phonemes.
METHODS

Study Design

A single-subject A-B-A withdrawal design was employed for this study. Initial speech and language assessments and conversational speech samples were collected to determine the speech sounds or speech behaviors to be targeted in intervention. These targets were treated in the phonetic environment of individual words, phrases, or sentences, depending on the communication development and needs for the participant.

During data collection, the participant was audio-recorded while imitating a sentence provided by the clinician. The participant repeated or read these sentences for data collection during periods of baseline and intervention. Sentences varied at each data collection point; however the phonetic targets remained consistent through the course of data collection.

Data were obtained for 30 sessions, and data collection occurred during three phases: baseline, treatment, and post-treatment. Baseline was obtained in sessions 1-4, during which time the participant showed a consistently low level of intelligibility producing his targeted speech sounds. The treatment phase consisted of 24 treatment sessions, sessions 5-28, which included a 3-week break between sessions 12 and 13. It was expected that a regression in intelligibility would be observed after the 3-week break in intervention, and gradually show continued improvement during the following 17 treatment sessions. Treatment once again ceased for a 4-week period of no intervention, and no data were collected. Post-
treatment data were obtained 4 weeks after treatment ended and occurred over 2 sessions, sessions 29 and 30, to determine if production of speech targets or speech behaviors had maintained, regressed, or improved since the end of the final treatment phase.

Participant

One child diagnosed with CAS participated in the study. The child, MA was 10 years 3 months at the start of this study. A parent-interview revealed that MA was adopted from Thailand at the age of 16 months. When he was 20 months old, MA’s parents shared their concerns with their pediatrician that he was a quiet baby. His mother characterized his speech development as “very slow,” and that sounds and words appeared and disappeared from his vocabulary. At two-and-a-half years of age, a pediatrician diagnosed MA with Worster-Drought cerebral palsy and asthma. His parents were referred to a developmental clinic for children at Kaiser Health System for additional speech and motor assessments, where he received sporadic physical, occupational and speech therapy for the next 2 to 3 years.

At three years of age, MA was enrolled in an Early Intervention program, and received regular speech, occupational and physical therapy. At the age of 4, MA’s Early Intervention speech therapists first suggested MA was “apraxic,” with which his speech therapist at Kaiser concurred. At this time, it was also suggested MA was affected by Attention Deficit Hyperactivity Disorder, or ADHD, and participate in a Ritalin trial to manage his impulsivity in the classroom. MA’s
family pediatrician concurred with the diagnosis of ADHD. Once he took Ritalin regularly, MA gained greater control of his gross motor skills. His mother reported that he also began using more words in his daily speech. By the time MA was enrolled in kindergarten, his gross motor skills were commensurate with his same-age peers. His speech, however, was still considered highly unintelligible by his parents, teachers, and speech therapists. MA was later referred to the PSU Child Speech Clinic for continued speech therapy. MA’s diagnosis of CAS was confirmed 2 years prior to this study.

At school, MA was qualified as “speech disordered” and “other health impaired” to receive speech therapy services, academic assistance, and limited occupational therapy. Though his academic skills were behind his classroom peers in all areas except reading, MA functioned independently in the general education setting. He was placed in a general education classroom and received pull-out services for speech, math, and handwriting skills. Specifically, he attended 20-minute speech therapy sessions three times a week, daily assistance in math, and occasional occupational therapy for his handwriting skills.

At the PSU Child Speech-Language Clinic, MA regularly attended speech therapy by graduate student clinicians for 8 consecutive terms prior to this study. MA was seen for two consecutive terms by this study’s clinician from January through June of 2004, and participated in treatment based on the Integral Stimulation approach prior to the start of this study.
During this study, MA attended two 50-minute articulation therapy sessions a week, which were conducted at the PSU Child Speech-Language Clinic and at his place of residence by the examiner. Prior to baseline data collection and treatment, MA's articulatory and language skills were assessed using the Goldman-Fristoe Test of Articulation-2, or GFTA-2, and the Expressive One-Word Picture Vocabulary Test –Revised (Gardner, 1990), or EOWPTV-R. Formal assessments of MA’s articulation and language skills are listed in Table 1. A standard score of <40 on the GFTA-2 ranked MA below the first percentile, and indicated his single word articulation was well-below typically developing same-age peers. Due to the numerous speech errors with which MA presented – including cluster reduction, final consonant deletion and syllable deletion – it was not known which grammatical markers were present in his speech. Thus, a true measure of MA’s language skills was not possible to obtain. However, as the EOWPVT-R results suggest that MA’s expressive vocabulary skills are similar to those of his peers, it is likely that MA’s severe speech delay is negatively affecting overall expressive language and that that his overall expressive language skills will improve with continued speech treatment.

The data obtained from spontaneous speech samples used for preliminary analysis were phonetically transcribed. These speech samples were compared to sounds produced by typically-developing children of the same age to determine the most appropriate therapy targets during the clinical research intervention. The
speech sounds /s/, /z/ and /ʃ/ were deemed stimulable and developmentally appropriate, thus were selected from these formal and informal measures as speech targets during treatment.

Table 1

**Summary of Tests Administered**

<table>
<thead>
<tr>
<th>Test Administered</th>
<th>Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldman Fristoe Test of Articulation 2nd Edition</td>
<td>Standard Score: &lt;40</td>
</tr>
<tr>
<td>Expressive Oral Word Picture Vocabulary Test - Revised</td>
<td>Standard Score: 106</td>
</tr>
</tbody>
</table>

MA’s diadochokinetic rates were assessed as below average in the production of “kuh,” “puh-tuh,” and “puh-tuh-kuh.” MA’s facial features appeared properly aligned and were symmetrical at rest and during speech production. He demonstrated appropriate oral movements, such as puckering or smiling, within normal limits. A hearing screening conducted at the PSU Clinic indicated that MA’s hearing was also within normal limits.

A spontaneous speech sample showed that MA presented with a limited phonemic repertoire with frequent sound substitutions, omissions, distortions, and cluster reductions across sound classes. Errors in MA’s speech occurred with greater frequency as his utterances increased in length. He also presented with inconsistent articulatory productions. Table 2 illustrates speech errors demonstrated in the production of vowels. Vowel errors occurred less frequently
than consonant errors. MA’s vowel distortion errors of consisted of
diphthongization, neutralization, derhoticization, and tense/lax distortions. His
percent vowels correct was calculated as 77% correct.

Table 2

Summary of MA’s Vowel Errors

<table>
<thead>
<tr>
<th>Monophthongs</th>
<th>Errors</th>
<th>Diphthongs</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>/i/</td>
<td>/ɔ/</td>
<td>/eɪ/</td>
<td>/ɛ, ə/</td>
</tr>
<tr>
<td>/ɪ/</td>
<td>/i, a/</td>
<td>/aɪ/</td>
<td>/ɛɪ/</td>
</tr>
<tr>
<td>/ɛ/</td>
<td>/æ, eɪ, aɪ/</td>
<td>/aʊ/</td>
<td>/eɪ/</td>
</tr>
<tr>
<td>/æ/</td>
<td>/ɛɪ/</td>
<td>/oʊ/</td>
<td>/aʊ/</td>
</tr>
<tr>
<td>/a/</td>
<td>/ʌ/</td>
<td>/ɔʊ/</td>
<td></td>
</tr>
<tr>
<td>/u/</td>
<td></td>
<td>/ʊ/</td>
<td></td>
</tr>
<tr>
<td>/ʊ/</td>
<td></td>
<td>/ɛ, a/</td>
<td></td>
</tr>
<tr>
<td>/ɔ/</td>
<td>/ou, e, a/</td>
<td>/ɛ, e, ew/</td>
<td></td>
</tr>
<tr>
<td>/ʌ/</td>
<td>/aɪ/</td>
<td>/o, ɔ, u/</td>
<td></td>
</tr>
</tbody>
</table>

Consonantal speech errors demonstrated are illustrated in Table 3. MA had
the greatest error frequency with fricatives /s, z, ʃ, ʒ, ɕ, θ/. These were frequently
marked by omission errors or substitution errors with the sounds /f, v/ in all word
positions. MA also substituted the velars /k/ and /g/ with coronal or labial
consonants. Affricate /tʃ, dʒ/ were reduced to /d/ or substituted with /v/. Errors in
consonant clusters generally consisted of cluster reductions and frequent substitutions. MA’s percent consonant correct was calculated as 45%.

MA demonstrated use of a perceptibly faster rate of speech, and generally did not self-monitor his speech. Communication breakdowns that resulted from MA’s inaccurate articulations were not repaired. A generally flat prosody was noted in MA’s speech; and variations of inflection at times contradicted syntactic meaning. Throughout the speech sample, oral groping was observed in MA’s speech behaviors and accompanied the production of problematic speech production.

Treatment targets were determined based on analysis of the spontaneous speech sample and information yielded from the GFTA-2. Criteria for determination of treatment targets included the stimulability of speech sounds and developmental norms for speech sound acquisition. The speech sounds /s, z, Ѵ/ were selected as speech treatment targets. All three sounds were stimulable, developmentally appropriate and generally substituted with the sounds /f, v/. Improvement of these sounds would increase MA’s intelligibility and add both semantic and syntactic meaning to his speech.
### Table 3

**Summary of MA's Consonant Speech Sound Errors by Word Position**

<table>
<thead>
<tr>
<th>Consonants</th>
<th>Errors</th>
<th>Clusters</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Medial</td>
<td>Final</td>
</tr>
<tr>
<td><strong>Stops</strong></td>
<td>/p/</td>
<td>/t/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/b/</td>
<td>/d/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/t/</td>
<td>/k/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/l/</td>
<td>/v/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/d/</td>
<td>/t, k/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/k/</td>
<td>/t, f/</td>
<td>/v/</td>
</tr>
<tr>
<td></td>
<td>/g/</td>
<td>/t, d/</td>
<td>/t, d, ʔ/</td>
</tr>
<tr>
<td><strong>Nasals</strong></td>
<td>/m/</td>
<td>/n/</td>
<td>/ŋ, ʔ/</td>
</tr>
<tr>
<td></td>
<td>/n/</td>
<td>/ŋ/</td>
<td></td>
</tr>
<tr>
<td><strong>Liquids</strong></td>
<td>/l/</td>
<td>/n/</td>
<td>/n/</td>
</tr>
<tr>
<td></td>
<td>/l/</td>
<td>/w/</td>
<td>/w/</td>
</tr>
<tr>
<td><strong>Glides</strong></td>
<td>/w/</td>
<td>/ʔ/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/y/</td>
<td>/h/</td>
<td>/ʔ/</td>
</tr>
<tr>
<td><strong>Fricatives</strong></td>
<td>/f/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/v/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/l/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/j/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/g/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/h/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/b/</td>
<td>/f, v/</td>
<td>/f, v/</td>
</tr>
<tr>
<td></td>
<td>/s/</td>
<td>/f, v, t/</td>
<td>/f, f/</td>
</tr>
<tr>
<td></td>
<td>/s/</td>
<td>/f, v, ʃ/</td>
<td>/f, v/</td>
</tr>
<tr>
<td><strong>Affricates</strong></td>
<td>/tʃ/</td>
<td>/ʃ/</td>
<td>/ʃ/</td>
</tr>
<tr>
<td></td>
<td>/sʃ/</td>
<td>/ʃ/</td>
<td>/ʃ/</td>
</tr>
</tbody>
</table>


Materials

Treatment sessions included the use of books, objects such as small speech-stimulating manipulatives, card games and an electrical toy train set. Self-recording sheets were utilized for the purpose of self-monitoring production of correct speech sounds and behaviors, and positive verbal reinforcers served as the reward system for accuracy in the production and self-monitoring of his targeted speech sounds/behaviors. Data were audio recorded using a Sony TCM-20DV standard cassette recorder, and video recorded using a Sony DCR PC-101 digital camera and taped on Sony Mini Digital Video Cassettes.

Treatment Procedures

The principles of cognitive motor learning were addressed through the integral stimulation approach throughout treatment sessions. Concerning precursors to learning, speech activities presented in each session were designed to be motivating and were based on MA's interests, as suggested by him or his mother. Speech activities occurred while reading from client-selected books, playing client-selected card games or using an electrical model train.

Conditions of practice were addressed each session by providing MA the maximum opportunity to practice the targeted speech movements, as deemed appropriate for his age and tolerance to treatment. Treatment of specific speech targets occurred for short periods of time, ranging between 1-3 minutes. Targets were targeted in a randomized manner throughout the course of the session. The clinician tracked the number of trials attempted on each target and the order in
which they occurred to ensure practice distribution of speech targets occurs. The speech targets were designed in the most facilitative contexts for each participant. Clinician models occurred both auditorily and visually, and the participant was routinely instructed to “watch me and listen to me” prior to executing specific articulatory movements, utilizing both direct visual models and models produced while the participant and clinician both faced a mirror. According to the level and frequency of accurate production of the target, the models were delayed or reintroduced in a hierarchical manner to foster greater independence of MA’s speech productions.

The feedback given during sessions was specific, and occurred for both correct and incorrect productions (for example, “You made a strong /s/ sound at the beginning of “sat”). Feedback in the form of knowledge of results occurred as encouraging and motivating comments (for example, “Way to go, you did it!”). The participant was also asked to evaluate his own speech productions intermittently and informally during each session. Self-monitoring occurred through the use of self-scoring cards, in which the participant “scored” his productions as correct by drawing a smiley face, and incorrect by showing drawing a frown face. Totals were not tallied at the end of self-evaluations to avoid a “test” atmosphere.

Influences of rate were addressed at the beginning of each session. MA and the clinician took turns reading client-selected passages from books while tapping one syllable per word. This provided a rhythm to which MA read. Rate was
informally assessed as decreased or increased in the production of speech sounds, whole words, and longer utterances of phrases or sentences. MA self-monitored his rate of speech on a self-rating chart during these activities. If he heard himself produce the sounds, words, or phrases slow enough to hear each sound he printed in the written passage, he drew a “smiley face.” If he did not hear all of the sounds in the written passage, he drew a “frowny face.”

Speech probes were devised as sentence lists which MA would repeat or read given an auditory and visual model, and audio recorded during each session. The sentences would vary each session, and no sentence was repeated throughout the study. Speech probe sentences were designed to imitate natural speech for MA’s same-age peers. Based on typical language and syntactic structure used by MA’s same-age peers, each speech probe contained words with either /s/ in initial, medial and final position, /z/ or /j/ in initial and final position. Each sentence contained 16 to 24 phonemes to reflect the various length of utterances used in natural speech. Words selected for each sentence were determined as frequently-occurring words for same-age peers, and were designed to reflect the vocabulary used in the academic and home environments. Sentences in each probe were randomly selected by the clinician from the entire sentence inventory. Approximately 6 to 8 sentences were selected for each speech probe.

In addition to data collection, session events reflections on the success of treatment and were informally recorded by the clinician. The time at which each
session began, a description of the participant’s engagement during treatment, and a record of treatment attendance were noted in a daily journal by the clinician for future reference as it related to treatment.

Baseline

Establishment of baseline measures took place in the clinic rooms of the PSU Child Speech-Language Clinic. Baselines measures were collected in November, 2004. MA consistently produced the speech sounds and behaviors identified as treatment targets in individual words, short phrases or sentences for no less than three consecutive data collection events. Data were reviewed to determine whether criteria for stability had been reached (Barlow & Hersen, 1984). When stability of treatment targets had been met, treatment was begun during the next scheduled session. If the criteria for stability were not met, baseline data collection was continued until stability of treatment targets was achieved. Data for baseline were audio and video recorded, and phonetically transcribed by the clinician for consistencies in speech production or speech behaviors. No intervention strategies were implemented during baseline.

Data Collection and Analysis

Observation and data recording occurred during the first 15 to 25 minutes of each session utilizing video or audio recording devices. The clinician, trained in broad transcription using IPA, performed a phonetic transcription of the sentences produced by the child during data collection. During data collection, the examiner asked the child to repeat six or seven sentences that were audio recorded for later
phonetic transcription. The same listener was utilized throughout the course of this study, and the accuracy of the child's speech productions was charted over time to determine the effects of Integral Stimulation on overall intelligibility of each data collection session.

For each data collection point, sentences were selected at random from a pre-generated list of sentences created by the clinician (see Appendix C). The clinician modeled each sentence the child was to repeat. The clinician and child were audio recorded while saying the sentences. Each sentence contained the speech sounds targeted in treatment for each child. The sentences varied during each data collection point. Of each recording, 100 phonemes were counted in the calculation of speech intelligibility, beginning after the first ten phonemes of each sample. Transcriptions of MA's utterances were compared to adult target utterances for production comparison using LIPP (Oller, 2000) and were computer analyzed. Speech probes were analyzed from each baseline, treatment session, and once again 4 weeks upon withdrawal from treatment.

Speech intelligibility was measured by the percentage of correct production of all consonants, vowels and total phonemes in each speech probe. Percentages were calculated by dividing the number of correct productions by the number of production targets, and multiplying by 100. The percentage of speech production accuracy was charted over time. Progress was assessed by an increase in percentage of correct productions.

*Setting*
The participant attended two 50-minute speech therapy sessions in the PSU clinic two times a week. Treatment sessions are conducted in a clinic room from 2:30 to 3:20 p.m. for the first 2 and the last 16 data collection sessions. It was necessary to conduct treatment and data collection for sessions 3-15 at the participant’s residence in his family room, from 6:30 to 7:20 p.m., as a change in his family’s transportation schedule precluded him from attending sessions at the PSU clinic for 6 weeks.

The PSU clinic room contained one child-sized rectangular table and an adequate amount of floor space, and had adequate lighting. Objects in the clinic room were limited to the materials selected for each treatment session. Auditory and visual distractions were minimal to none in this environment. The participant’s residential family room included open space on the floor and diffused but adequate light. Distractions were moderate to in this environment, and included a television, video games, books, family photos, various seasonal or holiday decoration, family pets, and the occasional sound or appearance of family members. Treatment was conducted on the floor at both locations, and when available, on at the table per space requirement of treatment activity.

Reliability

A second observer trained in transcription of disordered speech using IPA symbols phonetically transcribed random samples of recorded utterances to ensure the reliability of the primary observer’s report of an increase or decrease in speech intelligibility over the course of the study and consistency between transcriptions.
Inter-rater reliability was completed for 5% of all recorded utterances, and calculated as 98% reliable. The same second observer also reviewed 5% of all treatment sessions on video recordings to ensure that treatment was consistent and congruent with Integral Stimulation treatment practices and principles.
RESULTS

This study examined the effectiveness of the Integral Stimulation approach when used as an articulation treatment for a child with CAS. Speech probes containing the treatment targets initial and final /s, z, ñ/ administered during every session were used to gather data on percentage of correctly produced phonemes during baseline and treatment phase, and once again 4 weeks post-treatment. It was hypothesized that MA’s percentage of correctly produced phonemes would increase over time as the Integral Stimulation approach was employed in speech therapy. Pre- and post spontaneous speech samples were also compared to assess treatment effects.

Baseline was obtained within the first four sessions in November and followed by a 24-session treatment period. Treatment began in late November and included a 3-week break in data collection between sessions 11 and 12, during which time no treatment was administered. Treatment resumed in January, and continued through to mid-March. Post-treatment data were collected 4 and 5 weeks post-treatment (PT).

It was necessary for data collection and speech therapy to occur in two locations throughout this study: the PSU Speech Clinic, and in the participant’s place of residence. Data were initially collected at the PSU Speech clinic for the first three of four baseline sessions. Baseline was achieved by the fourth session, which was conducted at MA’s place of residence. Treatment was initiated and data
were collected at MA’s home from sessions 5-13. Treatment sessions and data
collection were conducted once again in the same clinic room at the PSU Speech
Clinic for sessions 14-28. Post-treatment data were collected during sessions 29
and 30 in the PSU Speech Clinic in a room similar to the formerly used treatment
room.

Figure 1 illustrates MA’s performance during speech probes as the
percentage of the total phonemes he correctly produced, charted over time during
baseline, treatment, and PT. MA demonstrated a consistent level of performance
on speech probes during baseline of approximately 63% correct. The first nine
sessions of the treatment phase were conducted at MA’s residence, sessions 5
through 13. During sessions 5 through 11, his speech performance remained fairly
consistent with little to some variation and minimal improvement. A dramatic 15%
drop in performance occurred between sessions 11 and 12, upon return from a 3-
week break from treatment. In the subsequent five sessions, treatment sessions
resumed at the PSU speech clinic; and during this time, MA’s speech performance
steadily increased. By session 17, MA reached 80% accuracy during speech
probes. From sessions 18-28, MA demonstrated variable performance on speech
probes, with the highest percent accuracy of 81% correct on session 21, and the
lowest percent accuracy of 64% correct. The final speech probe was calculated as
68% accurate. Post-treatment data collection sessions 29 and 30 show MA’s
speech probe performance was calculated at 63% and 84% accuracy, respectively.
Figure 1. Percent accuracy for MA of total phonemes on all speech probes.
Figure 2 compares percent accuracy of consonants and vowels produced during data collection as charted over time. Percent accuracy of vowel production occurred at a considerably higher level than consonant production. Also noted is a high level of variability between sessions. Additionally, the percentages of accurately produced vowels do not indicate any marked articulatory improvement occurred over the course of treatment. Percent accuracy of consonant production was similar to that of vowels in its variability of speech performance during the first 12 sessions. However, accurate production of consonants significantly increased from 46% to 80% between sessions 12 and 17. Throughout sessions 18-28, accuracy of consonants remained higher than consonant accuracy before the 3-week break in treatment, yet alternately fluctuated between increased and decreased performance. Vowels were produced with greater accuracy throughout sessions 18-28, yet generally imitated the variable increases and decreases seen in accuracy of consonant production. During PT, accuracy of consonants and vowels simultaneously dropped during session 29; and then showed an increase in production during the final session of this study, session 30.
Figure 2. Percent accuracy of MA of consonants and vowels on all speech probes.
MA demonstrated self-corrections during data collection, reflecting integral stimulation treatment principles. At several points throughout data collection, MA self-corrected his speech errors made during speech probes by restarting a word until he produced it correctly before completing the sentence. MA’s rate of restarting words ranged between one to three times per self-correction. These self-corrections occurred with greater frequency throughout the latter portion of this study and were recorded again four weeks post-treatment.

Figure 3 illustrates the change in accuracy of all phonemes produced given MA’s first and last production attempts during baseline, treatment, and post-treatment phases. Figure 3 shows MA sporadically self-corrected during the first half of the treatment phase. During the latter half of data collection, MA increased his both use of self-corrections across sessions and the number of self-corrections made in each session. With the exception of one instance, all attempts at self-correction of phonemes correlate with an increase in intelligibility.

Percent of correct production of phonemes /s, z, ð/ targeted in intervention are illustrated in Figures 4, 5 and 6, respectively, and reflect MA’s use of self-corrections during speech probe performance, and measure the accuracy of his last attempts when he self-corrected his speech. Figure 4 shows a noteworthy increase in accuracy of production of /s/ in the sentence-length probes. Sessions 14-17 show the greatest continual increase in accuracy of /s/ during speech probes, in which MA’s production accuracy of /s/ begins at 14% and rises to 80%. Though
Figure 3. Frequency of self-corrections for MA on all session probes.
MA’s production of /s/ fluctuated between sessions 16-30, he remained at or above 80% correct and demonstrated 100% accuracy of /s/ in the final speech probe administered during the final post-treatment session.

Figure 5 shows MA’s accuracy of /z/ during speech probes. Of the first 16 sessions, MA’s accuracy of /z/ was measured as 0% during speech probes upon self-corrections. It is noted that during session 8, MA incorrectly restarted production of /z/ after initially producing it correctly. This yielded a final percent correct of 0% for /z/ during data collection, and suggested that MA was capable of producing /z/ but not on a consistent basis. An increase in MA’s use and accuracy of /z/ is noted between sessions 17-30, and fluctuated between 0% and 100%. His accuracy was of /z/ measured as 25% and 50% during the final post-treatment sessions, respectively.

Figure 6 illustrates MA’s high level of accuracy in /ʃ/ production, though his consistency in accurately producing this sound was variable throughout sessions 24 through 30. MA did not show an increase in production accuracy of /ʃ/ during the course of the study.
Figure 4. Percent accuracy for MA of /s/ on all speech probes.
Figure 5. Percent accuracy for MA of /z/ on all speech probes.
Figure 6. Percent accuracy for MA of /S/ on all speech probes.
Two spontaneous speech samples were collected pre and post-treatment. The first was administered on October 12, 2004, before baseline measures were obtained. The last speech sample was taken on April 14, 2005, 5 weeks post-treatment. Computer analyses calculated the percentage of correct production of total phonemes, consonants and vowels produced in each speech sample. Figure 7 shows the comparison of accuracy of percent phonemes correct (PPC), percent vowels correct (PVC) and percent consonants correct (PCC) across pre- and post-treatment spontaneous speech samples. The data show that an increase from 45% to 50% for consonants, 77% to 82% for vowels, and 57% to 62% for overall phonemes was seen between pre- and post-treatment speech samples.
DISCUSSION

This discussion examines the Integral Stimulation approach as it pertains to cognitive motor learning, treatment design, and its relation to the participant’s increase in overall speech intelligibility. This discussion also examines the effects of consistency of treatment environment; and potential impact the participant’s age, motivation, participation and longevity in prior articulation treatment have on the results of this study.

The present study examined the efficacy of an Integral Stimulation treatment approach with a child with CAS. Prior to treatment, MA demonstrated a consistently low level of articulatory performance on speech probes, a perceptually fast rate of speech, and reduced levels of self-monitoring during speech probes and spontaneous speech. As the Integral Stimulation approach was initiated in treatment sessions, MA demonstrated fluctuating levels of articulatory performance. The results show that as treatment progressed, MA demonstrated an increase in overall accuracy through improved production of speech, most notably in consonant production.

The goals of intervention during both treatment periods were to 1) increase his automaticity of articulatory movements that included the target phonemes /s, z, š/ at syllable, word and phrase level; 2) facilitate MA’s use of a reduced rate of speech during treatment activities; and 3) increase his use of self-monitoring and self-assessment of speech accuracy. MA engaged in treatment activities that
allowed maximum repetitions of articulatory movements that targeted the phonemes /s, z, ʃ/. MA increased his accuracy of production of the sounds /s, z/ at the syllable, word and phrase/sentence level. Though he demonstrated the ability to produce /ʃ/ at the syllable, word and phrase/sentence level, MA did not consistently produce and use this sound during treatment activities and during speech probes. Additionally, upon informal assessment and daily observation, MA routinely practiced speaking at a reduced rate during treatment activities. During these activities, he was required to distinguish his correct sound and word productions from his incorrect productions, document his accuracy, and compare his findings with the clinician. MA was able to do so with increased consistency as treatment progressed. As his perception of correct and incorrect articulations increased, MA began to self-monitor and self-correct his speech errors with fewer clinician-provided prompts. As his frequency and accuracy of attempts to self-correct increased, MA’s performance on speech probes likewise increased.

The data suggest that use of the Integral Stimulation approach effectively improved MA’s overall speech intelligibility, and indicate that overall improvement occurred in his speech production, specifically in production of consonant sounds, and in his increased use of self-corrections during speech probes. Figures 1 and 2 shows the production of total phonemes, consonants and vowels, respectively, during all speech probes, and illustrate that consonants showed greater growth over time. Specifically, MA’s increased accuracy of
targeted consonants /s/ and /z/ is shown in figures 4 and 5, respectively. Figure 3 documents MA’s frequency of use of self-correction during speech probes, which resulted in an increase in his speech intelligibility. Analyses of speech samples obtained pre-and post-treatment show a 5% increase in accuracy of production of total phonemes correct (PPC), vowels correct (PVC) and consonants correct (PCC), as illustrated in Figure 7. MA’s spontaneous production of speech sound /s/ was also recorded during a post-treatment spontaneous speech sample, suggesting that he is able to use /s/ with greater automaticity. Figure 1 illustrates MA’s inconsistent performance on speech probes during data collection which occurred at his home in the evening. The data also suggest the need to explore the unreliable speech performance throughout the treatment phase, and variable production of target /ʃ/ on speech probes.

As hypothesized, an increase was seen in MA’s performance on speech probes across sessions. The data support the hypothesis that MA’s increased performance on speech probes was a result of his regular participation in systematic speech therapy based on the integral stimulation treatment approach. Repetitive practice of difficult articulatory movements was engaged in routinely to allow for greater automaticity. The clinician regularly provided feedback in the form of results and knowledge of performance and results, with greater emphasis on the latter. Speech targets were presented and treated in a hierarchical manner, beginning with single syllables and progressing on to words, phrases and sentences.
Practice of speech targets initially occurred in a blocked manner to ensure the targets were produced consistently; and subsequent practice of speech targets occurred in a random manner to practice the movements in the context of other articulatory movements. Speech therapy sessions were distributed over time to maintain a higher frequency of speech practice in treatment. Elements of rate were addressed in treatment during each session through MA’s engagement in self-pacing practices, by tapping single syllables per word while reading, imitation and spontaneous speech.

MA’s ability to self-correct speech errors is evident throughout the course of this study. As noted in Figure 3, MA demonstrated an increase in attempts to self-correct his speech that resulted in increased accuracy of speech production. One component of the principles of cognitive motor learning and the integral stimulation approach addressed during treatment was MA’s practice of self-monitoring speech production. MA was required to read or imitate words or phrases, and then assess his production accuracy in terms of what and how speech targets /s, z, ñ/ sounds were produced. Errors commonly made that significantly compromised his speech intelligibility were sound substitutions of /f, v/ for speech targets /s, z, ñ/ and consonants /ð, θ, tʃ, dʒ/. Visual and auditory assessment of speech production initially aided his ability to identify when he made speech errors. MA’s ability to auditorily assess his speech production, make repairs during speech
tasks, and increase his use of self-monitoring skills by the conclusion of this study suggest that MA’s cognitive motor learning has increased

As hypothesized, MA’s overall speech intelligibility increased during participation in treatment based on the integral stimulation approach. By comparing MA’s pre- and post-treatment spontaneous speech samples, the data suggest MA improved his accuracy of production of consonants and vowels, increasing each by 5%. Bearing in mind that CAS is not known to quickly respond to speech treatment, a 5% increase in speech intelligibility can be seen as somewhat slow but steady progress. Looking closer at speech sounds targeted in treatment, a noteworthy increase in speech target /s/ is noted between pre-and post-treatment spontaneous speech, which corresponds to the change noted in the same target during speech performance probes throughout treatment. In addition to MA’s spontaneous production of /s/ during the post-treatment speech sample, he produced /s/ correctly in conversational speech seven times during spontaneous conversation with the clinician without cues or prompts to make corrections. This spontaneous use of /s/ began 4 weeks post-treatment, and was not observed during any portion of baseline or treatment phases. In addition, MA has begun to spontaneously and correctly use the target sound /s/ in conversation at home and in his school environment. MA’s mother reported that he began using /s/ in his conversational speech in the home a few days before the final speech sample was taken. MA’s classroom teacher and school speech-language pathologist confirmed this change in his speech at school following the same timeline. MA’s mother
noted that this sound has been absent from his phonetic repertoire up until this time, and noticeably impacted his speech intelligibility in both contexts. The emergence of /s/ in MA’s spontaneous speech supports the theory that cognitive motor learning occurred, as it is possible he has begun to generalize use of this speech motor skills to new speech environments.

Greater improvement was seen in MA’s production of consonants during speech probes compared to his production of vowels. This may be accounted for by the fact that sounds targeted were consonants. Accurate production of all sounds was addressed during the study, but vowels were not an isolated sound family targeted in treatment. It is noted that MA’s production of certain vowel sounds during speech probes tended towards over-articulation. These phonetic differences in speech production were noted to occur during production of a neutral vowel, the schwa specifically, when used in the articles “a” and “the,” but did not represent phonemic differences that increased or decreased his intelligibility.

Limitations and Cautions

What must also be addressed are MA’s inconsistencies of speech production during speech probes. Two contributing factors unique to the participant must be addressed. First, MA is a school-aged child who has received speech therapy since the age of 3. MA’s age may have an impact on the progress he made in treatment, as older children with severe speech disorders and who have been in previously been in speech therapy generally make slower progress in therapy. Additionally, MA worked with this particular clinician for 6 months in
treatment based on the integral stimulation approach prior to his participation in this study. The progress documented in this study measures only the changes made after the initiation of this study, and does not represent MA’s increase in intelligibility upon long-term participation in treatment based on the Integral Stimulation approach. It is noted by the clinician that prior treatment targets included /s, z/ in open syllables, initial, medial and final word positions, and in facilitative contexts of 2-4 word phrases.

During treatment sessions, MA increased his consistency in production of speech targets when given maximal cues – both auditory and visual – and much repetitive practice. Though his accuracy of production notably increased during sessions, his performance on speech probes did not always reflect gains made during practice of speech targets. The variable nature of MA’s performance on speech probes throughout this study may also be addressed by the nature of CAS; specifically, of its hallmarks, CAS is often characterized by its inconsistencies in speech production and slow progress in therapy (Davis et al., 1998). Throughout the treatment phase, MA demonstrated inconsistencies in production of sounds, syllables, words and phrases. Accurate productions of speech sounds were frequently followed by misarticulations and occasional oral groping behaviors. It appeared that in one moment he “had” an articulatory pattern, but then “lost” the movement in the following attempt.

Another plausible explanation for variable performance on speech probes was the structure of the speech probes themselves. Designed to imitate phrases and
sentences commonly used by peers in MA’s age group, the phrases varied in
length, ranging from 16 to 25 total phonemes per utterance. As CAS is also
marked by increased articulatory breakdowns in longer utterances, greater demand
may have been placed on MA’s capacity to program and plan the movements
required of articulatory configurations within these longer utterances, precipitating
articulation errors.

Although overall improvement in MA’s speech was noted, MA’s
performance on speech probes was variable across sessions. The first baseline
measure shows a considerably higher percentage of correct phonemes than the
subsequent three measures. Varying in accuracy by Sessions 12 through 17, the
data suggest MA demonstrated an increase in articulatory performance, specifically
in his consonant production percentages. Aside from this 5 to 6-week increase in
performance, MA’s overall production fluctuated, frequently by 10% between
sessions. Possible confounding variables and distinguishing characteristics of
CAS, such as its variable consistency of speech production, poor response to
treatment, examples may have contributed to his inconsistent performance.

While the inconsistent performance often noted in CAS may be a factor,
additional confounding variables may include the both the time of treatment and
the environment in which it was administered. Shortly after baseline was begun,
MA’s family had a change in their weekday schedule that precluded MA’s
participation in this study at the PSU Speech Clinic. It was necessary to continue
data collection and subsequent treatment sessions in his home. Sessions 5-11 were
conducted at MA’s home between the hours of 6:00 -7:30 p.m. These sessions were considerably later than the speech appointments he formerly attended at the PSU Child Speech Clinic. Sessions conducted in the home were frequently delayed by MA’s family meal routines; or interrupted by typical household distractions such as MA’s personal objects of interest, individuals entering and leaving the room in which data collection and treatment occurred. MA’s demonstrated an elevated level of distractibility and a decreased level of focused concentration at his home than when he was seen in the clinical environment. Parent report confirmed that MA experienced increased hyperactive and distractible behaviors in the evenings, a result from the combination of his medication for attention deficit hyperactivity disorder wearing down, general fatigue from his extended day at school, and change in routine for his speech therapy appointment.

It is also plausible that MA’s performance on speech probes and in treatment at home reflects his level of motivation and focused attention to engage in data collection and speech therapy activities. This directly relates to the principles of cognitive motor learning, in terms of the influential precursors that facilitate learning of cognitive motor skills. Strand (1999) asserts that focused attention facilitates active participation in the therapy process, and that “if attention and effort do not match the processing demands required for whatever one is trying to do, performance will be degraded” (p. 547). If MA’s processing capacity was impacted by an attention deficit and environmental distractions or disruptions during treatment sessions, his ability to attend during performance probes may have
been negatively impacted. Thus, his capacity to attend and process during speech treatment and performance probes was not commensurate with the processing demands of the activities.

Schmidt and Wrisberg (2004) discuss motivation factors in relation to cognitive motor learning. They state that individuals with diminished motivation levels to learn generally do not fully engage when learning and practicing new skills, and at best, “make only half-hearted attempts” (p. 191). While MA was generally cooperative during data collection and treatment sessions, his level of interest, engagement and motivation in improving his speech at home was lower as compared to his level of motivation to work on speech while at the PSU Clinic. If he was required to attend to a speech therapy session after a long day away from home, other environmental temptations may have contributed to a lack of enthusiasm in maintaining attention and active participation during treatment sessions.

In addition, the home environment brought a new element to MA’s speech therapy sessions. As he had received speech therapy services at the PSU Clinic for several years, he had not received this type of service in his home from this clinician. All of the therapy conducted in his home occurred in the living room, with both MA and the clinician seated on the floor. MA usually removed his shoes prior to therapy sessions. The level of lighting in MA’s home was dimmer than in the clinic rooms, which MA possibly perceived as a more relaxed atmosphere than the PSU Clinic. This change in aesthetic and ambient environmental qualities may
have contributed to MA’s speech performance at home. MA’s overall demeanor differed at home compared to when he attended sessions at the PSU Clinic. Initially, MA was prone to sporadically leave the treatment environment to obtain a beverage or personal belonging, or to communicate a message to a family member, all of which helped to interrupt the flow of treatment or data collection. MA tended to want to engage in play activities and share novel objects of interest with the clinician. His success during speech activities was also more variable during this time, which is reflected in his performance on speech probes administered at home. It was necessary for the clinician to establish a new set of behavioral expectations that differed from those exercised in the clinical setting. Once the expectations and therapy session “rules” at home were established, MA was able to participate more fully in treatment sessions. The change in treatment location presented a limitation for future replication of this study. The change in MA’s attitude and demeanor during treatment conducted in the home deviated from his demeanor during treatment at the PSU Clinic. Ideally, the treatment environment should have remained constant throughout the study, to minimize the change and potential effects that treatment time and environment had on the study participant.

Upon further examination of location of treatment, it must be noted that the change in treatment location may have yielded yet another effect. It is plausible that treatment conducted in the home may have contributed to greater cognitive motor learning, thus led to greater carryover of MA’s speech skills into new contexts and environments. Though ideal performance on speech probes was not
observed in the home, an immeasurable level of cognitive motor learning may have occurred while at his home. Thusly, when MA was required to perform the same speech tasks when treatment sessions resumed in the PSU Speech Clinic, an increase was seen in his performance because greater cognitive motor learning had occurred. As better performance does not necessarily indicate greater learning, it is possible that MA had to work harder to produce what appears as decreased levels of performance while at home compared to when he was initially seen in the PSU Clinic. If a high level of performance on speech tasks was achieved in the home, both a natural speech environment and an unnatural treatment environment for MA, greater generalization of those speech skills could occur.
CONCLUSION

The results of this study indicate that use of an Integral Stimulation approach as an articulatory treatment for CAS increased a child’s use of self-monitoring and self-correction of speech errors, facilitated increased production of overall intelligibility, increased production accuracy in 2 of 3 speech targets, and increased potential for generalization of speech skills to new speech environments and situations. Though the participant demonstrated variability throughout the first phase of treatment, the data suggest cognitive motor learning occurred through his improved production of two of the three speech sounds targeted throughout intervention, increased self-monitoring of speech production and self-correction of speech errors. The results are also similar to those found in a similar study conducted in 2000 by Strand and Debertine, who indicated that the Integral Stimulation approach facilitated increased speech performance and overall speech intelligibility of a five-year-old girl with severe CAS.

Strengths of this study include the systematic and hierarchical design and implementation of treatment across sessions. The clinician had a thorough understanding of the Integral Stimulation approach, and operated under the guidance of a certificated speech-language pathologist who specializes in CAS and is regarded as an expert in the treatment of this disorder. Treatment sessions were methodically planned and executed, and allowed the flexibility necessary to engage a young child with diverse interests and behavioral needs. Documentation of session events also made it possible to reflect back on specific treatment sessions
throughout the course of this study, which added greater clarity to the clinician’s long-term perspective on progress and analyses of the results.

Other strengths include the participant’s regular attendance and participation in treatment sessions, which add greater meaning to the data as documented over time. Speech probes were designed to reflect the vocabulary and language used by typically developing peers. Time and method of speech probe administration was consistent across sessions, which minimized variability of performance due to unfamiliarity with data collection procedures.

Limitations to the study include the change in treatment and data collection time and location during the 10 sessions that included the last baseline measure and first 9 treatment sessions. This environmental change may have affected the participant’s level of engagement and performance during treatment and data collection, but its impact was minimized by the maintenance of efforts to control the home environment by the clinician, the participant and his family.

Another limitation to this study includes the inadvertent exclusion of speech target /ʃ/ from several data points. As /ʃ/ is not a phoneme used as frequently as /s/ and /z/, the number of sentences created for its use during speech probes was comparatively limited. The process of speech probe sentence randomization resulted in an imbalanced number of sentences containing /ʃ/ across the course of the study, resulting in an inaccurate reflection of the participants’ use and production accuracy of the specific speech sound. It is the clinician’s belief that the
participant demonstrated the ability to use /ʃ/ in two to three-word phrases and sentences, but reverts to substituting /f/ and /v/ for /ʃ/ in longer utterances.

Perhaps the most pronounced limitation to this study is that it examined the progress made by only one participant in treatment using the Integral Stimulation approach. As it is difficult to theorize that the results yielded from the research on one individual bares relevance to other cases, the need for continued research utilizing larger sample sizes again reiterated. Qualitative, small-scale studies may provide depth of insight to relatively new or less-understood speech disorders; however, they do not provide the statistical significance yielded by studies of larger sample sizes. Quantitative research will provide a more objective perspective on efficacy studies for treatment of CAS. Additionally, longitudinal research will provide a broader data base from which to interpret results, and yield greater insight to how the disorder interacts with specific treatment design.

Research implications generated by this study echo those previously stated by Rosenbeck et al., (1974) and Stand and Debertine (2000): continued research in this area of treatment is necessary to further both our understanding of the nature of CAS and determine the most efficacious treatment practices. Likewise, the clinical implications generated by this study are simple. Many individuals with CAS are profoundly impacted by the degree to which their speech is affected by the disorder, and experience frustration and resignation when some measure of success is not achieved after years of speech therapy. Speech-language pathologists are
commonly frustrated by the perplexing nature of the disorder, and seek answers to long-standing questions regarding the best practices recommended for treatment. In order to effectively understand and treat CAS, the need for continued research remains a pressing need.
REFERENCES


APPENDIX A

PARENT INFORMED CONSENT FORM

Dear Parents/Guardians,

I am contacting you to invite you to participate in a project involving children with Childhood Apraxia of Speech using a specific form of speech therapy. My name is Anita Jensen, and I am a graduate student in the Portland State University Speech and Hearing Sciences program.

The purpose of this project is to understand the effectiveness of a specific treatment for developmental speech delays in children. It will assess the effectiveness of Integral Stimulation for speech therapy. Completing research helps us to understand the best ways to treat difficulties with speech in children.

Prior to beginning therapy, I will conduct a short speech assessment of your child to determine the best treatment goals for your child. Assessment activities include pointing to pictures, playing with toys, responding to questions, and talking with me during conversation and play. Upon completion of the communication assessment, therapy will occur two times a week at PSU where your child will receive therapy free of charge.

The most prominent error patterns your child demonstrates will be treated with Integral Stimulation therapy during each session. Each session will be 50 minutes long and will consist of 45 minutes of therapy, and 5 minutes of data collection by repeating sentences. I will audiotape and video tape your child during the session. 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 children. At the end of the research project, your child/family will have the option to continue receiving services at the PSU clinic for a nominal fee.

Participation in this project should not be harmful in any way to your child. Treatment sessions will be designed very much like the treatment he or she previously received at the PSU Child Speech Clinic. We will schedule your child’s speech therapy sessions at a time that is mutually convenient. Following completion of the project, we will give you a report on your child’s progress and that outlines the results of the study. We will keep confidential both your and your child’s name and all information gathered during this project by using pseudonyms 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 educational and research purposes 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.
I would be glad to talk with you about the project, and answer any questions you might have. You may contact me at 503.636-1381. You may contact my adviser, Christina Gildersleeve-Neumann at 503.725.3230. If you are willing to participate, please sign one copy of the attached consent form and return it to me in the enclosed envelope.

Thank you so very much for considering participating in our project. We feel strongly that these kinds of projects will help us better understand speech difficulties experienced by children. This will help us provide better services to help children overcome articulation and phonological difficulties.

Sincerely,
Anita Jensen, Graduate Student, Speech and Hearing Sciences Program, Portland State University

I give my permission for my child, ________________________________, to participate in the research on speech therapy intervention.

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

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If you have concerns about your participation or this study, please contact either Dr. Christina Gildersleeve-Neumann at 503.725-3230 or the Human Subjects Review Committee, Office of Research and Sponsored Projects, 111 Cramer Hall, Portland State University, 503.725-4288
APPENDIX B

CHILD ASSENT FORM

Child’s name
Your mom said it would be okay if I worked with you on speech this year. If you choose to, we’ll do lots of different activities to help make your speech we’ll do some fun activities and play games that help us make really good sounds, and work on those sounds when we speak. You will also read or repeat some short sentences each time we meet. We’ll work together for 50 minutes a day, two days a week at PSU.

If you want to rest, or stop completely, just tell me – you won’t get into any trouble! In fact, if you don’t want to do it all, you don’t have to. Just say so. Also, if you have any questions about what you will be doing, just ask me to explain.

If you want to try it, please sign your name on the line below.

Signed___________________________________________________________________ Date________________
APPENDIX C

SPEECH PROBE SENTENCES

1. Can I have a snack?
2. What time is it?
3. I need some help.
4. I don’t know what I need to do for homework.
5. Want to know what I did in school?
6. It hurt my eyes.
7. The kids are playing outside.
8. I was sick yesterday.
9. Hey, that’s my dinosaur.
10. I decided to stay.
11. The puppy made a mess in my room again.
12. The cow ran loose in the yard.
13. I had to stay home because I had a cold.
14. I saw the car skid over the line.
15. I’m asking you again.
17. Don’t ask me again.
18. May I get a snack now?
19. I need an answer in one hour.
20. Any chance it will work?
21. Who are you talking to?
22. That was a simple problem.
23. What were you saying?
24. There was ice on the pond.
25. Promise you won’t be mad?
26. My homework is in the study.
27. I hope it snows this year.
28. Elvis is sitting on the fence.
29. Do I have to baby sit tonight?
30. I guess we don’t get a snack today.
31. Did you bring the caboose?
32. My teacher is in his office.
33. This is a seven-story building.
34. I’m just testing the new lights.
35. Always listen for trains at the crossing.
36. You can’t go unless Mom says it’s okay.
37. That was the best pumpkin pie I ever had.
38. Wow that stuff really stings my eyes.
39. Is he a student from the other class?
40. That song is so old.
41. Can I have some more salmon please?
42. My friend can be really bossy sometimes.
43. He shot from the center line.
44. What’s missing from this story?
45. No, I said do it this way.
46. The rider fell off of his saddle.
47. We saw a submarine on TV.
48. I remembered my medicine this morning.
49. Mom got a new bicycle.
50. The policeman saved the boys.
51. Give me two pieces.
52. We should go now so we won’t be late.
53. Do we get to see Santa this year?
54. My sister and I made a snowman today.
55. An icicle fell from the house.
56. He didn’t know so I gave him a hint.
57. Elvis is the biggest cat we own.
58. Is your dog scared of my cat?
59. Don’t sneak up on me like that.
60. My eyes hurt from watching TV.
61. I let Miles use my Gameboy for a while.
62. I hung my stocking next to the fireplace.
63. Can you show me how to ski?
64. The sky filled with smoke.
65. Eat something, you look sick.
66. Don’t get snippy with me.
67. I had to have my tonsils out.
68. I’ll wash and you rinse the dishes.
69. The ship is sinking fast.
70. The police dog saved the little boys.
71. My cursive is getting better with more practice.
72. The toaster caught on fire.
73. Hey, can you boost me over this fence?
74. Do we have a math test of a spelling test today?
75. I have gum stuck on my shoe.
76. Did you see my new stopwatch?
77. I didn’t notice anything out of place.
78. I stumbled and fell down the stairs.
79. Are you selling the car?
80. We are going someplace new for breakfast.
81. Do we need to get some more soda?
82. We took a short trip to the store.
83. What show do you want to watch?
84. Stop teasing me!
85. I left my new coat somewhere at school.
86. What is the best way there?
87. Do we need ice in the bucket?
88. I put salve on my burn.
89. This is a sorry sight.
90. He swung his bag from side to side.
91. Is Bob your only son?
92. This is such a small boat.
93. We ate the same thing for dinner again.
94. You are acting very silly.
95. Should I put this stuff upstairs?
96. May I have some more ice cream, please?
97. We lost two games in a row.
98. How many should I take?
99. I forgot to get my homework.
100. What does the last step say?
101. Somebody called to speak with Mom.
102. The sheet is upside down.
103. I hit my shin on the table corner.
104. Can we sit in the shade?
105. I should see if Mom needs help.
106. Is the seat too short for you?
107. My cat is shedding up a storm.
108. Stop pushing in line.
109. Hey, someone took all my shoes.

110. Does your sunburn hurt?

111. When the ice is gone we can go outside.

112. I saw seven cats.

113. The school bus is coming soon.

114. Elvis ate a smelly mouse.

115. I’m going to the candy shop with Mom.

116. Stand in line against the wall.

117. She is making some dessert for us.

118. Bend your knees when you jump.

119. Shoot the basketball.

120. We had to shovel a lot of snow.

121. She could hear the bees buzzing.

122. My teacher said I did a good job.

123. I shook the can of soda.

124. Why should I shave my head?

125. Don’t disturb the monkeys.

126. The phone is off the hook again.

127. Show a little school spirit.

128. Stalling means you’re wasting time.

129. She passed a piece of candy to me.

130. We read the book, “A Missing Piece.”
131. I shiver when I am cold.

132. He is a guest on a TV show.

133. Are we going shopping at Safeway?

134. We saw many animals in the zoo.

135. We can share toys for a while.

136. I'm sure he said he would be back.

137. The shuttle flew in outer space.

138. Where is the pepper shaker?

139. Pass me the peas, please.

140. She’s going to get more sugar.

141. The ball hit me on my nose two times.

142. Did you see my new shiny shoes?

143. Who is giving us a ride home?

144. Was she going to say something?

145. My coke has no more fizz.

146. They will ship my book to his house.

147. Shush the dog, he’s too loud.

148. Why is your coat so shabby?

149. Show me where you keep your shampoo.

150. The score was five to zip.

151. I smeared paint on my jeans.

152. He sells cars to many customers.
153. You are losing another game to me again.

154. Can you keep a secret?

155. The ship can be seen in the summer.

156. My cat weighs seventeen pounds.

157. Is your sister two years older than you?

158. When is the St. Paddy’s Day parade?

159. Will the movie be shown again on Tuesday?

160. Stop, the cement is not dry yet.

161. Buckle your seatbelt for safety.

162. She went home with a sudden headache.

163. Are you a citizen of the U.S.?

164. The glass will shatter everywhere.

165. Wind swept the fishing boat away.

166. When is it going to be over?

167. I’m saying something so please listen.

168. May I use your cell phone?

169. You must be a very busy person.

170. Sharpen your pencil before each test.

171. Can you shut the outside door?

172. I’m sorry for stepping on your shoes.

173. Don’t shout in my face, please.

174. Both of my knees have a bruise.
175. The ground shook for seven seconds.
176. Is a shoe shop open nearby?
177. The lambs and sheep were fast asleep.
178. Batman is the best super hero.
179. Is your cocoa too hot to sip?
180. Where is he going away for summer?
181. Simon says touch your knees with your hands.
182. Use a fork to mash your potatoes.
183. She was a nice person to talk to.
184. Sorry, we have no soda pop.
185. The stairs are too steep and icy.
186. Did you see a new how on TV?
187. Maymay is blind in both eyes.
188. My shirt has powder on it.
189. I slid into home base.
190. Someone’s stole my ice cream!